National Plant Genetic Resources (NPGRC) Genebank Review 2020

Genebank reviewed	National Plant Genetic Resources Centre – Zambia Agricultural Research Institute
Site visit dates	September 16 - 18, 2019
Review report date	24 April 2020
Institution and Crop Trust responses	
Place	Lusaka, Zambia
Genebank manager	Graybill Munkombwe
Review panel	Paula Bramel Simon Linington Bonny Ntare Milko Škofič
Crop Trust staff	Nora Castañeda

Nr.	Reviewers recommendation	Timeframe	Responses
1	We recommend that a long-term plan be developed for the sustainability of the operation of the seedbank at NPGRC and when the upgrade is completed, a costing study of routine operations be done as a basis to to secure adequate annual funds for the conservation and use of the collections.	Q1 2023	NPGRC: We are agreeing that a sustainability plan for the NPGRC is necessary. The plan will be worked on with the help of Crop Trust during project implementation. Crop Trust: The Crop Trust agrees with the recommendation and NPGRC's response. To reach a steady state of operation it will be important to have well-established processes and to clear all backlogs.
2	We recommend that NPGRC invest in enhancing staff capacity for the long-term through: ● On-site capacity building by experts to train staff and upgrade key processes ● Exchange visits with ICRISAT, IITA, ILRI, etc. to build capacity for specific processes ● Staff succession planning to address the potential loss of long-term staff with key knowledge of the collection or genebank management	2020 – Q1 2023	NPGRC: As part of the sustainability of the project, we are in agreement that staff need on site capacity building through training and staff upgrading to handle key processes, exchange visits to international genebanks and a plan of succession for all key positions in collection and genebank management. Crop Trust: The Crop Trust supports this recommendation. Training on technical aspects of germplasm collection management is needed to upgrade the operations of NPGRC. High-level support from NPGRC and ZARI management will be required to encourage staff participation and to enable potential

			changes in processes and institutional culture. Working in a QMS framework will provide support to NPGRC on staff succession planning.
3	It is recommended that a study be done to formally determine redundancy with other collections held by national and international institutes that were either involved in joint collecting with NPGRC or are serving as host sites for duplicates. This in-depth analysis of the uniqueness of the accessions should lead to opportunities for prioritization of accessions and crops for long term conservation by NPGRC and opportunities for rationalization by all collection holders. It would also give NPGRC an opportunity to recover lost accessions through repatriation or recollection.	Q2 2020	NPGRC: We agree with the recommendation and therefore a study on redundancy of collections held by our genebank and international institutes will be conducted to determine the uniqueness of the accessions. Crop Trust: The Crop Trust supports this recommendation. In the context of a global rational system of PGRFA, it is critical to understand which accessions in the genebank will be difficult or impossible to replace and therefore deserve priority attention and urgent safety duplication. Special attention is advised to avoid unnecessary duplication. Based on this study, we encourage NPGRC to select unique crops and accessions, which will be used to assess genebank management performance under the Seeds for Resilience project.
4	We recommend that NPGRC update their inventory to accurately reflect the current composition of the collection; the status of accessions whether under active management or historical; clarify and record the MLS status of all accessions; and add all available passport and characterization data. This updated accession level information should be shared with users using Genesys.	Q4 2020	NPGRC: As part of genebank management, we are in agreement with the recommendation that the inventory of the germplasm collection be updated, passport and characterization data added and accession level information shared with users on Genesys. Crop Trust: The Crop Trust agrees with the recommendation and with NGPRC's response. An accurate inventory, once obtained, is essential to the effective management of the collection and should thereafter be kept up to date, as well as relevant information published on Genesys. It is important that the MLS status of material held by NPGRC is clearly stated. The Crop Trust encourages NPGRC to update the notification letter of material available in the MLS and submit it to the ITPGRFA Secretariat.

5	To address the lack of secure safety back-up, we recommend that NPGRC prioritize unique accessions by crop and arrange for safety duplication for all those accessions that are not already safety duplicated, with an institution outside Zambia to serve as a primary black box. For those NPGRC accessions that have already been deposited in Svalbard by SPGRC, NPGRC should instruct SPGRC to update the inventory of samples deposited in Svalbard o include the NPGRC accession numbers as “Other accession designations”. NPGRC should dispatch seed of priority unique accessions to Svalbard for accessions that have not yet been deposited there.	2020 – 2023	NPGRC: The genebank is in agreement with the need for back-up of unique accessions. These accessions will be prioritized for safety duplication. The NPGRC will also request SPGRC for an update of the inventory of samples to include accession numbers. Crop Trust: The Crop Trust supports this recommendation. We encourage NPGRC to prepare a plan for all unique accessions to be safely duplicated in Svalbard. Coordination with SPGRC is essential to avoid unnecessary duplication of effort. Passport information of NPGRC accessions duplicated at SPGRC should keep a NPGRC identifier.
6	We recommend that NPGRC adopt a quality management system (QMS), including the development and regular updating of standard operating procedures (SOPs) for routine operations, as well as any new processes.	2020 - 2023	NPGRC: As recommended, the NPGRC has started the process of adopting QMS with the help of Crop Trust. Monthly online meetings have been planned to guide NPGRC staff on QMS. Crop Trust team will help in this capacity building. SOP have been developed by SPGRC and Crop Trust also will help the genebank update SOP for routine operations. Crop Trust: The Crop Trust agrees with the recommendation and NPGRC’s response. The Crop Trust will continue to provide technical support to NPGRC on this, working towards the adoption of a minimal QMS by the end of 2023. It is important that the adoption of a minimal QMS is supported and encouraged by NPGRC and ZARI management.
7	We recommend that the procurement plan in Table 5 be implemented with careful consideration of each item by NPGRC staff and with the guidance in the relevant subsection of “Seedbank operations for long-term conservation and active use of the collections” in the full review report.	2020 - 2023	NPGRC: We agree with the recommendation on the implementation of the procurement plan, taking careful consideration for all indicated items. Crop Trust: The Crop Trust supports this recommendation. Particular attention needs to be given to re-organizing the current layout of the genebank, in order to have a proper area dedicated to germination testing and seed health testing.
8	We recommend that the significant backlog in testing for seed viability be addressed with the purchase of suitable equipment and lab setup to test viability, as well as through training to increase technical skills in permanent staff, aiming for a capacity	2020 – 2023	NPGRC: Agree, a set of equipment has been proposed that will enable NPGRC to carry out the necessary seed viability tests. Training of genebank staff will be required to enhance technical

