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System Level Review of Genebank Costs and Operations
September 2020

Paper 2a: CGIAR Genebank profiles 2020

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Each CGIAR genebank manager was asked to provide information based on a standard template, not to exceed 2 pages in length, consisting of: Background; Expertise & specialism; Scope; Critical needs in the next 3 years (include staff needs); Opportunities under One CGIAR; and, a Longer-term vision for the genebank. The template is similar to one presented in the 2016 Genebank Platform proposal. These are their responses provided in their own voice. Additional information on each genebank is provided in the supplementary document Paper 2B or can be sourced from the Online Reporting Tool data, the Standard Operating Procedures and from Genesys.

1. AfricaRice	
Background	The AfricaRice genebank holds globally the third-largest rice collection after the International Rice Research Institute in the Philippines and the Dale Bumpers National Rice Research Center in the USA (https://www.genesys-pgr.org/). It has the largest indoor and outdoor facilities in Africa that are accessible for partners in the region for germplasm conservation, safety backup, regeneration/rejuvenation, and characterizations. It is the basic component of the Rice Biodiversity Center for Africa (RBCA) founded in 2019. The mandates of RBCA include (i) managing routine genebank operations in accordance with the CGIAR genebank's performance targets on germplasm availability, germplasm distribution, safety backup, passport data completeness index (PDCI), and quality management system (QMS); (ii) conducting scientific studies using rice genetic resources on gene discovery, donor identification, and pre-breeding to promote germplasm use; (iii) serving as a showcase of and raising public awareness on rice biodiversity; (iv) sharing resources, knowledge, and expertise with the national genebanks in Africa to advance scientific research in the continent; and (v) promoting collection and conservation of rice biodiversity in Africa.
Expertise & specialism	The genebank is managed by Marie-Noelle Ndjiondjop who has more than 20 years of experience in rice R&D at different capacities. She is supported by a senior consultant in rice genetics and four Senior Research Assistants who are responsible for (1) germplasm regeneration and characterization, (2) data management, (3) conservation, safety duplication, and distribution, and (4) post-harvest processing (drying and packaging) and monitoring.
Scope of the genebank	The AfricaRice genebank holds 21,300 accessions that are publicly available in Genesys and about 1,500 accessions that are not yet publicly available due to limited curation and incomplete supporting data. The collection represents the two cultivated species (*Oryza sativa* and *O. glaberrima*) and five indigenous African wild species (*O. longistaminata*, *O. barthii*, *O. punctata*, *O. brachyantha* and *O. eichingeri*). The *O. sativa* group is made mainly of African sativa accessions. Approximately 88% of the collection originated within Africa, and most of which are African rice (*Oryza glaberrima*) and African sativa. The target users of the rice collections are NARS breeders, universities, research institutes, CG centers, NGO's, farmer organizations, and research institutes across all continents. For Asian users, however, we distribute rice collections only when the requested accessions are not available at the IRRI genebank.
Major achievements of the last 5 years	Below is a summary of the main achievements of the last 5 years (2015-2019) 1. **Germplasm availability**: The proportion of available rice germplasm collection that is clean, viable, and with a sufficient quantity of seed for immediate distribution to users by the end of 2019 was 66%. 2. **Germplasm distribution (use)**: We have made extensive efforts to increase the distribution of our collection to the global rice community. Since 2015, we have distributed a total of 24,607 samples to 72 institutions across 43 countries. Nearly 53% of our publicly available rice accessions were distributed 1-61 times, 3 times on average. 3. **Safety backup (security)**: The proportion of rice germplasm that are conserved in Long Term Storage (LTS) and safely duplicated at both the Svalbard Global Seed Vault (SGSV) and the National Center for Genetic Resources Preservation (NCGRP) increased from 40% in 2015 to 65% in 2019. 4. **Passport Data Completeness Index (PDCI)** increased from 5.0 in 2015 to 7.6 in 2019.

1. AfricaRice	
	5. **Quality management system**: A draft of eight Standards Operations Procedures (SOPs), flow charts, risk assessment, and a mitigation book, AfricaRice's policies book and the genebank quality management system book were made available in 2019. 6. **Phenotypic characterization and evaluation**: We have characterized a total of 10,436 accessions for multiple phenotypic traits (phenotypic descriptors, grain physical and chemical characteristics, abiotic and biotic stresses). 7. **Molecular characterization**: To understand the extent of genetic diversity in our collection, identify redundancies and genetically unique accessions (https://pubmed.ncbi.nlm.nih.gov/29093721/) for use in rice genetic and breeding studies, and gene discovery (https://link.springer.com/article/10.1007/s00122-018-3268-2), we have so far genotyped 8,378 accessions using DArTseq technology and found that nearly 3% of our rice collection was either taxonomically misclassified or mislabeled during routine genebank operations. To minimize such types of errors, we identified diagnostic DArTseq SNPs (https://link.springer.com/article/10.1007/s11032-018-0885-z) and converted a subset of them to KASP assay for low cost and routine genotyping quality control analysis. 8. **Subsetting**: Using different criteria, we have developed 8 subsets of rice collection (https://www.genesys-pgr.org/subsets/v2r8GGVmq7k) that may help in promoting the use of our collection in research, breeding, and education. The subsets are grouped based on their tolerances/resistances to drought, iron toxicity, submergence, stagnant flooding rice yellow mottle virus, African gall midge, bacterial blight or their anaerobic germination. The accessions of these subsets have been most widely distributed over the last 25 years. 9. **Construction of new genebank facilities:** The new genebank and auxiliary labs at M'bé, Cote d'Ivoire have been fully constructed and commissioned to meet the FAO/IBPGR international standards. They have been fully equipped for seed testing, processing and storage at 5 °C (MTS) and -20 °C (LTS) with a capacity of 60,000 rice accessions. With the availability of the new genebank, AfricaRice successfully transferred all the accessions from Benin and Nigeria to Cote d'Ivoire in 2018, regenerated and/or repacked and barcoded them. 10. **Capacity building**: The genebank provided extensive technical backstopping to NARS partners from Mali, Chad, Benin and is supervising/training one Ph.D. student in rice genetic resources. In addition, the genebank staff have also received training on data management, germplasm regeneration and characterization, seed quality management, and seed health testing. 11. **Publication**: Since 2015, the AfricaRice genebank has published 16 research papers in international peer-reviewed journals and 3 book chapters.
Critical needs in the next 3 years (include staff needs)	During the last 5 years, we have made a lot of efforts in building the new genebank in M'bé, relocating the seeds of the MTS from Cotonou (Benin) and the LTS from Ibadan (Nigeria) to M'bé (Côte d'Ivoire), repacking the entire collection, redoing the inventory, relocating key staff, and replacing the national staff who were laid off in Benin etc. Consequently, routine genebank operations and research activities have been unavoidably affected to some extent. Below are highlights of the main components that we plan to accomplish in the next three years (2021-2023). 1. Continue the routine genebank operations

1. AfricaRice	
	2. Continue characterization of the remaining rice collection to get insight on the genetic variation and population structure of the entire collection using molecular and phenotypic data. 3. Work to address and close recommendations of the 2020 Genebank External Reviewers. 4. Increase the size and the representativeness of our collection of the landraces and African indigenous wild rice species either through acquisition from NARS genebanks or by conducting targeted collections with NARS partners. Most of our activities in 2021-2023 will be managed by existing staff. However, we request additional fund to hire a Postdoctoral Researcher for 2-3 years to (i) handle some of the Genebank External Reviewers recommendations (e.g., recommendations 4, 5 and 12); (ii) finalize our efforts in curating about 1,500 accessions that are not yet publicly available, and (iii) manage analyses of DArTseq genotype data and phenotypic data of nearly 9,000 accessions. In addition, we also request the US $45,000 to purchase and install a modern seed germinator that will improve our viability test. *Please see Table 1 for a summary of our estimated budget in 2021-2023.*
Opportunities under One CGIAR	We expect that under One CGIAR, germplasm exchange among the genebanks within CGIAR will be much easier and more frequent, and advanced technologies in germplasm conservation will be adopted faster with the intervention of the One Genebank Platform.
Longer-term vision for the genebank	The long-term vision for the genebank is to (i) effectively and efficiently conserve the existing rice germplasm while making continuous efforts to collect and store new germplasm; and (ii) provide donors for traits of interest to breeding programs. Identification of appropriate donors for traits that are required by products but that are not existing in the currently available elite germplasm is a challenge to breeding programs. But this could be achieved by characterizing and establishing passport data for all the genebank collections. The AfricaRice genebank is in the right position to work on the germplasm characterization, both phenotypically and genetically. Completion of passport data for the genebank collections, however, may take years and require continuous financial support.
Additional comments	

2. Alliance-Bioversity	
Background	The Bioversity International *Musa* Germplasm Transit Centre (ITC) is hosted by the Katholieke Universiteit Leuven (KULeuven) in Belgium. Bioversity does not have its own field station but instead collaborates closely with national genebanks through its MusaNet network, who carry out fieldwork on its behalf. MusaNet's thematic groups (Conservation, Diversity, Evaluation, Information and Genomics) also provide expert guidance. The primary objective of the ITC is to conserve and make publicly available its collection to the highest standards possible. Beyond that role, significant value has been added to the collection by cryopreservation, seed banking, molecular characterization, phenotyping, genomics, bioinformatics and comprehensive accession-level documentation.
Expertise & specialism	Nicolas Roux (Genebank Manager and *Musa* Program Leader) coordinates the work on banana genetic resources and management systems within the Alliance Bioversity-CIAT and within the wider research community as MusaNet coordinator. Ines van den Houwe (Genebank Curator) has more than 20 years of experience managing and developing the *in vitro* banana collection in Leuven. Bart Panis (Cryopreservation specialist) Pioneer in developing cryopreservation protocols in numerous crops. Julie Sardos and Rachel Chase (Characterization specialists) verify the genetic integrity of the material maintained at ITC by molecular characterization and morphological characterization respectively. Max Ruas (Database manager) has expertise in data management and maintains the *Musa* Germplasm Information System (MGIS) which contains information on the ITC and 29 national collections to date. Sebastien Massart manages virus indexing and sanitation is managed by (Honorary Research Fellow of the Alliance Bioversity and GHU representative for Bioversity and hosted by the University of Liege (ULg) in Gembloux, Belgium. External to the ITC, molecular characterisation is carried out at the *Musa* Genotyping Centre hosted by the Institute of Experimental Botany, Czech Republic. The field component of the genetic integrity check (Field Verification) is conducted with USDA-TARS in Puerto Rico.
Scope of the genebank	The ITC holds 'in trust' the world largest banana collection under the auspices of the FAO. It currently maintains 1,627 banana accessions from 38 countries as *in vitro* collection, backed-up by a cryopreserved collection to safeguard global *Musa* diversity in perpetuity. The ITC also serves as a vital safety backup and transit Centre for national banana genebanks and ensures that germplasm is clean of pests and diseases and freely available under the International Treaty. In the past 35 years, the ITC has distributed over 18,000 banana samples to researchers and farmers in 113 countries. Target users are mainly National Agricultural Research Systems (NARS) (62%) in developing countries, where bananas are an essential crop for subsistence agriculture or the local market. The remaining 38% is requested by advanced research institutes and universities in developed countries.
Major achievements of last 5 years	In 2019, the ITC upgraded the genebank database system, enhancing the recording and tracking of accession data in the lab and greenhouse. We now use tablets on which the Musa Genebank Management System (MGBMS) web application runs. Security measures were taken to back up the system and a recovery scheme has been put in place. Significant improvement in the recovery of cryopreserved material. The age of a plant from which the meristem is excised has a significant effect on the cryopreservation efficiency. When tips are isolated from 4 weeks old plants compared to 6 or even 8