	to carry out seed viability tests at the rate of at least 1,000 accessions per year. While this capacity is being built, NPGRC should use the viability test results from SPGRC to prioritize regeneration and viability monitoring. An alternative will be to collaborate with SPGRC to use their facilities to help reduce the backlog.		skills. In the interim, before purchase of equipment, the genebank will collaborate with SPGRC to do viability testing. Crop Trust: The Crop Trust agrees with this recommendation and NPGRC's response. We support NPGRC in establishing a methodology, workflow and plan to address the seed viability backlog. It is important that the plan prioritize accessions identified to be unique. A formal agreement (e.g. MOU) might need to be in place between NPGRC and SPGRC to carry out such a collaboration.
9	We recommend the adoption of a process to determine and monitor the number of seeds available per accession (e.g. systematically document baseline packet weights, distribution packet weights, and 100/1000 seed weights) to ensure that acceptable thresholds are maintained.	2020 - 2023	NPGRC: We are in agreement with the recommendation for the adoption of the monitoring system of number of seeds per accession, distribution bags weights per accession and document that in our database. We will also estimate 100/1000 seed weights in order to conserve an acceptable quantity of seed per accession. Crop Trust: The Crop Trust supports this recommendation. It is important that the room where these measurements are to be taken is properly set up, as indicated in the review report. We encourage NPGRC to record information on seed number directly in the genebank database and use it, together with viability test results, to decide when regeneration is needed.
10	We recommend, as a priority, that the base pack of the most original seed lot for all the accessions be relocated into a base collection and conserved in freezers dedicated for long term storage, where the temperature can be maintained in a constant and optimal range with minimal disturbance. Newly regenerated material should also be stored in base collection freezers. All the distribution packs should be stored in different freezers.	Q4 2020	NPGRC: As recommended, the NPGRC will dedicate some freezers for base collection which will have minimum disturbance. Active collection will be maintained for purposes of undertaking regeneration, characterization and for distribution to users. Crop Trust: The Crop Trust supports this recommendation and NGPRC's response. We encourage NPGRC to continue sending duplicates of its base collection to SPGRC.
11	We recommend that NPGRC deploy a routine formal process for soliciting and using feedback from recipients to improve the use of the collection and seedbank operations with actions such as: ● Conduct routine user surveys on the use of the collections, delivery timelines, quality of seed received and other useful information.	2020 - 2023	NPGRC: ● We are in agreement with the proposed recommendation for the establishment of a formal user feedback mechanism in part to inform the decision making at NPGRC e.g. quality of seed. We will also institute a

	● Fully implement DOI to better link to information generated on the accessions. The seed sample for each accession at SPGRC is still the original seed from NPGRC. Thus, DOIs assigned to SPGRC for NPGRC should be the ones given for the accessions in Genesys rather than the ones that have currently been given to SPGRC. ● Develop a procedure for ensuring that information on the evaluation and use of the distributed germplasm is shared with the seedbank to enrich the accession level databases.		mechanism for obtaining information on evaluation and use of our germplasm by others. ● Agree, and the process of registering accessions on the Treaty's DOI server has already started with 330 rice accessions registered. Crop Trust: The Crop Trust supports this recommendation. We encourage NPGRC to continue requesting DOIs for all its accessions and working in collaboration with SPGRC, so that the linkages between duplicated material are clearly indicated.
12	We recommend that NPGRC develop and implement a realistic five-year plan to securely regenerate at least 600 accessions per year, giving priority to those that were collected in the 1980s and 1990s. Priorities for regeneration should be based on new data made available from seed viability tests and seed counts carried out by NPGRC. While these data are being generated, NPGRC should use the viability test results from SPGRC to prioritize accessions for regeneration that are below acceptable viability or seed number thresholds. NPGRC should also engage with SPGRC and other local research organizations for help to address the regeneration backlog.	2020 - 2023	NPGRC: We agree with the recommendation. A realistic plan for regeneration of germplasm accessions should be in place to allow for systematic rejuvenation of conserved accessions with priority given to older germplasm accessions in the genebank. Adequate amount of land has been identified outside Mount Makulu Research Station for purposes of regeneration of conserved accessions. Crop Trust: The Crop Trust agrees with the recommendation. It is important that the regeneration plan gives precedence to unique, threatened accessions of selected crops that fall below seed quantity and viability thresholds. Further details about the regeneration plan should be described in the project workplan. We support NPGRC in collaborating with other institutions in regenerating seed material.
13	Urgently, we recommend that the current cassava collection in the field be secured with irrigation and safety duplicated with a CGIAR genebank. Collecting missions should be undertaken to reconstitute the local sweet potato landraces that were lost.	2020 - 2023	NPGRC: We are in agreement with the recommendation that irrigation is urgently required for the field genebank of cassava to safeguard the living collection and duplicate the materials to a CGIAR genebank. Collection missions for sweetpotato are planned to be undertaken after installation of a functional irrigation system. Crop Trust: It is important that NPGRC works in coordination with IITA to identify unique cassava material (e.g. not yet conserved at IITA), to clean the material, and to safety duplicate it. Similarly,

			sweetpotato re-collecting, cleaning and safety duplication will need to be coordinated with CIP.
14	There is a backlog of information stored on paper that needs to be digitized, but this must not be done at the expense of the other high priority routine operations, so the reviewers recommend that temporary staff be hired and dedicated to digitization activities.	2020 - 2021	NPGRC: Agreed on the need to digitize information associated with the germplasm collection which currently are in hard copies. We do also agree to hire temporary staff to carry out this activity. Crop Trust: It is important that priority is given to full passport information, and to characterization and evaluation data obtained since 2015.
15	We recommend that all efforts are made by ZARI to enhance internet connectivity at the genebank to the server to allow for the full implementation of SDIS or other seedbank information systems such as GRIN-Global.	2020 - 2021	NPGRC: Agreed, internet connectivity has now been restored and is working properly. Crop Trust: The Crop Trust agrees with this recommendation and congratulates NPGRC for addressing this issue after the review visit. We acknowledge that NPGRC currently uses SDIS to manage the passport data of its collections and equipment inventory (i.e. freezers). We would support NPGRC in testing GRIN-Global as a system to manage accession inventories.
16	We recommend that NPGRC organize facilitated meetings at agro-ecological zone level (2-3) of representatives of farmers' organizations, NGOs, local government agencies, research institutions/universities based in the zones, and local seed producers (max. 40 participants per zone). In order to elevate the profile of the national seedbank and raise awareness on the importance of supporting it, the reviewers strongly recommend that ZARI holds at least two facilitated high-level meetings with key policymakers during the implementation of the project.	2020 - 2024	NPGRC: Agree, we need to raise the profile of the genebank in order to receive more support from all stakeholders. Similar activities will be planned for different regions within the country. Stakeholders such university students will be engaged to carry out evaluation and characterization of accessions. Meetings will be organized for key policy makers to sensitize them about the importance of NPGRC. Crop Trust: It is important that a structured communications plan is first developed, as this can guide NPGRC's efforts to enhance its communications with all stakeholders, including genebank users. The Crop Trust will support NPGRC in designing and implementing a communications plan aiming to enhance the genebank's visibility.
17	To address the limited use of national collections to enhance crop diversity to mitigate the effects of climate change, we recommend that NPGRC and ZARI facilitate technical support in the evaluation, characterization, and multiplication of accessions	2020 - 2024	NPGRC: Agreed ● NPGRC staff together with the technical working group will identify core collections of underutilized, climate-smart crops in order to improve them. This will mitigate the effects of change.

	of underutilized and climate-smart crops for direct use in the cropping system by the following actions: ● Together with the Technical Working Group of researchers/scientists, identify a core collection of underutilized and climate smart crops (e.g. Bambara, finger millet, sorghum, popular vegetables landraces and some CWR) for use in crop improvement ● Multiply/bulk seed of selected accessions for distribution ● Together with scientists/researchers, conduct phenotypic/genotypic characterization for climate-smart traits ● With user groups, provide technical support in the evaluation of characterized accessions for climate-smart traits with researchers and NGOs that can then facilitate access to seed and knowledge to farmers. ● With researchers, undertake introgression and genetic enhancement with selected accessions to develop diversified populations ● Conduct participatory selection with farmers to identify preferred resilient varieties (medium-term) ● Seek the registration and seed multiplication of selected varieties ● With support from NGOs, facilitate access to seed and knowledge to farmers (long-term).		● Bulk seed of improved climate-smart varieties will be multiplied for wider distribution. ● Phenotypic and genotypic characterization will be conducted to identify climate-smart traits in them. ● We will offer technical support in the evaluation of characterized accessions for climate-smart traits with researchers and NGOs that can then facilitate access to seed and knowledge to farmers. ● We will undertake introgression and genetic enhancement with selected accessions to develop diversified populations ● Participatory variety selection with farmers will be conducted on-farm. Farmers will give their preference in terms of varieties that are resilient to climate change. ● The NPGRC will seek to release varieties of the selected climate-smart varieties. ● Access to seed will be facilitated in collaboration with stakeholder NGOs. Crop Trust: Given restricted resources we would prioritize: ● The identification of promising landrace material through participatory field evaluation trials. ● Multiplication and distribution of promising landraces displaying climate-smart traits. ● Registration and multiplication of selected accessions. ● Preparation of core collections based on passport and characterization data. It is important that NPGRC selects the most promising crop for climate-change affected regions of Zambia, for which NPGRC conserves a substantial diversity of accessions. Collaboration with relevant researchers and breeders is key and Crop Trust would support outsourcing some of these activities with specialized NGOs or other institutions based in Zambia.
18	We recommend that a detailed risk management matrix (such as Table 6) is agreed upon and used as the basis for monitoring	2020 - 2023	NPGRC: We agree that there is a need for a risk management matrix as a tool for monitoring genebank risks on an annual basis, giving updates to the Crop Trust.

	risk for the seedbank on an annual basis with updates provided as needed by NPGRC to the Crop Trust.		Crop Trust: The Crop Trust supports this recommendation and agrees with NPGRC's response. Work on QMS will provide support to NPGRC to strengthen its risk management.

National Plant Genetic Resources Centre – Zambia Agricultural Research Institute, Lusaka, Zambia

External Review Report

April 27, 2020

Review Team:

- **Paula Bramel**
- **Simon Linington**
- **Bonny Ntare**
- **Milko Škofič**

Executive summary

The “National seeds collections for climate-resilient agriculture in Africa – Seeds4Resilience” project aims to safeguard selected national seedbanks in Africa and empower them as entry points for developing new, climate-resilient crop varieties. As the first step in the implementation of this project, an external review was commissioned to review the current institutional capacity, technical capacity, adequacy of facilities, and adequacy of operational procedures to meet the challenges of long-term conservation and use of key global collection held by national seedbanks. The external reviewers utilized a baseline survey, intensive site visits, and consultative discussion of each seedbank to assess the short term and long-term upgrade needs for NPGRC-ZARI to meet international seedbank standards to better secure conservation and use for the future.

The National Plant Genetic Resources Center (NPGRC) was established in 1989 by the Zambia Agricultural Research Institute (ZARI) on behalf of the Zambia government in a cabinet Gazette. NPGRC operates under ZARI. ZARI is one of 10 departments within the Ministry of Agriculture (MA). Each of the departments is headed by a director who reports to the Permanent Secretary. ZARI has a mandate to conduct public good agricultural research and provide associated services. The Plant Genetic Resources Program, under which the NPGRC falls, is in the Crop Improvement and Agronomy thematic area. Crop Improvement and Agronomy develops and adapts appropriate crop varieties (food and cash crops) and agronomic technologies for all categories of farmers in different agro-ecological regions of Zambia. The overall objective of the Plant Genetic Resources Program is the long-term support of agriculture in general, and crop research and development in particular, contributing to improving the yields and quality of crops available for farmers. To achieve this objective, a national seedbank was established with the aim of mobilizing and conserving the maximum genetic variability of indigenous and locally adapted crops, their wild relatives and useful weedy and wild plant species.

NPGRC indicated in the baseline inventory that they currently conserve 6,439 accessions from 37 crops. About 64% of the accessions are included in the MLS as Annex 1 crops but they also have collections of a number of traditional crops that are of high cultural and nutritional value. Two thirds of the accessions were collected in the 1980s and 1990s. Thus, a majority of the accessions are traditional varieties or landraces which have evolved through farmers’ selection and are adapted to localized agroecological conditions with limited risk of introgression from improved germplasm due to limited breeding efforts at the time of collection. This indicates NPGRC could be conserving a high proportion of unique accessions from some key food security crops.

The Crop Trust utilizes a set of indicators to monitor various aspects of a seedbank performance. The baseline performance for NPGRC for this set of indicators was reviewed. There were significant gaps identified for seed viability monitoring; seed health testing; regenerations; safety backup at sites outside Zambia; documentation and sharing of accession level information; and the use of a quality management system with written, accurate standard operating procedures for the key routine operations. Key recommendations were made to address these gaps. Many of these gaps were due to shortfalls in the current operational procedures, equipment, and facilities.