2. Alliance-Bioversity	
	weeks old plants, average % of survival of the thawed material is considerably higher (13%) and the success rate of the experiments (replicate sets of meristems of an accession) increased from 54% to 88%. Using younger plants resulted in a gain of time for the cryopreservation workflow but also an increased post thaw recovery rate of the cryopreserved material.
Critical needs in the next 3 years (include staff needs)	1. Virus indexing and sanitation of BSV infected accessions will be increased in order to ensure that 90% of ITC germplasm is available for distribution. 2. Safety duplication will be boosted to ensure that 90% of accessions are backed up via cryopreservation. 3. Operations and workflows will be fully digitized and integrated into MGBMS. 4. Data from MGIS will be cleaned and uploaded to Genesys. 5. All Standard Operation Procedures (SOPs) will be completed and approved. 6. The seedbank will be launched and will be distributing seeds of banana wild species upon requests
Opportunities under One CGIAR	Opportunities for the ITC for closer collaboration, merging and division of roles under One CGIAR and One Genebank Platform: 1. Agreement on a common process for MTS and LTS across clonal crops (not necessarily same protocols, but overall agreement on how to manage accessions that need to be kept in MTS (in vitro) and in LTS (cryo) and safely duplicated.. 2. Agreement on similar methods for virus indexing (including the latest developments based on virus indexing) and on virus therapy (thermotherapy, chemotherapy, cryotherapy). 3. Data management common system to at least to develop common rules for standardization through SOP to ensure One CGIAR approach for data management with some flexibilities to adapt rules whenever necessary.
Longer-term vision for the genebank	By 2030, the ITC will conserve the total diversity of *Musa,* with better representation of wild genotypes and more knowledge related to germination, preservation, population genetics and collection of wild bananas. Wild genotypes will be conserved in vitro and in the form of seeds that could be distributed from the seed bank to be hosted at the Meise Botanical Garden and managed by the Alliance of Bioversity-CIAT. At least 90% of the accessions will be cryopreserved and safely duplicated (cryopreserved black box in another country). The ITC in Leuven will also serve as a cryo-vault for other collections willing to have their collections safely duplicated according to agreed international policies. Passport data and any other Characterization and Evaluation data from at least 60 ex-situ collections will be exchanged through the MGIS database, and after quality verification in MGIS, will be made available through the multi-crop database Genesys. Adding traditional knowledge to ITC accessions from partners or from collecting missions and linkage to Crop Wild Relative or in situ platform being put in place with other Clonal crops Centers in the context of the RTB-CRP. This platform will help identify populations at risk and to identify cultivars/species with strong potential for breeding. Genotyping studies will further elucidate the taxonomy and link genes to phenotypic traits (GWAS), while the evaluation of biotic and abiotic stresses using improved protocols and technologies, will reveal important 'climate smart' traits inherent in *Musa* diversity.

2. Alliance-Bioversity	
	Research on genetics and epigenetics will allow a better understanding of somatic variation in banana and the development of a system for early detection and control. Genomics and bioinformatics analyses will play an increasingly important role in understanding the genetic variation of banana diversity. Finally, stronger linkages among researchers of different disciplines and regional networks will be forged in order to develop projects and guidelines that result in positive and lasting impacts on banana production systems and livelihoods.
Additional comments	

3. Colombian genebank of the Alliance of Bioversity & CIAT	
Background	The Colombia genebank of the Alliance of Bioversity & CIAT manages the globally largest collections of beans and tropical forages (as seed and whole plants) and cassava (*in vitro* and as bonsai plants). Current facilities are old, too small and ill-suited for a genebank. A new state-of-the-art facility, called *Future Seeds*, is being built. The genebank currently uses five field sites in close proximity to headquarters, covering a range of soil types and elevation levels for diverse bean and forage taxa (one high-elevation site has yet to be established).
Expertise & specialism	Peter Wenzl (Genetic Resources Program Leader) Geneticist/physiologist with 20 years of project-leadership experience in genetic resources and crop improvement Marcela Santaella (Operations and Quality Manager) Plant pathologist with training and hands-on experience in project management Luis G. Santos (Seed Conservation Coordinator) Agronomist and Industrial Engineer Javier Gereda (Bean Regeneration Coordinator) Agronomist with experience in the seed industry Juan José González (Forage Regeneration Coordinator) Agronomist by training Mónica Vélez (In-Vitro Conservation Coordinator) Cellular/molecular biologist with training in statistics and systematics Juan Carlos Guerrero (IT Coordinator) Industrial engineer with a degree in informatics management Dimary Libreros (Documentation Specialist) Agronomist by training with almost two decades of experience with PGR data Maritza Cuervo (Germplasm Health Manager) Virologist with a 14-year track record of managing the germplasm health laboratory Mónica Carvajal (Digital Genebank Scientist) Virologist by training, now leading the genotyping/sequencing of accessions and establishing a DNA collection
Scope of the genebank	The genebank conserves the globally largest collections of *Phaseolus* beans (including five domesticated species), cassava, and tropical forages. The collections, totalling 67K accessions, were originally established as working collections for CIAT's crop programs, before being combined into a genetic resources program. A total of 450K bean, 50K cassava and 94K forage samples have been historically distributed to CIAT's crop program, NARS, universities, farmers and other users. Forage accessions have been assigned to priority classes in collaboration with ILRI, following recommendations of the *Tropical Forages Strategy*, with the intention to archive low-priority accessions. Once the *Future Seeds* facility becomes operational, the genebank's scope in terms of collections conserved has room to expand, for example by becoming the LAC distribution hub for WorldVeg.
Major achievements of last 5 years	● Steady progress has been made towards Genebank Platform performance targets, which may be achieved for the bean and forages collections by Dec 2020, despite the prolonged COVID-19 lockdown. ● Distribution of cassava accessions had to be halted in Jan 2017 because of new insights into the pathogenicity of frogskin-disease phytoplasma. A testing and phytosanitation campaign subsequently restored availability of accessions for distribution from 9% in Jan 2017 to 86% by Dec 2019. ● The construction of the new iconic and environmentally sustainable *Future Seeds* facility is progressing and will be completed in Q2-2021 - funding and COVID-19 lockdown conditions permitting. The facility will support all types of conservation methods (seeds, *in vitro*, cryo, field; all supported by a germplasm health lab), relieve the space constraints in the current genebank building, and could be used

3. Colombian genebank of the Alliance of Bioversity & CIAT	
	as a platform to consolidate more collections and offer safety-duplication services to other genebanks.
Critical needs in the next 3 years (include staff needs)	● The genebank's historical strategy for conserving cassava requires an overhaul to ensure the safety of the collection (see Observations 1 and 14 of the 2019 genebank review). The field collection was eliminated several decades ago, the *in vitro* collection has been sub-cultured for 30–40 years without rejuvenation, a considerable number accessions have been lost because of mites and bacterial contamination following a temporary relocation of the collection in 2011, several wild accessions have stopped producing roots *in vitro* and are at risk of being lost, and there have been no funds to build a base collection using an existing cryopreservation protocol. The prolonged medical leave of the *in vitro* laboratory manager and the limited number of staff permitted to work on sub-culturing accessions because of COVID-19 are further threatening the collection. A comprehensive strategy involving rejuvenation, cryopreservation of a phytosanitarily clean and genetically non-redundant accession subset, and the conservation of wild accessions as seeds, needs to be implemented but will require more qualified staff, including an IRS-level *in vitro* specialist. ● Genebank information management has historically been handled in a somewhat ad-hoc manner due to a combination of budget constraints and the need to achieve the Genebank Platform's performance targets with the time and resources available. As a consequence, the data of the two seed collections is currently dispersed across several legacy databases containing hundreds of partly redundant and disconnected tables holding data formatted in a variety of ways. Recovering, cleaning and migrating this data into GRIN-Global is a mission-critical prerequisite for data-driven genebank management in the future, but will take time and resources as has been outlined in our response to Observation 4 from the 2019 genebank review. Cassava data has already been migrated into GRIN-Global, but requires more curation and standardization to adhere to international MCPD and other data standards. ● After a period of funding constraints, the genebank's emphasis during the last 8-10 years has been on regenerating the maximum number of bean and forage accessions to prevent losses of accessions and to achieve Genebank Platform performance targets. Several staff with a background in agronomy (rather than collection curators) were hired for this purpose. As the genebank is approaching the 90% mark of successfully regenerated accessions, there is a need to again hire collection curators. Merging the bean and forage teams into a single 'agronomy-support' team should free up resources that could contribute to hiring collection curators. The resulting agronomy support team could also regenerate other crops than beans or forages.
Opportunities under One CGIAR	● There are synergies between the two Alliance genebanks in terms of the Leuven genebank's expertise in mainstreaming cryopreservation (needed for the cassava collection) and the Colombia genebank's access to regeneration sites that could be used for characterizing banana accessions. ● Our ongoing collaboration with ILRI has the objective to create a consolidated CGIAR-wide tropical-forage collection with a single access point on the web and distribution points at ILRI and the Alliance.

3. Colombian genebank of the Alliance of Bioversity & CIAT	
	● The coordinated genetic characterization of cassava accessions conserved at the Alliance and IITA will provide a framework for rationalizing and targeting conservation and distribution efforts. ● There is an opportunity to consolidate more collections in the new Future Seeds genebank. The new facility, in combination with nearby regeneration sites at a variety of elevation levels, provide sufficient capacity to conserve additional crops in the form of seed, in vitro and 'in cryo' collections, without substantially increasing the fixed costs to operate the genebank's facilities and regeneration sites. As an example, the Alliance and WorldVeg are planning to use Future Seeds as a vegetable distribution hub for Latin America. Also, CIAT has previously offered CATIE assistance in the conservation of their collections. ● *Future Seeds* includes a *Digital Genebank* module in anticipation that digital tools and information are going to increasingly drive PGRFA conservation and use. The module, comprising a high-throughput DNA-extraction lab, servers for computation-intensive analyses and an open-office area for data scientists, will support the genebank's role as a regional hub for the Diversity Seek (DivSeek) initiative. *Future Seeds*, furthermore, is co-located with the leadership of the CGIAR's Big Data Platform, which could create innovation opportunities in the digital domain linked to PGRFA. ● The Alliance co-leads the CRP on Climate Change, Agriculture and Food Security (CCAFS) and the HarvestPlus program on biofortified crops, providing opportunities for synergies with two key research areas that could benefit from a more widespread and systematic deployment of PGRFA.
Longer-term vision for the genebank	The *Future Seeds* genebank will strive to become an international hub for PGRFA conservation in the tropics. The facility will create economies of scale for conserving seed, cryo, and *in vitro* collections of multiple crops, provide access to regeneration sites at multiple elevations in short driving distance, and offer safety-duplication services to other international genebanks, national genebanks in the region, and community seed banks in Colombia. *Future Seeds* will work to promote excellence in genebanking in the region by exploring opportunities for capacity-building in collaboration with universities. The facility's *Digital Genebank* module will aim to attract a critical mass of visiting researchers from national genebanks and universities to jointly innovate around the use of genomic data and digital tools for improving genebanking methodologies, comparing *ex situ* to *in situ* diversity, and encouraging a broader use of PGRFA for climate adaptation and enriching diets. *Future Seeds* will also leverage its iconic and environmentally sustainable design for public advocacy and education purposes, including the hosting of international meetings and offering educational materials for visitors with a particular emphasis on audiovisual tools for the younger generation.
Additional comments	A PowerPoint presentation with more information about the current genebank and the new *Future Seeds* facility can be downloaded here (large file including a video showing construction progress).

4. CIMMYT	
Background	The CIMMYT genebank is a well-equipped, purpose-built facility, partly powered by solar panels. The genebank functions at high levels of efficiency, distributing sometimes up to 30,000 samples annually.
Expertise & specialism	Tom Payne (Wheat Germplasm Bank manager) with nearly 32 years of involvement as a wheat scientist in various countries with CIMMYT. Denise Costich (Maize Germplasm Bank manager, retiring 30 September 2020) with extensive experience in maize crop wild relatives, and the molecular genetic analysis of the crop. Dr. Terrence Molnar will succeed Denise Costich as curator and manager of the maize collection. Terry is an experienced maize breeder from North Carolina State University, Pioneer/Corteva, and most recently at CIMMYT. Dr. Amos Alakonya (Seed Health Laboratory manager) responsible for achieving and maintaining ISO17025 accreditation, and CIMMYT's Stewardship of Excellence standards. Dr. Filippo Guzzon (Post-Doctoral Fellow - Conservation and Enabling Use of Maize and Wheat Diversity)
Scope of the genebank	CIMMYT manages a diverse maize and wheat collection. It starts with the seed. CIMMYT's germplasm bank is at the center of CIMMYT's crop-breeding research. The maize collection of over 28,000 accessions includes the world's largest collection of maize landraces, created and maintained by farmers over many generations, as well as the teosintes (*Zea* spp.) and *Tripsacum*, the wild relatives of maize. It is also the global source for CIMMYT's 600+ inbred lines. The wheat collection numbers about 150,000 accessions from more than 100 countries, and consists of bread wheat, durum wheat and triticale landraces, cultivars, genetic stocks, breeders' materials and wild relatives. CIMMYT is actively assessing the diversity of the maize and wheat seed collections using genomics technologies. Much of the collection has been genotyped using DArTseq technologies. Developing links between accession data and data from breeders are another focus of work. The genebank has been a pioneer in using GRIN-Global and in maintaining an ISO 9001:2015 standard. The Seed Health Unit ensures that all seed conserved in the genebank, as well as any seed imported to or exported from any of CIMMYT's research locations, meets international phytosanitary standards. The Seed Health Unit has attained ISO/IEC 17025 accreditation.
Major achievements of last 5 years	--The maize and wheat collections reorganized five areas enabling joint service activities. A new era of joint management, with a single national scientist as the coordinator of both collections, has begun. The database is managed by a single, shared national scientist (1 FTE GRIN Global and barcoding improvements are also conducted jointly. The Viability Unit is another shared service, under the supervision of Dr. Filippo Guzzon and staffed with 2 national scientists from each collection plus a manager. Development and implementation of our ISO management is overseen by a single shared manager. --With funding from the Federal Ministry for Economic Cooperation and Development, Germany, the CIMMYT genebank coolant system was retrofitted to use a new more climate-friendly, recommended refrigerant, R-404A. The new system will also reduce annual electrical energy consumption by about 25 percent and will complement the GIZ-funded solar voltaic system installed for the genebank in 2014. Built in 1996 with state-of-the-art facilities, the germplasm bank cooling system has been using the refrigerant HCFC-22/R-22S, now recognized as a threat for the ozone layer and a potential contributor to global warming. This refrigerant is being phased out in many

countries under the Montreal Protocol on Substances that Deplete the Ozone Layer, according to Tom Payne, head of wheat genetic resources at CIMMYT. "The lifespan of this equipment is expected to exceed 20 years," Payne said. "The technical crews involved in installing the new cooling system are working under temperatures ranging from 0 to -18 C and they have to make sure during installation that vault temperatures don't deviate from the standards required for long-term conservation of maize and wheat seed."

--The Maize Germplasm Bank has adopted a more efficient, streamlined seed conditioning workflow, modeled after the USDA Ames Maize Collection's schema. The MGB seed conditioning room was remodelled to provide several independent work stations for individual staff members, who complete all phenotyping, image scanning and documentation steps for the conditioning of newly-harvested regenerations. In addition, using funds obtained from crowdsourcing, three crop wild relative facilities were constructed: an isolation screenhouse for teosinte and a temporary shadehouse for Tripsacum at CIMMYT-Tlaltizapan; and, a shade house for outdoor natural seedling vernalization at CIMMYT-Toluca for wheat.

Below is a summary of the main achievements as of 2019

1. **Germplasm availability**: The number of legally and physically available maize and wheat germplasm collection that is clean, viable, and with a sufficient quantity of seed for immediate distribution to users by the end of 2019 was 28,585 and 127,649, respectively.
2. **Germplasm distribution (use)**: CIMMYT fulfilled 306 germplasm requests in 2019, sent to countries requesting maize (43) and (35) wheat.
3. **Safety backup (security)**: The number of maize and wheat germplasm safely duplicated at both the Svalbard Global Seed Vault (SGSV) and the National Center for Genetic Resources Preservation (NCGRP) 21454 and 125011, respectively.
4. **Passport Data Completeness Index (PDCI)**. Genesys uses the PDCI as an indicator of the completeness of published passport data. The 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. The average PDCI score for CIMMYT's 206,767 maize and wheat accessions is 6.47, with minimum score of 3.65 and maximum score of 9.10.
5. **Quality management system**: The CIMMYT Germplasm Bank is ISO9001:2015 certified.
6. **Molecular characterization**: To increase utilization of CIMMYT Germplasm Bank **materials** for crop improvement, the Seeds of Discovery (SeeD) initiative uses cutting-edge genetic analysis technology to explore the diversity of the CIMMYT maize and wheat genebanks to identify useful, novel genetic diversity to introduce to breeding programs. SeeD will help breeders develop the improved varieties farmers need to feed a growing population in a changing climate. Approximately 120,000 wheat and 28.000 maize samples have been genotyped by the project, generating comprehensive datasets using DArTseq technologies.
7. **Subsetting**: The CIMMYT Wheat Germplasm Collection has defined over 50 trait based subsets that may help in promoting the use of our collection in research, breeding, and education. The subsets have been published in GeneSys and CIMMYT GRIN Global.

4. CIMMYT	
	8. **Publications**. The CIMMYT Germplasm Bank staff authored 14 peer reviewed publications in 2019.
Critical needs in the next 3 years (include staff needs)	--More training for the staff in areas critical for their work (e.g. data analysis, plant pathology, seed biology, seed health, germplasm conservation & share policies); --A more safe work environment especially for personnel in frequent contact with seeds, dust, agro-chemicals and therefore mycotoxins (e.g. seed processing area). For example, installation of laminar flow hoods in the processing areas, to reduce contact with toxins of the seed and provide a more sterile work environment. --Reconfiguration of the work spaces: perhaps move the viability lab to a larger space; creation of a joint maize + wheat processing area. --Improve communication of what is being done and what is held in the Germplasm Bank. There is a need to provide for an opening of opinion, so that team and individual ideas can be shared and discussed. And, there is a need to pave paths towards career development.
Opportunities under One CGIAR	--Enhance the collaboration, also in terms of collection composition of the other CG banks conserving the same crop genepool (IITA and ICARDA) --Increase learning opportunities across genebanks, in areas that can benefit CIMMYT genebank operations (seed processing and automation from IRRI, Viability testing from CIAT) --More access to NARS partners in areas where CIMMYT operation are not strong (e.g. South-East Asia, West Africa)
Longer-term vision for the genebank	--Be allowed to have a more dynamic management of the collection composition (easier archiving or donate collection to other genebanks) --Targeted acquisition of some underrepresented germplasm, for example: Central American teosintes, European flints, endangered populations of wheat wild relatives --Include innovations in our processes: dry chain technology, automation of the germination testing through image analysis --Technical and knowledge support to national-community germplasm conservatories that are in the frontline of PGR conservation, in order to improve their processes and back-up their collections --Be a knowledge and training hub for wheat and maize conservation at global scale (taking inspiration from the Millenniums Seed Bank Partnership): provide training to national partners on wheat and maize genetic resources conservation, some of the trained people will be the future managers and technicians of their organizations, this will enhance PGR conservation at a global scale.
Additional comments	The Germplasm Bank is committed to providing healthy, viable seed and reliable information on the collection of the genetic resources of maize and wheat that it protects; as well as carry out the activities required for its Introduction, Regeneration, Conditioning, Conservation and Distribution, complying with international agreements and standards with trained personnel, to guarantee compliance with the requirements of our clients; Thus committing to comply with the ISO 9001 Standard and continually improving the effectiveness and efficiency of the Quality Management System.