Each of the steps in the flow of seed through the seedbank operations were reviewed as well as the adequacy of the workspaces, laboratories, drying unit, seed storage freezers, and field sites to meet the needs for secure, cost-effective, sustained conservation for the long term. The various risk associated with their current processes were identified and upgrade recommendations made to mitigate these risks and to improve the flow of the operations to address the significant gaps.

The reviewers also considered the degree and effectiveness of the current use of the collection. They assessed the interaction with users through distribution of accession nationally and internationally. The engagement with users was reviewed in relation to the effectiveness of feedback from users to improve seedbank operations well as to enhance

accession level information for future users. The level of engagement of NPGRC with stakeholders and users to enhance the use of accessions in the collection, especially to mitigate the impact of climate change, was assessed. Finally, the level of the current engagement of NPGRC within the global conservation system was reviewed. A key set of recommendations were made for action to be taken to enhance the use of the accessions and the engagement with stakeholders for the longer term.

A comprehensive risk assessment was done by the reviewers with the identification of key actions required to mitigate these risks. Generally, the reviewers found that NPGRC is an important national collection in the global system that conserves unique accessions of key crops. It has all the essential facilities, equipment, expertise, and operational processes required for long-term conservation, but these are not operating at optimal levels. Thus, a set of key recommendation have been made by the reviewers to upgrade the seedbank operations to meet the future challenges for sustained, secure, cost-effective conservation and enhanced use.

List of recommendations

Recommendation 1: The reviewers recommend that a long-term plan be developed for the sustainability of the operation of the seedbank at NPGRC and when the upgrade is completed, a costing study of routine operations be done to secure adequate annual funds for the conservation and use of the collections.

Recommendation 2: Generally, the reviewers recommend that NPGRC invest in enhancing staff capacity for the long-term through:

- On-site capacity building by experts to train staff and upgrade the key processes
- Exchange visits with ICRISAT, IITA, ILRI, etc. to build capacity for specific processes
- Staff succession planning to address the potential loss of key long-term staff with key knowledge of the collection or genebank management

Recommendation 3: It is recommended that a study be done to formally determine redundancy with other national and international collections held by national and international institutes that were either involved in joint collecting with NPGRC or are serving as host sites for duplicates sites. This in-depth analysis of the uniqueness of the accessions should lead to opportunities for prioritization of accessions and crops for long term conservation by NPGRC and opportunities for rationalization by all collection holders. It would also give NPGRC an opportunity to recover lost accessions through repatriation or recollection.

Recommendation 4: The reviewers recommend that NPGRC update the inventory to accurately reflect the current composition of the collection; the status of accessions whether under active management or historical status; clarify and record the MLS status of all accessions; and add all available passport and characterization data. This updated accession level information should be shared with users using Genesys.

Recommendation 5: To address the lack of secure safety back-up, the reviewers recommend that NPGRC prioritize unique accessions by crop and arrange for safety duplication for all those accessions that are not already safety duplicated with an institution outside of Zambia to serve as a primary black box. For those NPGRC accessions that have already been deposited in Svalbard by SPGRC, NPGRC should instruct SPGRC to update the inventory of samples deposited at the Svalbard Seed Vault to include the NPGRC accession numbers as “Other accession designations”. NPGRC should then dispatch seed of priority unique accessions to Svalbard to fill gaps for accessions that have not yet been deposited there through SPGRC.

Recommendation 6: The reviewers recommend that NPGRC adopt a quality management system (QMS), including the development and regular updating of improved standard operating procedures (SOPs) for current processes for routine operations, as well as any new processes.

Recommendation 7: The reviewers recommend that the procurement plan in Table 5 be implemented with careful consideration of each item by NPGRC staff and with the guidance of the discussion in the relevant subsection of “Seedbank operations for long-term conservation and active use of the collections” in the full review report.

Recommendation 8: The reviewers recommend that the significant backlog in testing for seed viability be addressed with the purchase of suitable equipment and lab setup to test viability, as well as through training to increase technical skills in permanent staff , aiming for a capacity to carry out seed viability tests at the rate of at least 1,000 accessions per year. While this capacity is being built, NPGRC should use the viability test results from SPGRC to prioritize regeneration and viability monitoring. An alternative will be to collaborate with SPGRC to use their facilities to help reduce the backlog.

Recommendation 9: The reviewers recommend the adoption of a process to determine and monitor the number of seeds available per accession (e.g. systematically document baseline packet weights, distribution packet weights, and 100/1000 seed weights) to ensure that acceptable thresholds are maintained**.**

Recommendation 10: The reviewers recommend, as a priority, that the base pack of the most original seed lot for all the accessions be relocated into a base collection and conserved in freezers dedicated for long term storage, where the temperature can be maintained in a constant and optimal range with minimal disturbance. Newly regenerated material should also be stored in base collection freezers. All the distribution packs should be stored in different freezers.

Recommendation 11: The reviewers recommend that NPGRC deploy a routine formal process for soliciting and using feedback from recipients to improve the use of the collection and seedbank operations with actions such as:

- Conduct routine user surveys on the use of the collections, delivery timelines, quality of seed received and other useful information.
- Fully implement DOI to better link to information generated on the accessions. The seed sample for each accession at SPGRC is still the original seed from NPGRC. Thus, DOIs assigned to SPGRC for NPGRC should be the ones given for the accessions in Genesys rather than the ones that have currently been given to SPGRC.
- Develop a procedure for ensuring that information on the evaluation and use of the distributed germplasm is shared with the seedbank to enrich the accession level databases.

Recommendation 12: The reviewers recommend that NPGRC develop and implement a realistic five-year plan to securely regenerate at least 600 accessions per year, giving priority to those that were collected in the 1980s and 1990s. Priorities for regeneration should be based on new data made available from seed viability tests and the seed counts carried out by NPGRC. While this data is being generated, NPGRC should use the viability test results from SPGRC to prioritize accessions for regeneration that are below acceptable viability and seed number thresholds. NPGRC should also engage with SPGRC and other local research organizations for help to address the regeneration backlog.

Recommendation 13: Urgently, the reviewers recommend that the current cassava collection in the field be secured with irrigation and safety duplicated with a CGIAR genebank. Collecting missions should be undertaken to reconstitute the local sweet potato landraces accessions that were lost.