5. CIP	
Background	CIP has three global programs, one of which is dedicated to biodiversity conservation (in situ and ex situ), information management, CWRs, enhanced use, and monitoring PGRFA legal frameworks. The mandate of the CIP genebank include (i) managing routine genebank operations and strive to achieve the performance targets on germplasm availability, germplasm distribution, safety backup, completeness of passport data, and maintenance of an extensive quality management system (ISO 17025); (ii) conducting research studies on our genetic resources collection [potato, sweetpotato, and Andean Roots and Tubers (ARTCs)] to aid in measuring genetic diversity, identification of duplicates, gene discovery, linking markers to traits of interest (GWAS), whole genome sequencing/discovering variants, intra and interspecific phylogenetics, population structure, domestication, determining hybrids in the collection, and research related to overcoming bottlenecks in cryopreservation, in vitro conservation and clonal crop virus detection\cleaning - all to promote germplasm use; (iii) serving as experts on issues related to biopiracy, digital sequence information (DSI), and legal aspects of access and benefits of PGRFA ; (iv) capacity building of national genebanks, Peruvian farmers, and other researchers to advance scientific research and/or promote biodiversity and conservation; and (v) promoting collection and conservation (ex situ and in situ) of root and tuber crops. CIP has a highly complex collection of difficult-to-conserve clonal and seed crops with the largest *in vitro* and cryo collection in the CGIAR. Field and screenhouse collections are managed at two sites due to needs of conducive growing conditions for these crops in addition to the main Lima campus which houses the germplasm collection. The collection also includes many wild species maintained as seed and an extensive herbarium collection with over 70,000 specimens. CWRs are generally very time consuming and labor intensive to produce seed quantities sufficient enough for distribution purposes. A large-scale cryobank for potato has been operationalized with over 3500 accessions conserved and a high total plant recovery rate. Cryo for sweetpotato is in earlier stages of being developed/operationalized. Andean Root and Tuber Crops (ARTC) comprise nine families of non-Annex 1 crops, held *in vitro* and in the field, which is an important economical collection to farmers located in the Andes. Approximately, 50% of the ARTC collection has legal certainty (obtained prior to 1993,) but most can't be shipped outside of Peru because of a lack of routine virus diagnostics which need to be developed in order to meet phytosanitary requirements of most importing countries. Research has advanced to use NGS to determine the viruses that infect these crops but no routine testing has been developed at this time.
Expertise & specialism	Noelle Anglin (Head of Genebank) Joining the CIP genebank from USDA ARS genebanks working both in clonal and seed germplasm collections. Noelle has many years of experience in genetic resources conservation, molecular biology, population genetics, pathology, data analysis and more recent involvement in legal aspects of genetic resources (ITPGRFA, DSI, CBD, etc.). Norma Manrique (Genetic Resources Conservation Manager) has recently joined CIP leading day to day operations. She has expertise in genetic resources conservation, in vitro, cryo, molecular biology with significant experience in potato. Rene Gomez (Senior curator) curates the cultivated potato collection. Expert in potato taxonomy with more than 20 years' experience working with native Andean potato.

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	Rene began a potato repatriation program 20 years ago working with farmers in Peru returning native varieties to suit their needs. Alberto Salas (Senior advisor, former consultant) is a retired but very active world expert in wild potato taxonomy and biogeography. He was responsible for collecting much of the CIP potato collection. He is available for consultation as needed. This position (wild potato curator) is actively being recruited. Genoveva Rossel (Curator) Expert in sweetpotato genetic resources with 10 years' experience. She also has experience in molecular markers. Ivan Manrique (Curator) curates the ARTC collection with more than 10 years' experience. Ana Panta (*In vitro* specialist) Cryopreservation and *in vitro* specialist who has worked more than 25 years at CIP and heads the *in vitro* labs. Rainer Vollmer (Cryopreservation leader) Cryopreservation specialist who leads the large-scale cryopreservation of potato and sweetpotato. Edwin Rojas (Software developer) leads database development at CIP and advises other CGIAR Centers in data management and barcoding along with GG development. Oswaldo Chavez (Database manager) data management, software design and statistics Reynaldo Solis (Phytosanitary/quarantine specialist) manages the quarantine and phytosanitary cleaning of accessions. Newer staff member to CIP Open position (In vitro specialist) manages sweetpotato in vitro, washing and sterilization, and seed and *in vitro* safety duplicates in Huancayo, SGSV, EMBRAPA and CIAT. Currently this role is being covered by Ana Panta and Gisella Carpio. Rosario Falcon (Germplasm acquisition & distribution) specializes in germplasm requests and distributions and ISO/QMS. Fanny Vargas (Curator) manages the herbarium collection Gisella Carpio (Genebank specialist) – administrative support, liaison between genebank staff, partners, CIP to coordinate projects, budgets, etc. Temporarily leading washing and sterilization and safety backup group. Jan Krueze (Head, Virology) specialist in virology, who manages the GHU
Scope of the genebank	Conservation, characterization, and documentation of over 17,700 accessions most of which (67%) are maintained *in vitro*. CWRs of potato, sweetpotato, and Andean roots and tubers are maintained and distributed as seed collections. Focus of the collection is predominantly on landraces (maintained in vitro) with most of the potato collection originating or collected in South America/Peru. Breeding lines and improved varieties represent a very small portion of the potato cultivated collection (5.6%) and improved varieties often do not get incorporated in the ex situ collection until after 20+ years of release and significant impact is demonstrated from a single line (i.e. – C-88). Sweetpotato is in the process of reducing breeding lines (1607 accessions) that were donated from IITA as they have been suggested to not be valuable by CIP breeders. All new cultivated acquisitions are genotyped and compared to the fingerprints collected on the entire cultivated collection before incorporation with no duplicated material considered in the acquisition process, saving considerable expense. Potato has performed morphological evaluations to eliminate putative duplicates in the past and now few duplicates exist in the cultivated collection. Sweetpotato is undergoing a duplicate evaluation and reducing material as genetically identical material is identified both genotypically and phenotypically.
Major achievements of last 5 years	● In 2013, had approximately 10% of the accessions available for distribution, due to major errors in identity. All germplasm distributions were stopped and a project started to fix these errors in late 2013/2014. Currently, 66% of potato, 36% of

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	sweetpotato, and 3% of ARTCs are available for international distribution. (More ARTCs would be available if virus diagnostics could be developed because in theory over 50% of the collection is legally available). ● Over 3,500 potato accessions conserved in cryopreservation with strict QC measures ensuring a high percentage of total plant recovery ● ISO 17025 QMS accreditation maintained for 11 years – lead to improved protocols, data handling, tracking, and no cases of positive material being shipped to other countries ● Led CG genebanks in the use of GLIS-DOIs for all accessions, capacity building, and informatic tools for GG, barcoding, etc. ● A healthy passport data completeness index (PDCI) currently at 7.38 ● Identity verification completed for 90% of the in vitro cultivated potato collection ● First genebank to employee "QMS genotyping – checking identity - by randomly sampling 10% of the collection and recollecting genotyping data in order to identify new potential errors occurring in the collection from routine handling and manipulation ● Employed small RNA sequencing and assembly to identify viruses infecting yacon, oca, and ulloco (ARTCs) and sweetpotato ● Research on liquid culture media and meristem regrowth reducing time required for virus cleaning ● Entire cultivated potato collection genotyped with 12K SNP array ● Entire cultivated sweetpotato collection genotyped with 20 SSR markers and DArTseq ● ~50% of the oca and ulloco (ARTCs) cultivated collection genotyped with DArTseq ● Whole genome sequencing of 12 potato landraces including diploids, triploids, tetraploids, and pentaploids – complex genomes ● Over 1500 CWRs of potato genotyped and 500 in sweetpotato ● ~200 Wild potatoes accessions collected in Peru in 2017/2018 after 20 years of no collecting in Peru ● ~30 new cultivated potatoes being introduced from Pasco region in Peru after genotyping 500 samples from partners and determining unique material ● 20-year program of repatriation of native potato landraces back to farmers in Peru driving use of landraces – largest distribution of repatriated material occurred in 2019. The genebank has given over 10,000 samples back to 95 communities. Survey data collected to determine impact of repatriation program and a GCDT fellow working on analysis/publication. ● Nine subsets developed to increase use of germplasm http://genebank.cipotato.org/gringlobal/methodaccession.aspx ● Fully barcoded in every process/activity ● Website developed to search and order germplasm, track information on use and satisfaction automatically, and promote the genebanks mission and research publications ● Comprehensive catalogs developed for ulloco, oca, and mashua with detailed passport, maps, and photos of each accession. https://cgspace.cgiar.org/bitstream/handle/10568/65110/78185.pdf?sequence=2&isAllowed=y
Critical needs in the next 3 years (include staff needs)	Conservation needs: Increase storage period of MTS for sweetpotato and Andean roots and tubers which need constant propagation and attention, operationalize LTS (cryo) for sweetpotato and Andean roots and tubers as a conservation strategy to reduce the reliance and cost of in vitro, research on more efficient seed regeneration protocols (i.e.

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	– sweetpotato CWRs very low production of seed), and continue monitoring and fixing genetic identity issues in vitro or elsewhere as a 0% error rate even with barcoding is not realistic. Use needs: Operationalize small RNA sequencing and assembly approach for all crops in order to speed up the bottleneck of virus testing in clonal crops, expand and promote the repatriation program in Peru to drive an increase landrace distributions, collect evaluation data on the collection to help users better choose accessions to suit their needs, and embrace the digital genotyping/genomics age by expanding molecular characterization to drive distributions to our users. Safety backups: secure a safety backup site for the cryo material and reduce in vitro safety backups. Resources: Reaching the 90% accession availability performance target is a huge bottleneck and likely will still take 5+ years to accomplish. Additional resources are needed to speed up this process as we have strict limitations on how many samples per year can be processed for virus indexing and cleaning due to the high cost and limitations in GH space.
Opportunities under One CGIAR	The Clonal Community of Practice (CoP) which includes CIP, CIAT, Bioversity, and IITA are closely working together on clonal issues such as MTS, cryo, phytosanitary bottlenecks, along with sharing protocols, developing strategies, and capacity building. CIMMYT, CIAT, and CIP are working together on germplasm collecting projects in South America. This was temporarily delayed due to COVID19. A15 genebanks all work together with the policy module to respond to complex legal issues governing acquisition and distribution of genetic resources. The One CGIAR offers the opportunity to continue working as a genebank multi-center community of practice that addresses the global needs for ex situ and in situ biodiversity conservation and use for agriculture and food systems. This is a critical global function that needs to be maintained under the One CGIAR.
Longer-term vision for the genebank	Our long-term vision is to have 90% of the germplasm collection available to users and backed up at a secondary location so that CIP can receive an LPA. This is our single most difficult performance target to reach and will take a lot of time to hit this target. The biggest bottleneck in achieving this goal is phytosanitary virus testing and cleaning of clonal materials and the constant propagation required to safety backup in vitro collections annually. COVID19 and extensive quarantine periods have demonstrated the difficulty to stay on top of the propagations needed for renewing in vitro safety backups. Several bilateral projects are helping us to improve methods for virus testing and meristem regrowth so that materials can be tested and available to users faster. However, more work is required to get this operationalized at CIP. The vision for the future of genebanks should embrace the digital nature of the 21st century. Since the 1990's, it has been clear that all businesses have moved into the digital age with enhanced methods for big data handling, bioinformatics, including the potential of artificial intelligence (automatization, algorithms, modelling, image processing) to facilitate information analysis and decision making, and making it readily available

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	through different means (cell phone, internet, etc.) and the genebanks need to follow suit to stay relevant. It is not difficult to imagine that genebanks could be more digital in nature by having users access genotyping and phenotyping data in silico to meet their needs. This would be accomplished through high density genotyping, trait mining, whole genome sequencing, GWAS, and extensive phenotyping which would create an extensive digital catalogue of each accession. This would also help users sort through thousands of accessions to reach the relatively few accessions that they need for their research. A former genebank leader once wisely said "an under characterized genebank is an underutilized genebank". Most genebanks still suffer from being under characterized.
Additional comments	Generally, staff levels are very low, education expectations are low, and so is their associated pay. This typically means a lot of training required in basic scientific concepts (i.e. – replications, controls, etc.) along with their technical training and leadership training. We need more stability in staff contracts along with hiring more educated staff that do not need as much investment in training. The main issue is this comes with increased personnel costs. This is especially important in the in vitro laboratory and cryopreservation where many staff are not even required to have a bachelor's degree. We could also benefit from supervisors leading the various teams being more highly educated.

6. ICARDA	
Background	The drylands of Central and West Asia and North Africa (CWANA) region where ICARDA is located encompass four major Centers of crop diversity, and the prevailing traditional farming systems and natural habitats still harbor valuable genetic resources. ICARDA has assembled an important world resource of plant germplasm of its mandate crops and forages (over 143,000 accessions) in its genebank. An eminent position among this germplasm holds the wheat collection, covering all the range of diversity of the crop during the thousand years of evolution, from the wild material (Aegilops spp. and wild Triticum), the primitive cultivated forms (such as einkorn, emmer, spelt, etc.) up to the traditional landraces, obsolete varieties and current elite lines. A large proportion of this genetic diversity, including landraces and wild relatives of crops, has been collected from stress prone l environments. The collections include priceless germplasm from Afghanistan, Iraq, Palestine and other areas affected by conflict. Particularly important are the landraces and wild relatives of ICARDA-mandate crops collected from their natural habitats where they have been evolving under harsh conditions over centuries. Of these, about 90% have been georeferenced, and 80% characterized, to enhance their utilization in crop improvement programs. ICARDA is extensively using the Focused Identification of Germplasm Strategy (FIGS) as a sub-setting strategy to respond to requests from partners for specific sets containing adaptive traits of interest. The genebank is located at two sites: Morocco for the conservation of cultivated species of wheat, barley, chickpea and lentil; and Lebanon for crop wild relatives of cereals and legumes, and temperate forage species. In addition, due to appropriate existing facilities (e.g. isolation cages), Lebanon is serving as a hub for open pollinated crops, such as faba bean and grasspea. The strategic positioning of ICARDA's genebank in two places, all along the arc that extents between the southwest Asia and north Africa region has allowed ICARDA to provide technical backstopping and expertise to the national genebanks of all the countries being each one at different stage of development and under different specific needs. This has allowed ICARDA to be a leading institute for these countries, contributing significantly to the proper conservation and management of their national wealth.
Expertise & specialism	**CONSERVATION:** ● **Best practices of management of PGR**: ICARDA genebank staff (All newly recruited during the past 5 years) are trained on SOPs (ALL) ● **Establishment of genebanks**: Experience in designing, supervising the construction, and equipping of genebank facilities (Yazbek+Tsivelikas) ● **Collecting novel diversity and GAP analysis**: expertise in collecting guided by in-depth ecogeographic surveys and gap analysis and trait-based, a prerequisite of reducing duplication and targeted acquisition and for adding novel diversity (Tsivelikas+Yazbek+Kehel) ● **Taxonomy**: with a collection of more than 700 species of crop wild relatives and native forage and range species, taxonomy is essential to confirm accession identity and trueness to type (Yazbek+Al-Beyrouthy) ● **Crop Wild Relatives and cross-pollinated species**: continuous optimization of regeneration and seed processing protocols has enabled our staff to excel in handling these difficult species (Yazbek+ Al-Awar)

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	● **Seed longevity:** On going PhD research on seed longevity under supervision of Richard Ellis (Reading) and Fiona Hay (Aarhus), a key to improving efficiencies in conservation and regeneration practices (Jawad) ● **Population genetics and quantitative genetics**: Population studies for global wheat and barley diversity for better conservation (identification of duplicates, genetically close accessions) and precise use by maximizing diversity within FIGS subsets (Kehel). ● **In situ/On farm conservation**: expertise in Dryland Agrobiodiversity *in situ* conservation, to improve conservation and use of PGRFA along the chain from *in situ* conservation and collection, to *ex situ* conservation in genebanks, to research and breeding, to farmers (Yazbek) **USE:** ● **FIGS and data mining**: ICARDA is leading the work on focused identification germplasm strategy (FIGS) to mine Genebank accessions for useful and adaptive traits. ICARDA is in continuous finetuning of FIGS algorithms for a more precise predictive characterization. This is augmented in last year with the inclusion of genomics targeting quantitative traits (Kehel). ● **Pre-breeding:** ICARDA is promoting and exploiting the crop wild relatives through the pre-breeding efforts in order to enrich cultivated genepool with novel diversity and to derive unique germplasm with better adaptation to major biotic and abiotic adversities (Aberkane+Tsivelikas) and is linking with the existing breeding programs for uptake of the crop wild relatives. ● **Impact assessment:** ICARDA has developed expertise on assessing the impact of the use of plant genetic resources on the widening of genetic base of its mandate crops and the extent of adoption of derived varieties, linking directly the conservation with the exploitation and use (Aberkane).
Scope of the genebank	**Scope in terms of Collection** The scope of the ICARDA genebank is the conservation and sustainable use of non-tropical dryland agrobiodiversity. This includes genetic resources of cereals (barley, bread wheat and durum wheat and their wild relatives), food legumes (Kabuli chickpea, grasspea, faba bean, lentil and pea), temperate forage and range/pasture species (*Medicago, Trifolium, Vicia* and more than 480 other taxa). In total, more than 143,000 accessions belonging to 258 genera and 1346 species and subspecies are held in-trust under the auspices of the International Treaty on PGRFA by ICARDA genebanks in Lebanon and Morocco as of April 2019 (Table 1). The collections are rich and unique and are composed of 60% landraces, 6% wild relatives, 20% genetic stocks/breeding line and the remaining native forage and range species. **Scope in terms of core activities** The ICARDA genebank undertakes all core activities of a reliable international genebank focusing on collecting, conserving (incl. monitoring of viability and seed health), distributing (guided by FIGS) and documenting genetic resources. These core activities are complemented/supported by research on prebreeding, impact assessment, rhizobium conservation and *in situ* conservation Range of activities: ● Ensuring efficient *ex situ* conservation of genetic resources by applying best practices. ● Enriching genebank holdings with novel diversity.

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	● Contribution to the assessment of status and threats of dryland agrobiodiversity and promoting its *in situ*/on-farm conservation and sustainable use ● Contribution to the use and evaluation by users of genetic resources through the efficient sub-setting using FIGS approach and pre-breeding efforts ● Training and technical backstopping to the genebanks in CWANA region ● Contribution to the establishment of a Global System for conservation and sustainable use of agrobiodiversity
Major achievements of last 5 years	**CONSTRUCTION OF GENEBANKS BUILDINGS & FACILITIES** ● Lebanon genebank Construction: with a capacity of 70,000 accessions. This genebank is fully operational and high standards are applied. It is dedicated to the conservation of crop wild relatives, cross-pollinated self-compatible legumes, and cross pollinated self-incompatible native forage and range species ● Morocco genebank construction: with a capacity of 150,000 accessions. This Genebank is expected to be fully operational by the end of 2020 with high standards to be applied. It is dedicated to the conservation of self-pollinated cultivated species of ICARDA mandate crops. **RECONSTRUCTION OF COLLECTION** a. **Acquisition** - Adding novel diversity by joint collecting missions organized based on gap analysis - ICARDA's genebank has acquired 15,759 new accessions and enriched its collection through collecting missions across multiple countries conducted by ICARDA in collaboration with partners from NARS and other advanced institutes. **For the following activities, it is important to keep in mind that 5 years ago, we had ZERO accessions, regenerated, conserved, safety duplicated and available for distribution. The numbers below were achieved in 5 years only, and not cumulative from previous years.** b. **Intensive regeneration and characterization** - Over the past 5 years, unprecedented task of intensive regeneration (at an extraordinary average of 30,000 accessions per year) have been underway at genebanks in Morocco and Lebanon by using retrieved safety duplications of the original collection from Svalbard Global Seed Vault (a total of 116,476 accessions) and new acquisitions since 2012 (15,759 new accessions) . c. **Conservation**: A remarkable total of 107,000 accessions are efficiently regenerated and conserved in active and base collections d. **Safety duplicated**: at two levels. 81,031 accessions were safely duplicated at first level (SGSV) and 35,049 accessions at second level. e. **Distribution**: So far, 83,702 accessions (out of the 91,751 multiplied or under multiplication accessions) are available for distribution. There are ongoing efforts to regenerate the remaining accessions. Distinguishably, worldwide dissemination of FIGS approach and the development of computer programs and user interface for users. **SOPs** A total of 11 SOPs have been drafted, with 5 of them finalized after auditing and closing report. **GENEBANK STAFF** In 5 years, the recruitment and training of two complete teams (a total of 3 IRS and 12 NRS incl. research assistants and research technicians) to undertake core activities.

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	Exceptional efforts were done by dedicated staff with long years of experience to pass their knowledge to newly recruited staff.
Critical needs in the next 3 years	**Intensive regeneration** More intensive regeneration (naturally leading to intensive testing for viability and seed health) is still needed to recompose fully the collection from safety duplications which requires more funding. This requires that material that was not sent to Svalbard, is retrieved from the first level safety duplication genebanks where it was sent. **Data curation and management** ICARDA continues to struggle with securing funds needed for the finalizing of the web base database which fits perfectly to the needs of the curators and workers in the genebank. **Green energy (Lebanon)** ICARDA genebanks in Lebanon (and Morocco), would benefit greatly from installing a solar system which would reduce its fuel consumption and make it less vulnerable to the volatile fuel market in the country. **Securing a safer job environment for Genebank staff** An extensive effort and resources were dedicated to recruit and train genebank staff in Lebanon and Morocco. This successful endeavour is at one risk. The recruited staff are all young professionals, which is great on one hand, but also makes them in continuous yearning to develop their capacities and be challenged. Securing a safer environment that allows them to grow is a necessity to retain these staff and continue building the knowledge in-house.
Opportunities under One CGIAR	● Consolidate the work of A15 group: shared experience and vision. Lessons learnt and policy work ● **Center of excellence for CWR conservation:** With the ongoing "One CGIAR" change process, an opportunity rises to harmonize with other genebanks the one of the most costly activities, regeneration, particularly regeneration of CWR. ICARDA genebank is well positioned to act as a regeneration hub for cereal and legume Crop wild relatives and cross pollinated self-incompatible native forage and range species. ● **Link with CtEH:** Housing the most diverse collection in terms of landraces and CWR of one of the 3 mandate crops within the emerging CtEH, ICARDA genebank is well positioned to provide these resources to breeders. ● **Geographic/regional significance** with the apparent focus of the One CGIAR on Africa, ICARDA genebank is again well positioned at the intersection between CWANA and Africa to serve as a capacity building hub within a larger alignment strategy with other international and regional African genebanks.
Longer-term vision for the genebank	We see the ICARDA genebank as the Center for: 1. Efficient conservation of Dryland Agrobiodiversity and distribution of crops of global significance 2. Center of excellence for CWR conservation, cross pollinated and forage and range species and utilization of CWR especially but not limited to climate change traits in collaboration with the 7 breeding programs 3. Center of education/capacity building for in PGR management: a. for National and regional genebanks in CWANA and Africa b. for emerging scientists through cooperation with renowned universities

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	4. Center of research on better predictive characterization and diversity studies using passport, characterization and genomic information. Information on the collection curated and accessible online to all users through a genebank information system
Additional comments	**ICARDA/SVALBARD:** The unfortunate war in Syria was an opportunity to prove the importance of Safety duplication, on the positive side of the story, SGSV and ICARDA received a lot of publicity due to this. A great deal of resources was put in the past 5 years to reconstruct the ICARDA genebank by all stakeholders. It is of utmost importance that these efforts continue to the finish line and ensure that one of the most important genebanks in the world, is fully available to the international community and its operation is back on track.