Recommendation 14: There is a backlog of information stored on paper that needs to be digitized, but this must not be done at the expense of the other high priority routine operations, so the reviewers recommend that temporary staff be hired and dedicated to digitization activities.

Recommendation 15: The reviewers recommend that all efforts are made by ZARI to enhance internet connectivity at the genebank to the server to allow for the full implementation of SDIS or other seedbank information systems such as GRIN-Global.

Recommendation 16: The reviewers recommend that NPGRC organize facilitated meetings at agro-ecological zone level (2-3) of representatives of farmers' organizations, NGOs, local government agencies, research institutions/universities based in the zones, and local seed producers (max. 40 participants per zone). In order to elevate the profile of the national seedbank and raise awareness on the importance of supporting it, the reviewers strongly recommend that ZARI holds at least two facilitated high-level meetings with key policymakers during the implementation of the project.

Recommendation 17: To address the limited use of national collections to enhance crop diversity to mitigate the effects of climate change, we recommend that NPGRC and ZARI facilitate technical support in the evaluation, characterization, and multiplication of accessions of underutilized and climate-smart crops for direct use in the cropping system by the following actions:

- Together with the Technical Working Group of researchers/scientists, identify a core collection of underutilized and climate smart crops (e.g. Bambara, finger millet, sorghum, popular vegetables landraces and some CWR) for use in crop improvement
- Multiply/bulk seed of selected accessions for distribution
- Together with scientists/researchers, conduct phenotypic/genotypic characterization for climate-smart traits
- With user groups, provide technical support in the evaluation of characterized accessions for climate-smart traits with researchers and NGOs that can then facilitate access to seed and knowledge to farmers.
- With researchers, undertake introgression and genetic enhancement with selected accessions to develop diversified populations
- Conduct participatory selection with farmers to identify preferred resilient varieties (medium-term)
- Seek the registration and seed multiplication of selected varieties
- With support from NGOs facilitate access to seed and knowledge to farmers (long-term).

Recommendation 18. The reviewers recommend that a detailed risk management matrix (such as Table 6) is agreed upon and used as the basis for monitoring risk for the seedbank on an annual basis with updates provided as needed by NPGRC to the Crop Trust.

Introduction to the external review

The Crop Trust has organized and facilitated a number of reviews to assess and monitor performance and identify improvements required to allow seedbanks to operate to internationally agreed management standards. This national seedbank review is an activity of the "National Seeds Collection for Climate-Resilience Agriculture in Africa- Seed for Resilience" project that is funded by the Federal Republic of Germany.

A review team was engaged to conduct a review of each of the five seedbanks with the key expertise needed to cover the various aspects of the review. The review team were:

- Paula Bramel: Chair of the review panel with experience in conducting seedbank reviews with expertise in institutional analysis, diversity assessment, and seedbank management
- Bonny Ruhemurana Ntare: Operations and use expert, to support the chair in the areas of general seedbank management and links with users
- Simon Linington: Equipment and facilities expert, who assessed in detail equipment status and needs

- Milco Škofič: Information systems expert, who assessed seedbank management data flows and software and hardware needs

The review took into consideration various aspects that affect the overall functioning of a seedbank, including technical, financial, organizational, regulatory, social, and environmental aspects. The exact terms of reference for the review are given in Annex 1.

For the Seeds4Resilience Project, Crop Trust staff and the reviewers prepared a baseline questionnaire on institutional, financial and technical topics and circulated it to all five pre-selected national seedbanks. The review team did a background review that included this baseline survey. Paula Bramel, Bonny Ntare, and the project manager visited the NPGRC seedbank from 16-18 September. Simon Linington and Milko Škofič were not able to travel but extensive teleconferences were arranged for them during the visit. The agendas of each visit are available in Annex **Error! Reference source not found.**.

The reviewers have prepared this report with their recommendations for upgrades at NPGRC and submitted it to the Crop Trust. The Crop Trust will prepare a recommendations matrix where the reviewed seedbank comments their agreement or an alternative to each of the specific recommendations of the review, which is then further discussed with the seedbank and eventually agreed by the Crop Trust. Based on this matrix, a recommendation action plan will be developed which will be used to design project agreements between the Crop Trust and the seedbank. The Crop Trust has used this approach with all international seedbanks, and it has proven to be an effective tool in the preparation of multi-year upgrading projects.

History and Mandate

The National Plant Genetic Resources Center (NPGRC) was established in 1989 by the Zambia Agricultural Research Institute (ZARI) on behalf of the Zambia government in a cabinet Gazette. It recognized there was a need to conserve this national heritage. Most of the early activities were in cooperation with ICRISAT since they also had a focus on collection and conservation of sorghum and millet diversity from Zambia and other African countries. The SADC Plant Genetic Resources Centre (SPGRC) was also established in 1989 with a 20-year commitment from the Nordic countries to the Southern African Development Community (SADC) regional and national genebanks. NPGRC received funds for operation and collection, as well as training, from the Nordic donors.

NPGRC operates under ZARI. ZARI is one of ten departments within the Ministry of Agriculture (MA). Each of the departments is headed by a director who reports to the Permanent Secretary. ZARI has a mandate to conduct public good agricultural research and provide associated services. The overall objective of ZARI is to generate and adapt technologies and make these available to farmers and other beneficiaries, in order to increase agricultural productivity and diversify production.

The Plant Genetic Resources Program, under which the NPGRC falls, is in the Crop Improvement and Agronomy thematic area. Crop Improvement and Agronomy develops and adapts appropriate crop varieties (food and cash crops) and agronomic technologies for all categories of farmers in different agroecological regions of Zambia. The overall objective of the Plant Genetic Resources Program is the long-term support of agriculture in general, and crop research and development in particular, contributing to improving the yields and quality of crops available for farmers. To achieve this objective, a national seedbank was established with the aim of mobilizing and conserving the maximum genetic variability of indigenous and locally adapted crops, their wild relatives and useful weedy and wild plant species. The objective of the seedbank is well supported currently by the institute and the ministry. The future commitment is less clear as ZARI did not share with the reviewers any long-term strategy or planning documents related to the seedbank.

Institutional Capacity

ZARI is a government department rather than a semi-autonomous institute so there is direct supervision of the management by MA but no other supervisory body, such as an advisory board. MA does report progress to, and get input from, formal stakeholder groups at national, provincial, district, and community levels. Supervisory committees have been established for specific projects, such as the World Bank-funded Agricultural Productivity Program for Southern Africa (APPSA) project.