7. ICRAF	
Background	ICRAF Genebank has a role of ensuring that the diversity of priority tree species with current or potential use in agroforestry systems, particularly from vulnerable tropical and subtropical ecosystems is optimally secured for current and future use. Trees differ from other crops and conventional germplasm conservation principles may only be applied partially. The large number of genera, long regeneration intervals, large growth forms, generally outbreeding reproductive systems and species-specific regeneration requirements of agroforestry trees require a complex and more flexible system for their management and conservation. In total, the Genebank holds a seed collection of 180 species and 17 species are maintained as living collections in field genebanks located at 22 sites in 16 countries. Field sites are managed in collaboration with national partners. Long-term storage is provided by Kunming Institute of Botany, China while Safety duplicates have been placed at Svalbard Global Seed Vault, Norway. The Genebank distributes over 4000 seed/seedlings samples annually translating to almost half a million planted trees that play multiple roles in the environment that are associated with global tree cover.
Expertise & specialism	Ramni Jamnadass (Theme Leader, Tree Productivity and Diversity) has extensive research experience in utilization, improvement and conservation of tree genetic resources. Alice Muchugi (Genetic Resources Unit Manager) has more than 20 years' experience in research on sustainable utilisation and conservation of indigenous plant genetic resources. Zakayo Kinyanjui (Seed Physiologist) has wide experience in seed research and developing germination protocols for several species. He has been managing the ICRAF seed-testing laboratory since 2014. Simon Kang'ethe (Database Officer) has over 15 years' experience in plant biodiversity research and conservation specialising on biodiversity informatics- plant genetic resources data collection and digitization, databases development and management, information systems analysis, documentation and retrieval of PGR data and information. Joyce Chege (Information Management Officer) Experience in managing and synthesizing information into knowledge products from various plant research disciplines including ecology, conservation and use for diverse groups of end users. Phoebe Mwaniki (Plant Pathologist, consultant) has more than 10 years research experience in characterization and management of plant fungal and bacterial pathogens. The Genebank is also supported by a dedicated team of seed laboratory technicians and assistant technicians who handle all genebank processes. In addition, there are over 20 key ICRAF staff in the regions coordinating field genebank activities.
Scope of the genebank	Seed Genebank collection in Nairobi has 6623 accessions comprising 190 species of multipurpose trees. Field genebanks hold recalcitrant seeded tree species. These are mainly fruit tree species. They are located at 22 sites in 16 countries holding 8957 accessions of 17 species. Distribution is mainly to bilateral development projects, NGOs and directly to farmers.

7. ICRAF	
Major achievements of last 5 years	1. Database management, quality and visibility-accession information published in GENESYS and is regularly updated. 2. Use of barcodes and tablets in seed genebank activities implemented for efficiency and reducing transcription errors; in addition, automation of data collection in some genebank operations using in-house developed Apps is in place and will be extended to all operations. 3. Quality Management System in place in all Genebank operations. Standard operational procedures of the various genebank operations developed or updated and are in use 4. Field genebank collection rationalisation- identification of priority species for management under the 'costed collection'. 5. Restructuring of the cold room storage and drying room by installation of new dehumidifiers to correct temperature and humidity conditions. 6. Seed quality management project successfully carried out to resolve issues dealing with low seed numbers when seeds are needed for routine viability testing. 7. Establishment of a genebank germplasm health testing laboratory at ICRAF.
Critical needs in the next 3 years (include staff needs)	1. Resources to assist in achieving Genebank Platform performance targets for selected priority species especially on security and availability. The genebank needs to undertake intensive multiplication, regeneration and re-collection; establish an LTS for ease of securing and managing the collection. 2. Implementing the use of barcodes and tablets in all genebank (seed and field) activities and develop more Apps to facilitate data collection. 3. Improvement on genebank data management and accession information sharing: Migrate and consolidate data in GRIN-Global; Develop new wizards, apps and information management systems to facilitate data collection in genebank operations; Enrich collection data with characterization data and relevant metadata for field sites. 4. Fully operationalize the germplasm health testing laboratory. 5. Additional staff needs: Botanist/Taxonomist & regularizing the Plant pathologist position. More staff time coverage for shared field genebank focal point staff.
Opportunities under One CGIAR	● More opportunities of working closely with CIAT and ILRI Genebanks (that also have some forage tree species in their collections). ● Since agroforestry systems comprise several components; there are numerous opportunities for collaboration with other crops and animal systems in addressing crop/animal-trees systems related research questions.
Longer-term vision for the genebank	100% of the Genebank collection is available for distribution and secured in LTS and safety duplication.

8. ICRISAT	
Background	ICRISAT manages collections of six crops of dryland cereals and grain legumes: pearl millet, finger millet, sorghum, chickpea, groundnut and pigeon pea and five small millets: kodo, proso, barnyard, little and foxtail millets. As well as managing the international genebank in Hyderabad, ICRISAT carries out conservation activities in two regional stations in Africa (Niger and Zimbabwe), which have limited facilities but represent important portals for collecting and distributing germplasm and interacting with key users and partners regionally.
Expertise & specialism	***Vânia Azevedo*** (Genebank Head, legumes scientists) Biologist, PhD in Molecular Biology, specialist in molecular characterization with focus in conservation since 2007. Genebank manager for many years in Brazil (Embrapa 2012-2018) and genebank head at ICRISAT for two years now. ***Hamidou Falalou*** (genebank curator in Africa, scientist) Crop physiologist, PhD in plant ecophysiology, specialist in crops phenotyping for response to abiotic stresses. Head of Crop physiology lab at ICRISAT Niger since 2008 and regional genebank manager since 2012. ***Mani Vetriventhan*** (cereals curator, genetic resources scientist), PhD in Plant Breeding and Genetics, and has expertise in plant genetic resource, and genomics; and looking after curation of cereals germplasm and their wild relatives, and related research to enhance the genebank operation and germplasm utilization in crop improvement. ***Senthil Ramachandran*** (legumes curator, genetic resources manager) M.Sc. (Agriculture) in Plant Breeding and Genetics, has expertise in plant breeding and plant genetic resource since 2012 (at ICRISAT), looking after curation of legume germplasm and their wild relatives, ***Ovais Peerzada*** (seed lab manager) Ph.D. in Seed Science and Technology with expertise in seed quality testing and seed longevity. Looking after the activities of seed distribution, acquisition, conservation, safety duplication at genebank and also involved in seed research for better management and utilization of genebank collections including longevity studies. ***Venkata Narayana*** (IT specialist) M.Sc. in Information Technology and has expertise in Microsoft Technologies, SQL Server, Oracle etc. with focus in development and Maintenance since 2007 (at ICRISAT). Involved Genebank databases and IT related activities. ***Muzamil Baig*** (Quality manager): B.Sc. in Biotechnology. MBA in Quality Management and experienced in implementation of QMS and 5S standards, certified lead auditor for ISO 9001:2015. Looking after implementation of QMS and best practices.
Scope of the genebank	***HQ.*** ICRISAT Genebank in Headquarters keeps a total of 128,155 accessions of eleven crops being 41,816 accessions of Sorghum, 24,373 of pearl millet, 11,797 of six small millets, 10,764 of chickpea, 15,622 of groundnut and 13,783 of pigeonpea. In 2019 we distributed 19,884 to 11 countries and added 3,580 (Since 2015 onwards) new accessions to the genebank. A total of 119,037 accessions are available (physically and legally) for distribution. Monitored 10,844 accessions for seed viability and safety duplicated 2,840 accessions in Svalbard, reaching 90% of the collection safety duplicated. We are a total of 42 staff. ***Niger*** ICRISAT Genebank in Niger keeps a total of 46,814 accessions being 10,673 accessions of Sorghum, 14,114 of pearl millet, 11,349 of groundnut, 1,039 of Foxtail Millet, 4,580 of finger millet, 521 of proso millet, 628 of kodo millet, 479 of barnyard millet and 375 of little millet. Keeps part of the first level safety duplication of ICRISAT pearl millet

8. ICRISAT	
	(5,205 accessions), small millets (7,622 accessions) and groundnut (2,006 accessions). The collection aims to meet the demands for germplasm of these crops from African countries and facilitate easy access to the germplasm collections in West and Central African (WCA). In 2019 we distributed 2,609 samples to 13 countries and collected 2,914 new accessions (including non-mandate crops) in Niger, Nigeria, Burkina Faso and Ghana. A total of 15,338 accessions are available (physically and legally) for distribution. We monitored 2,691 accessions for seed viability. We keep 13,792 accessions as black box to multiple NARS in the Region. Total number of staff is seven. ***Zimbabwe*** ICRISAT Genebank in Zimbabwe keeps a total of 8,259 accessions being 2,584 accessions of Sorghum, 3,296 of pearl millet, and 2,068 of finger millet. The aim is also to meet the demands for germplasm of these crops from African countries and facilitate easy access to the germplasm collections in East and South Africa (ESA). In 2019 we distributed 112 samples to 4 countries and collected 272 new accessions in Kenya in partnership with ICRISAT Kenya. A total of 5,601 accessions are available (physically and legally) for distribution. Total number of staff is four.
Major achievements of last 5 years	● Modernization of post-harvest seed processing as part of quality improvement. Threshing building is operational, and mechanization of seed processing is implemented (threshing, shelling, blowing, cleaning). This is already helping in getting quality outcome and optimum utilization of resources. ● Calibration of major and minor equipment in Genebank has been done successfully to increase the lifetime and quality of data and consequent reduction of maintenance and repair cost. ● Successfully implemented barcode for all crops in all steps (Field, characterization, monitoring, regeneration, distribution, inventory, glass house, in- vitro, botanical garden, safety duplication, etc.) including Niamey. ● Field day organized to benefit NARS scientists in 2019. ● SOPs implemented for major genebank activities. ● Safety duplication of 90% of the entire collection in Svalbard (2840 accessions deposited in 2019). ● Identified geographical and taxonomical gaps in collections of sorghum, pearl millet, and pigeonpea, to enrich genebank collection. 6642 accessions collected in Africa since 2015. Total collection increased in 4,234 accessions since 2015. ● Developed germplasm subsets, and identified trait specific germplasm resources for their utilization in crop improvement. ● Assessed within and among accessions diversity and appropriate sample size required while regeneration of sorghum, pearl millet and pigeonpea. ● Regional Genebank staff was trained in HQ in Genetic Resources activities and documentation and in databases management, provided locally to Niamey and Bulawayo staff. ● Assignment of DOI's to 104,985 accessions. ● Launching New ICRISAT Website in 2018 (includes Niamey, Zimbabwe and Kenya). ● Accessions and subsets are uploaded in Genesys. Gap filling passport data for 2000 accessions uploaded in Genesys. ● Monthly data backups kept in our server (including Niamey backup) ● Digitalization our distribution records (past 7 years already digitized) ● Passport and Characterization data uploaded in GRIN-Global. ● Accessions maintained only in field or glass house being duplicated in vitro.

8. ICRISAT	
	● Establishment of three new MTS cold rooms to increase space for enrichment of collections and complete renovation and inventory of one temporary cold room. ● Successfully completed the first Seed Quality Management (SQM) CoP project (post-harvest maturity of finger millet and foxtail millet) with promising results for better curation of both these crops. ● Modernization and renovation of the seed lab. Acquisition of germinators to reduce the time for processing of regenerated accessions to MTS. ● Successfully implemented barcoding for the procedure of seed germination testing and subsequent meta data recording. ● MOUs have been signed between MDRF, Chennai, India and EMBRAPA, Brazil in 2019 and a new MoU is being signed with NordGen and IPK. ● Niamey regional genebank facilities and lab Upgraded ● Germplasm collecting in gap areas of WCA and ESA in collaboration with NARS
Critical needs in the next 3 years (include staff needs)	● Modernization of genebank operation and quality improvement. ● Renovation of LTS cold rooms and implementation of barcode in LTS. ● Enriching collection by adding new diversity considering geographical and taxonomical gaps identification. ● Identification of possible duplicates through phenotypic and genomic investigation. ● Germplasm evaluation, and developing germplasm subsets focusing on traits of importance in each crop. Revaluation of the wild relatives' conservation, representation and needs. Germplasm first level safety duplication. ● Assessing within and among accessions diversity of chickpea, groundnut and small millets and to determining the appropriate sample size required for regeneration. ● Training on applicable treaties, conventions, legislation and principles to key staff. ● Backup for every month and all documents to be digitized. ● Implementation DOI's/Genesys in Regional genebanks. Images (Characterization, Seed color etc.) will upload to for every accession to Genesys and GRIN-Global. ● Citations to be uploaded to GRIN-Global. Upgrading capacity of equipment and facilities and staff training in GRIN-Global/Genesys software and seed processing ● Phytosanitary issue for germplasm distribution and pull the regional genebank to operate in standards. Strengthen collaboration and partnership with NARS by involving regional organizations and formalize agreements ● Additional sources of funding for sustainability ● Enhance germplasm utilization through seeds distribution and NARS training
Opportunities under One CGIAR	Germplasm safety duplication. Joint germplasm evaluation/regeneration/ characterization/genotyping. Collaboration for regeneration of accessions, which requires a specific climatic condition. Collaboration for seed research with other CGIAR genebanks and sharing of results. Genebank network in West and South African regions involving other CG Genebanks and NARS to answer to the regions demands and needs. ICRISAT genebank in Niamey will be a component of one CGIAR genebank consortium in WCA, which is an opportunity to optimize the long-term conservation among genebanks in WCA and also can conserve safety duplications of those genebanks. One CGIAR and One Genebank Platform is an opportunity to assist WCA Countries/Genebanks necessities of phytosanitary/quarantine issues for international germplasm distribution. Good opportunity for complementary actions in WCA with other genebanks, for instance share facilities use and training NARS partners
Longer-term vision for the genebank	● Adding new traits of importance to enhance value of conserved germplasm (for example, grain quality assessment, biotic and abiotic stress tolerance). ● High-throughput phenotyping, imaging, XRF and NIRS based characterization.

8. ICRISAT	
	● Genomic characterization of genebank collection and digital sequence identification (DSI). Digitalization of accessions characteristics. ● Identification of possible duplicates through phenotypic and genomic characterization. Accessions that are duplicated can finally be archived. ● Identification of new trait specific subsets for germplasm enhancement for their direct utilization in crop improvement. ● Automation of routine lab activities including seed monitoring and use of more modern tools for different kinds of analyses as image-based analysis and other non-destructive methods. More emphasis on seed research with special focus on seed ageing and dormancy mechanisms of crop wild relatives. ● ICRISAT genebank will be a benchmark for other genebanks and will guide others in implementation of QMS & 5S standards. ● Fill the gaps of all unexplored and under explored geographical areas to increase genetic diversity by 30% and easy access and exchange of germplasm. ● Enhance germplasm utilization in 25% through germplasm evaluation for desired traits, increased seeds distribution and capacity building of users ● Be key component in reaching the Development Goals
Additional comments	

9. IITA	
Background	The Genetic Resources Centre IITA is based at IITA HQ in Ibadan, Nigeria. It houses international collections of key staple crops and some underutilised but important legumes (cowpea, maize, soybean, Bambara groundnut, African yam bean and other legume species, banana, cassava and yam) requiring different conservation methods (seed, field and *in vitro* tissue culture and cryobanking). Germplasm collections are conserved, characterised, documented and made available for use and particular attention is given to phytosanitary issues including cleaning of clonal crops. GRC works closely with the independent Germplasm Health Unit (GHU).
Expertise & specialism	Michael Abberton (Genebank Manager): genetic resources, crop improvement, genomics and climate change. Lava Kumar: Head of GHU, supports germplasm phytosanitation and production of clean material, germplasm health certification and international transfer of germplasm. Badara Gueye (*In vitro* Specialist): tissue culture, *in vitro* genebanks and cryopreservation. Tchamba Marimagne (Database Manager): database design, administration and management specifically for genebanks. Rajneesh Paliwal: genomics including DNA fingerprinting, GWAS Nationally recruited staff have considerable experience and expertise particularly the three managers: Ben Faloye(fieldbank), Niyi Oyatomi (seedbank) and Abigael Adeyemi (*in vitro*). Emily Iwu deals with all administrative aspects including ordering, SMTAs, distributions etc. Many NRS have considerable experience and expertise in their areas and there has been little change in staffing in recent years.
Scope of the genebank	The total collection size is 36,711(as in ORT). In the seed collection: 17051 accessions of cowpea, 1936 wild *Vigna*, 1561 maize, 1801 Bambara groundnut, 4788 soyabean, 271 African yambean and smaller number of other legumes. For the clonal crops; 5839 accessions of yam,3184 cassava and 393 Musa. Yam and cassava are maintained firstly as field collection with the entire collections planted and harvested annually at two sites. Most of these collections are also maintained *in vitro* at the GRC building with a significant number safety duplicated also *in vitro* at IITA Cotonou, Benin Republic. Cleaning of clonal crops is carried out in GRC with indexing of both clonal and seed crops by GHU. In the last few years cryobanking has been established in GRC and cassava accessions are now being cryobanked with yam cryobanking initiated. Seed collections are maintained in MTS and LTS with two of each in the GRC building. They are indexed in screenhouses at IITA, Ibadan and most regeneration and multiplication are carried out in the field on site. Indexing is carried out by GHU working closely with seedbank staff. The seed collection is safety duplicated at CIMMYT (maize) and University of Saskatchewan/ CIAT (legumes) as well as at the Global Seed Vault, Svalbard. Distribution is carried out as seed and in vitro plantlets and with SMTA. GRC carries out distribution of breeders' lines. The collections mainly originate from across sub-Saharan Africa. Users are predominantly breeders and researchers in the public sector within Africa and beyond.
Major achievements of last 5 years	Significant progress has been made with respect to targets over the last five years. These include major progress in indexing and regeneration and in safety duplication of the seed collections. This has been enabled by significant investment in infrastructure, much of this funded by GIZ. The medium-term store has been thoroughly rationalised in terms of seed lots and plastic bottles replaced by aluminium foil. Seed longevity research is informing changes in protocols from harvest to store. Passport and characterisation data

9. IITA	
	are on GENESYS and all accessions have DOIs. We have implemented Grin Global for seed crops and we are doing so for clonal crops. All data throughout GRC are captured on tablets and all staff are trained on their use. All operations are barcoded, and a number of apps have been developed to aid everyday operations. Cryobanking (with significant investment in equipment including liquid nitrogen generator as well as in protocol development) has been introduced for cassava and now yam and the clonal crop collections are being fingerprinted by DArT for improved understanding of diversity (including a combined analysis with CIAT on cassava) and representativeness, to aid pre-breeding and genebank management. Research funded by BMGF is directed at increasing the speed of virus diagnosis in yam. Genotyping of the cowpea core and mini core have been carried out through partnerships and we have also developed FIGS subsets with help from ICARDA. Surveys of users show high satisfaction with GRC and the service provided. In the last few years, new collections have been carried out in Nigeria, Benin Republic and Cameroon particularly for yams and also Bambara groundnut. A review of GRC was carried out in 2019 and was largely positive and very helpful. We are addressing all recommendations. A number of SOPs are being rewritten following the review but in general significant strides have been made in terms of QMS including risk management. The second floor of GRC has been constructed and this will allow for necessary expansion of facilities including the cryobank and in vitro genebank downstairs. We have worked closely with national genebanks, particularly NACGRAB, where capacity building has been a continuous process.
Critical needs in the next 3 years (include staff needs)	There is need to complete the DArT genotyping of both in vitro and field accessions of clonal crops. This will inform genebank management (duplications, trueness to type) and impact on strategy for use of cryobanking and the fieldbanks. Genotyping of seed crops is well underway and needs to be completed. For this work we need to maintain current staffing with regard to genotyping and related capabilities. The security of our yam collection needs to be improved by (i) bringing all the field collection into in vitro (ii) increasing the speed of yam introduction, diagnostics and cleaning (iii) speeding up entry of yam accessions into the cryobank (iv) enhancing yam safety duplication initially in in vitro culture and then in another cryobank. Greater use of automation and image analysis in the seedbank is needed to reduce drudgery and to increase the speed and accuracy of operations. All recommendations of the recent review will be implemented including revised SOPS. Completion of the second floor allows expansion of the cryobanking room, the in vitro bank and seed germination lab. It will also allow redevelopment to allow a better flow of 'cleanliness' in vitro/ cryo and of temperature/humidity in the seedbank. The representativeness/composition of the collection will be improved by new acquisitions (e.g. cassava landraces from East Africa, a range of crops from Togo and South Sudan) and from managing duplications. For the fieldbank the main focus will be on increased use of mechanisation for greater efficiency and more support for this is required.