The director of ZARI is accountable directly to the Permanent Secretary of MA. The director manages through the Research Management Committee that also includes the two deputy directors. The Research Management Committee cuts across technical and administrative units. Each deputy director has management responsibility for technical programs and a region with its various stations. The annual planning meeting for all ZARI programs and regions allows for project proposals to be initiated by researchers. No system is currently being used to provide management with relevant information on key performance indicators. In fact, there are no technical and financial performance indicators at institution or seedbank level. These would only be implemented if a donor requested it for a project.

ZARI has the flexibility to comply with specific donor requirements in terms of impact monitoring. It has a unit specifically focused on this. There seems to be MA-level monitoring and measuring impact, but it was not clear how this is communicated or used.

Finances and accounting

ZARI operates under MA policy and administrative processes. All financial activities are managed under the Integrated Financial Management Information System. Most decision-making is vested in the director. There are internal controls guided by various regulations, such as the Public Code of Conduct, and financial regulations and public procurement regulations of 2011, to ensure that financial irregularities, including corruption, theft, embezzlement, fraud, misappropriation of funds, favoritism and nepotism are detected and counteracted. The Public Code of Conduct for all employees is in place for preventing, reporting, and dealing with matters of discrimination such as sexual harassment, sexual exploitation, sexual abuse and gender-based violence. ZARI did not share any documentation with the reviewers to support the information they provided. It is not clear to the reviewers how any of these reference documents are complied with.

The seedbank has a direct role in budget development, expenditure, and monitoring for its projects. For Treasury funds, they are only involved in budget development. ZARI scientists work together with the deputy director and director as projects are developed and implemented to ensure transparency in budget development and expenditure. It was not clear to the reviewers how this is done except in the review of expenditure for the quarterly financial reports that involve the project manager, deputy director, and the director. Expenditure reports and supporting documentation is held at the accounting unit in ZARI HQ.

ZARI does the financial reporting for the seedbank projects with separate accounts for donors while MA HQ does financial reports for Treasury funds. NPGRC has its own sub-account, which is managed by the accounting unit of the institute. Individual projects can have a separate account, and ZARI is willing to manage it according to the requirements of the donor. A finance manager is in charge of separate accounts.

ZARI does have a 15% overhead rate if allowed by the donor and this is split 5% to MA HQ and 10% to the department to cover indirect costs. ZARI is not currently able to accommodate cost recovery. This is not allowed as ZARI is a department within MA even though ZARI has entered into licensing agreements with the private sector for released varieties.

NPGRC is only involved in annual audits as requested. Audits are done as required by donors. The Auditor General audits MA once per year and reviews the reports of the internal auditors for Treasury funds and big projects. ZARI shared extracts of audited reports of the APPSA World Bank project for 2017 and 2018 conducted by the office of the Auditor General. None of the past audits shared by ZARI had issues. These were not externally

conducted audits. We have not received financial statements for NPGRC and therefore were not able to fully assess the current financial position, cash flow and the view of the external auditors with respect to NPGRC specifically.

Annual routine operational funds

In the baseline questionnaire, the estimated annual expenditure for the seedbank was ZMW 1,115,018. This was not disaggregated by source of funding, e.g. government core support or projects. The reviewers assumed this is the total budget but when it is compared with the annual budget allocation for each year in the baseline questionnaire (Table 1), the annual operating budget for NPGRC was significantly inadequate for three of the five years. There was no explanation for this shortfall in annual funding. This sort of variation in resources must be very disruptive and result in delays in many essential activities.

Table 1. NPGRC annual budget (in ZKW) for last five years (as provided in baseline questionnaire).

2015	2016	2017	2018	2019
1,100,000.00	648,250.00	1,160,000.00	470,887.00	844,784.00

It is not clear to the reviewers if budget fluctuations were a result of low MA allocations to ZARI or to low allocation to NPGRC by ZARI. ZARI did not share any annual financial statement for ZARI or for NPGRC. Thus, it was not possible to assess the income, expenditure, overall yearly balances, or other aspects of seedbank finance. It was not possible to assess the impacts of budget variation on the financial health of ZARI or the seedbank.

Currently the annual funds available for routine operations are inadequate and fluctuate widely year-on-year. Only the permanent staff costs are currently fully covered annually by the Treasury funding. The focus for addressing the gaps in annual funds has been on obtaining more short-term projects to increase funds for routine operations. There is little long-term planning to better meet the annual requirement by the institute or the seedbank. More strategic approaches must be made to ensure adequate resources are available to the seedbank for long-term conservation and enhanced use. There is a need to secure adequate annual funds for routine operations, so the project funds add value to conservation through greater use. This will require a better understanding of the cost of routine operations and more long- term planning for resources.

Recommendation 1: The reviewers recommend that a long-term plan be developed for the sustainability of the operation of the seedbank at NPGRC and when the upgrade is completed, a costing study of routine operations be done to secure adequate annual funds for the conservation and use of the collections.

Staff capacity for both long-term conservation and active use

NPGRC has five long-term staff currently. Four of the five have been working in the seedbank for 5-10 years. They all have attended short term courses on plant genetic resources management and more specialized subjects held by SPGRC. One staff member has an advanced degree (MSc). Current staff work well together as a team, but they do have gaps in expertise that will need to be considered in the future. The reviewers suggest that there is a need to consider strengthening the staff composition to include expertise in areas such as seed physiology or genetic diversity assessment. This might also be done through advanced degrees for some of the key current staff.

They currently operate with short-term or temporary staff when funds are available through projects. The need to expand routine operations to address the significant gaps in processes will challenge the current staffing levels. There will be a need to increase the number of medium-term and short-term staff. This will require efforts be made to ensure their capacity as well. In the past this might have been done through training programs for key staff that

would be incorporated into the improved operations, but this is not a secure approach given staff turnover. Currently there is no documentation of the key processes that could be used to ensure the capacity of the project-funded short-term staff and new long-term staff. This gap needs to be addressed.

Recommendation 2: Generally, the reviewers recommend that NPGRC invest in enhancing staff capacity for the long-term through:

- **On-site capacity building by experts to train staff and upgrade the key processes**
- **Exchange visits with ICRISAT, IITA, ILRI, etc. to build capacity for specific processes**
- **Staff succession planning to address the potential loss of key long-term staff with key knowledge of the collection or genebank management**

Composition of the collection in relation to the uniqueness of the accessions

In the inventory of the accessions given in the baseline survey, NPGRC is conserving a total of 6,439 accessions from 37 crops. The total number of accessions for the various crops are summarized in Table 2. According to the baseline inventory, about 64% of the accessions are included in the MLS as Annex 1 crops. They also have collections of a number of traditional crops that are not included in Annex 1 but are of high cultural and nutritional value. Two thirds of the accessions were collected in the 1980s and 1990s. Thus, a majority of the accessions are traditional varieties or landraces which have evolved through farmers' selection and are adapted to localized agroecological conditions. The age of the accessions would indicate that at the time of collection there was limited risk of introgression from improved varieties due to limited breeding efforts at the time.

Table 2. Summary of the total number of accessions of crops with Zambian origin conserved globally by reference to either (a) those conserved by NPGRC according to the inventory given in the baseline or reported by NPGRC to FAO-WIEWS, or (b) landrace accessions from Zambia conserved in other national or international genebanks according to accession information published in Genesys.

Crop	Genus	Species	Baseline	FAO WIEWS	Genesys[1]
			Number of Accessions		
Sorghum	*Sorghum*	*bicolor*	953	947	1024
Pumpkins and gourds	*Cucurbita*	sp.	701	777	269
Maize	*Zea*	*mays*	644	688	401
Pearl millet	*Pennisetum*	*glaucum*	626	301	206
Groundnuts	*Arachis*	*hypogeal*	515	515	964
Cow peas	*Vigna*	*inguiculata*	494	575	1024
Finger millet	*Eleusine*	*indica*	383	412	221
Rice	*Oryza*	*sativum*	293	336	309
Okra	*Abelmoschus*	*esculentus*	235	235	107
Bambara groundnuts	*Vigna*	*subterranea*	203	288	
Amaranth	*Amaranthus*	sp.	194	260	84
Beans	*Phaseolus*	*vulgaris*	183	209	637
Cotton	*Gossypium*	*hirsutum*	159	28	30
Pigeonpeas	*Cajanus*	*cajan*	124	140	171
Cassava	*Esculentus*	*manihot*	100	113	0
False Roselle and Roselle	*Hibiscus*	sp.	86	154	169
Ethiopian kale	*Brassica*	*carinata*	76	109	16
Sesame	*Sesamum*	*indica*	73	96	0
Sunflower	*Helianthus*	*anus*	70	69	28
Castor bean	*Ricinus*	sp.	68	91	0
Spider plant	*Cleome*	*gynandra*	66	83	11
Tomato	*Lycopersicon*	*esculentum*	42	42	2

[1] According to Genesys (2019) https://www.genesys-pgr.org/

Crop	Genus	Species	Baseline	FAO WIEWS	Genesys[1]
			Number of Accessions		
Pepper	*Capsicum*	sp.	31	93	82
African eggplant	*Solanum*	sp.	19	38	28
Sesbania	*Sesbania*		18	18	34
Wheat	*Triticum*	*aestivum*	17	17	71
Tephrosia	*Tephrosia*		17	18	15
Peas	*Pisum*	*sativum*	15	15	20
Tobacco	*Nicotiana*		14	14	31
Velvet beans	*Mucuna*	sp.	9	36	5
Yams	*Diascorea*	sp.		1	1
Sweetpotatoes	*Ipomoea*	*batatas*		194	1
Wild rice	*Oryza*	sp.		63	
Vigna sp.	*Vigna*	sp.		34	
Watermelon	*Citrullus*	*lanatus*		114	69
Jute Mallow	*Corchorus*	sp.		58	0
Cucumbers	*Cucumis*	sp.		261	105
Bottle Gourd	*Lagenaria*	*siceraria*		32	104
Livingstone potato	*Plectranthus*	*esculentus*		64	1
Minor crop collections			11	45	44
Total accessions			6439	7583	6282

We were also able to extract data for ZMB048 (the NPGRC seedbank) from the FAO-WIEWS database (http://www.fao.org/WIEWS/en/). We also determined the number of accessions from Zambia that were held by other national and international genebanks. This is also summarized in Table 2. The FAO WIEWS database also included the status in the Multilateral System (MLS) of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). The baseline inventory included 6,439 accessions from 37 crops while the FAO-WIEWS database included 7,583 accessions from 51 crops. It is not clear why there is a difference, but it could be concluded that the 14 crops not included, and the significant reduction in the number of accessions for many of the crops, could be due to loss of significant accessions or to an incomplete inventory given in the baseline. Many genebanks would categorize these missing accession as ‘historical accessions”. It is important to maintain an up-to-date inventory that reflects the current composition of the collection. The reviewers were told that all the accession of crops such as sweet potato and Livingstone potato had been lost in the field during a drought.

In the selection of NPGRC as a key national collection for support by the Crop Trust, the project concluded that NPGRC potentially held unique accessions for Annex 1 crop such as cowpeas, finger millet, pigeonpeas, and sorghum. To further assess the potential uniqueness of the accession currently conserved in Zambia, we compared the number of landrace accessions held at NPGRC Zambia against other national and international seedbanks with Zambian holdings. For some crop genera, such as *Sorghum*, *Vigna*, and *Phaseolus*, there are more accession held in genebanks outside Zambia than in the NPGRC collection. In other Annex 1 crop genera, such as *Zea*, *Pennisetum*, *Eleusine*, *Manihot*, and *Ipomoea*, there are fewer or no accession from Zambia conserved by genebanks outside Zambia. The S4R project manager, Nora Castaneda-Alvarez, was also able to compare the number of landrace accessions conserved and the mapping of these with geographical coordinates for the Annex 1 crops with those held by 47 other international and national seedbanks. Using accessions with geographical coordinates, landraces or traditional accessions were compared for overlaps in their distribution. Based on this analysis we identified that potentially the most unique Annex 1 collections are local collections of landraces of *Brassica*, finger millet, sweet potatoes, eggplant, cassava, rice, maize, cowpeas and Bambara groundnuts. This preliminary review of the uniqueness of the accession across crops indicates that there is merit in securing the long-term conservation of this unique collection and that it is of significant value to the global system.

Recommendation 3: It is recommended that a study be done to formally determine redundancy with other national and international collections held by national and international institutes that were either involved in joint collecting with NPGRC or are serving as host sites for duplicates sites. This in-depth analysis of the uniqueness of the accessions should lead to opportunities for prioritization of accessions and crops for long term conservation by NPGRC and opportunities for rationalization by all collection holders. It would also give NPGRC an opportunity to recover lost accessions through repatriation or recollection.

Baseline Performance Targets

The Crop Trust utilizes a set of indicators to monitor various aspects of a genebank performance. Table 3 gives the current status of NPGRC performance for these indicators. As indicated in the previous section, 98% of the current collection is comprised of species with orthodox (desiccation-tolerant and therefore storable) seeds. There is only a small field collection of cassava accessions.