9. IITA	
	An important area for GRC is capacity development. This is for GRC staff but also as part of our partnership with NARS especially in West Africa and including through the seeds4resilience programme. We look forward to doing far more in this regard and will need a staff member to dedicate significant time to it. Measures to increase awareness and distributions will be important including trait based subsetting but also improved communications, including on genebank impacts. IITA has a broad range of phytosanitary requirements for clonal and orthodox seed crops. Ongoing efforts on regeneration for phytosanitation and conservation of clean germplasm needs continuation to meet the genebank performance targets. Investments required to establish efficient protocols for phytosanitation of yam, and augment virus indexing protocols considering the new pest occurrence reports in the mandate crops conserved in the genebank. The Center plans to serve as a regional hub to support germplasm phytosanitation and germplasm transfers needs of other CGIAR genebanks hosted in the sub-region, as part of the shared service hub system to improve genebank operational efficiency.
Opportunities under One CGIAR	There are major opportunities for GRC from the emerging science domains and 'big lifts' of One CGIAR. The importance of genetic resources and biodiversity is well recognised. The Genebank Platform functions well and should not be subjected to major change. The Excellence in Breeding Platform and Crops to End Hunger Programme, while currently focused on variety development per se may bring possibilities of a more integrated approach to pre-breeding, trait dissection, introgression and allele mining. Joint working between the GB and EiB Platforms will be important. Other themes of the One CGIAR including the Two-Degree initiative on climate change and the Hidden Hunger theme will allow GRC to develop the impact of its work on underutilised legumes in West Africa. Efforts are underway to engage with CORAF and national authorities towards greater integration and efficiencies of genebanks in West Africa including IITA, ICRISAT and Africa Rice.
Longer-term vision for the genebank	All clonal crop accessions will be genotyped and cryobanked and safety duplicated the same way. Only unique and true to type accessions will be maintained *in vitro,* mainly for distribution. All aspects of yam tissue culture, cleaning, diagnosis and cryobanking will be greatly facilitated by new approaches. Automation and image analysis will be in place for many aspects of the work of the seedbank and all collections will be completely safety duplicated and also held at Svalbard. All accessions will be genotyped, and duplicates identified. Facilities will be expanded and reorganised for greater efficiency. Climate smart and nutritional subsets in place for all crops. Stronger links with the breeders enables GRC to play a full role in allele mining, trait dissection and introgression as part of pathway to use genetic diversity in pre breeding. For the underutilised legumes GRC will form a key part of the R4D leading to enhanced use of this crop and improved options for smallholder farmers in West Africa. Distribution significantly enhanced and GRC plays a full role in a network of genebanks in sub-Saharan Africa. Greatly enhanced collections of CWR to conserve rapidly eroding diversity combined with filling of important gaps in the landraces, particularly for underutilised legumes

10. ILRI	
Background	ILRI manages a collection of 18,635 tropical forage accessions representing over 1,400 species, and 600 genera, in Ethiopia. The extremely wide taxonomic diversity of the collection and the fact that it is mainly composed of wild species, demands a different management approach to typical crop genebanks. There are also four forage field sites located across Ethiopia: one highland; two mid-altitude (one specifically for acid soil adapted species), and; one lowland, dedicated to field conservation of approximately 1,500 accessions that need to be maintained vegetatively or produce recalcitrant or short-lived seeds.
Expertise & specialism	Ermias Haile, PhD (Genebank Coordinator): interests include the functional analysis of molecular and physiological responses associated with abiotic stress tolerance. Alemayehu Negawo, PhD (Germplasm Health Unit Coordinator): experienced in plant molecular characterization, tissue culture and genetic transformation. Meki Muktar, PhD (Forage Diversity Scientist): interested in plant molecular genetics, such as marker assisted selection, QTL mapping, candidate genes and genome wide association studies. Chris Jones, PhD (Program Leader): interests span a range of biotechnologies, applied to support plant selection and accelerate forage improvement. There are also experienced teams dedicated to the areas of: regeneration, seed processing and field site operations; germination and viability monitoring; information systems and database management, and; germplasm conservation, distribution and seed purity.
Scope of the genebank	Forage diversity is being lost due to increasing population pressure and poverty, leading to overexploitation of natural resources, and to climate change. The genebank is a key resource, providing one of the few options to build livelihoods for the rural poor. The genebank, consisting of a collection of legumes, grasses and fodder shrubs and trees, offers a unique resource for exploring and capturing forage diversity. Over 1,000 accessions are distributed annually across the globe, mainly in East Africa, and 10 accessions were released as new varieties in Ethiopia recently (2016 - 2018).
Major achievements of last 5 years	Construction of a new genebank building, including laboratories and office facilities. Changes resulted in an additional 56m^2 of medium term genebank storage and environmentally controlled conditions for long term freezer storage. Laboratory space was expanded to allow more room for plant disease diagnostics. In addition, two biosafety level 2 rooms and a climate-controlled greenhouse were added as a self-contained unit to allow research on diseases and organisms requiring moderate levels of containment. The analysis of over 30 years of germination data was used to develop evidence-based decision making to improve genebank viability monitoring. Results from this work supported longer regeneration intervals for some species and reduced numbers of seeds for testing, which led to increased efficiencies in genebank management. ILRI and CIAT signed an MOU to develop a joint agenda on the development and application of tropical and sub-tropical forages in Sub-Saharan Africa and Asia. Key to this was the establishment of a new joint ILRI/CIAT genebank manager position, which heads the ILRI Genebank while helping to manage the composition of the forage collections both at ILRI and CIAT.

10. ILRI	
	Establishment of the Germplasm Health Unit (GHU). GHU labs were established, staff recruited and health testing of stored and newly harvested seeds, as well as plants in the fields and screen houses, are in progress.
Critical needs in the next 3 years (include staff needs)	ILRI is working hard but is unlikely to meet the genebank performance targets of ensuring 90% of accessions held in the genebank are available for distribution by the end of 2021. Despite being amongst the most expensive collections per accession to maintain, the genebank remains under-resourced and since its establishment the Germplasm Health Unit (GHU) has been rapidly playing catch, with a significant backlog of samples and some health testing capabilities remaining to be established. ILRI management recognised this issue and has invested an additional $580k from reserves in extra genebank staff, equipment and laboratory redesign, over the last two years. Recently the genebank has experienced a problem of key staff turnover (the Genebank Manager & GHU Scientist) which is a major concern although recruitment of a new Genebank Manager has been initiated. Most genebank field sites in Ethiopia are not owned by ILRI and the legal basis for accessing some of them is unclear, so long-term access to field facilities is an issue. In addition, one site is at risk of germplasm loss mainly due to insufficient irrigation water, another potentially has water pollution issues and the town land development administration at a third have expressed an interest in the site. We need to install irrigation in sites where there is insufficient water to avoid the loss of germplasm during the dry season. We are exploring alternative sites as replacements for sites with ownership issues. Although we have built up a good working relationship and are making progress with the Ethiopian Biodiversity Institute (EBI), the genebank faces challenges related to the global distribution of non-Annex 1 germplasm. Until this issue is resolved we need to request EBI for a 'Special Access Permit' for international distribution of this germplasm.
Opportunities under One CGIAR	A more coordinated strategy for the curation and use of forage genetic resources globally. This has already started with the production of a "A Global Strategy for the Conservation and Utilisation of Tropical and Subtropical Forage Genetic Resources" in 2015 (https://www.croptrust.org/wp/wp-content/uploads/2014/12/Forages-Strategy.pdf). This can be expanded beyond the three collections (CIAT, ILRI and ICRAF) to consider other Centers that carry forage resources, e.g. ICARDA and ICRISAT. Also, a more integrated approach with other capabilities, such as the plant breeders working with Excellence in Breeding, to ensure the deployment of the best knowledge and technologies to the production of new forage varieties.
Longer-term vision for the genebank	The genebank material will continue to play a key role in making improved forage varieties available to support livestock production across the global tropics. In collaboration with partners, we aim to enhance the conservation and utilization of germplasm via molecular and phenotypic characterization supporting the production of climate resilient species/accessions. The recently revised 'Tropical Forages' database (http://www.tropicalforages.info/) will offer a window into the genebank for potential users to select species of interest. This would help the genebank to identify the most suitable accessions for further breeding and development of productive varieties. The genebank will be well integrated into the aims and ambitions of plant breeders working in National forage development programs.

11. IRRI	
Background	The T.T. Chang Genetic Resources Center in The Philippines is the largest collection of rice diversity in the world, with more than 132,000 accessions, including genetic stocks, landraces and wild relatives. It operates at high-levels of efficiency and throughput and has been able to meet increasing demands for germplasm while maintaining high standards of conservation.
Expertise & specialism	Expertise and specialty of IRRI genebank staff– ● Managing cultivated and wild rices collection ● Data and database management ● conservation research ● sequencing and informatics ● adoption of technology in operations – automation, AI
Scope of the genebank	IRRI has over 132000 accessions that originated from 132 countries. It is the most diverse and complete collection of rice germplasm. About 38% of the accessions are traditional cultivars or landraces, 11% are breeding materials or advanced cultivars and 3% are wild relatives. The species of rice conserved in the International Rice Genebank include: · Oryza sativa or Asian rice, which is the most commonly grown and eaten rice. It has several subtypes – indica, japonica (including temperate and tropical japonica), aus, aromatic · *Oryza glaberrima* or African rice originated in West Africa. It is not widely cultivated but has been used to breed other types of rice grown in Africa. · Twenty-four wild species of rice that are found in Asia, Africa, Australia, and the Americas. · Nine species from seven related genera
Major achievements of last 5 years	There were several accomplishments in the past five years. The below ones can be considered as major ones - ● Secured long-term funding by meeting all the performance criteria set by the Crop Trust ● SOP on all major operations (SOP manual and adoption) ● Implemented barcoding system in all major operations ● New seed processing and drying facilities constructed ● Renovation of office and labs (should have been completed but delayed due to COVID) ● Automation of operations: Seed sorter and germination scanalyzer were added. ● Successful completion of External Auditing review ● Implementation of the full cost recovery for the Genetic Stocks materials ● Distribution of over 128,000 samples to users within and outside CGIAR ● 2181 new accessions have been added to the collection ● >16000 accessions multiplied, >49,000 samples health tested, >135000 samples viability monitored ● Publication of genome sequences of over 3000 rice accessions ● 26 publications in peer-reviewed journals in the past 3 years
Critical needs in the next 3 years (include staff needs)	● The facilities have aged significantly and new facilities have to be built. In particular, the refrigeration units in the medium-term storage needs to be replaced. ● Upgrading and relocating the screenhouse to host the wildrice collection. ● Automating tasks such as irrigating in the screenhouse ● Installing solar power source to cut down huge electricity costs ● Staff needed to continue conservation research and utilization

11. IRRI	
Opportunities under One CGIAR	Opportunities exist to reduce cost and increase efficiency in conserving and utilization of rice germplasm by working closely with AfricaRice and other genebanks.
Longer-term vision for the genebank	● IRRI genebank is gene-rich but data-poor. Need to make it data-rich. Data will drive utilization of the valuable resources. ● Breeder-friendly genebank – breeders should be able to easily find the necessary material and the associated data on it. Data available should be as per their needs. ● Green-genebank – need to become carbon neutral. Adoption of solar and, possibly, methane harvesting ● Focus towards utilization – Collection and safe conservation were the priority of genebanks in the early phases. These have been achieved to a large extent. Now the focus should be utilization. Genebanks should be able to provide pre-bred material to breeders.
Additional comments	