Table 3. Baseline information on performance indicators

Baseline criteria	Number of accessions	% of total accessions
Composition of collections		
Number of accessions in total	6439	
Number of seed accessions	6338	98.4%
Number of accessions conserved *in vitro*	0	0.0%
Number of Field bank accessions	100	1.6%
Availability		
Viable tested	0	0.0%
Viability above 85%	0	0.0%
Health tested	0	0.0%
Adequate seed number	Not reported	
Included in MLS	4111	63.8%
Regenerated or multiplied in last five years	794	12.3%
Security		
Number of LTS	6338	98.4%
Safety duplicated at SPGRC	3260	50.6%
Safety duplicated outside country	0	0.0%
Safety duplicated at Svalbard or other site outside country	0	0.0%
Field collection maintained in two sites at least	0	0.0%
Distribution		
Total distributed nationally in last five years	329	
Total distributed internationally in last five years	283	
Number of countries distributed	6	
Information		
Minimum passport data (online)	4367	67.8%
Minimum characterization data (online)	2173	33.7%
Passport completeness index	not reported	
QMS		
Elements of QMS in place	0	
SOP written reviewed and approved	0	
overall satisfaction of seedbank users	Not reported	

The seedbank is an integral unit of the crop improvement program of the Zambian Agricultural Research Institute (ZARI) where the collections are fully owned and managed. The seedbank also operates in accordance with ITPGRFA with 59.6% of the accessions of Annex 1 crops included in the MLS but there are a few accessions of these crops (280) that do not seem to be included according to the FAO WIEWS database.

According to NPGRC in the baseline survey, they have MCPD passport data on about 68% of the collection but none of this is entered into an electronic searchable database nor is it online for the users to easily access. On the other hand, they also indicated in the site visit that 100% of the accessions had passport date entered into their database within SDIS at SPGRC as part of the accession registration process. It is not clear as to the status of the passport data although most of the accessions included in the FAO WIEWS database referred to in Table 2 had some passport data. Only about 35% of the accessions have been characterized for minimal descriptors.

Recommendation 4: The reviewers recommend that NPGRC update the inventory to accurately reflect the current composition of the collection; the status of accessions whether under active management or historical status; clarify and record the MLS status of all accessions; and add all available passport and characterization data. This updated accession level information should be shared with users using Genesys.

The secure conservation of accessions is increased by means of safety duplication outside the country. In the baseline, NPGRC indicated that 57.5% of the accessions are duplicated at the SPGRC seedbank located in Lusaka. The close proximity of these two sites means that the safety duplication does not meet international standards since both sites would face very similar risks. In addition, SPGRC has sent a safety duplication of accessions from the Zambia NPGRC accessions held in their collection to Svalbard. Unfortunately, these accessions are identified only using the SPGRC numbers. Should NPGRC need to recover these accessions, it would need to do so through a request to SPGRC which is the recognized depositor. To at least reduce any errors in the future, SPGRC should update the inventory of samples deposited at the Svalbard Seed Vault to include the NPGRC accession numbers as “Other accession designations” (https://www.nordgen.org/sgsv/index.php?page=depositor_guidelines).

Recommendation 5: To address the lack of secure safety back-up, the reviewers recommend that NPGRC prioritize unique accessions by crop and arrange for safety duplication for all those accessions that are not already safety duplicated with an institution outside of Zambia to serve as a primary black box. For those NPGRC accessions that have already been deposited in Svalbard by SPGRC, NPGRC should instruct SPGRC to update the inventory of samples deposited at the Svalbard Seed Vault to include the NPGRC accession numbers as “Other accession designations”. NPGRC should then dispatch seed of priority unique accessions to Svalbard to fill gaps for accessions that have not yet been deposited there through SPGRC.

Currently, there is a lack of written operational procedures/manual for all processes, including field operations and field genebank maintenance. The seedbank indicated that they followed an established protocol from the Handbooks for Seedbanks No. 8 Manual of Seed Handling in Genebanks (Swara et al. 2014). It was clear that this manual was used solely for very basic guidance for moisture testing. In all the processes, they had no formal documentation, nor do they routinely follow the Handbook No. 8 operational process.

Recommendation 6: The reviewers recommend that NPGRC adopt a quality management system (QMS), including the development and regular updating of improved standard operating procedures (SOPs) for current processes for routine operations, as well as any new processes.

Seedbank operations for long-term conservation and active use of the collections

During the site visit, the reviewers focused on understanding the current flow of routine operations from receiving seed or plant material into the seedbank through to storage of seed or establishment of accessions in the field seedbank. Similarly, sending material to the field for regeneration/multiplication and characterization through to its receipt in the seedbank again for processing. The various facilities in the building or fields were assessed for their adequacy for the current operation as well as for the increase workflow expected from the upgrade. The essential equipment was reviewed based on baseline information requested prior to the visit and the visit to the seedbank. Table 4 lists the flow of seed or plant material

through the various steps at locations in the seedbank as given in Figure 1. In general, the reviewers found that the NPGRC seedbank has many of the essential elements for ensuring the secure conservation and use of the accessions but has an investment need for key elements in facilities, equipment and expert services.

Recommendation 7: The reviewers recommend that the procurement plan in Table 5 be implemented with careful consideration of each item by NPGRC staff and with the guidance of the discussion in the relevant subsection of "Seedbank operations for long-term conservation and active use of the collections" in the full review report.

Table 4. Flow of routine seedbank operations

Step	**Description of activity**	**Location for activity in Figure 1**
Step 1a	Receive and store seed, inflorescence, fruit, or other plant material from field (multiplication, regeneration, collection) in paper or cloth bags with the field or collection label included inside.	Seed Processing Area
Step 1b	Receive vegetative propagules for cassava, etc. and store in bags until field has been prepared	Seed Processing Area
Step 2a	If plant material, then sun dry and thresh by hand in areas outside the receiving room	Seed Processing Area
Step 2b	Plant cassava sticks in field for establishment where plots are monitored and managed	Field seedbank
Step 3	Each seed lot is cleaned by winnowing, screens and hand picking with label from field included inside the bags	Seed Processing Area
Step 4	If from collection, then seed lots are registered in logbook with collection number. The accession number is then used for new labels.	Seed Processing Area
Step 5	Seed bags are put in drier on metal racks	Drying Room
Step 6	Moisture tested	Seed Processing Area
Step 7a.	When the required moisture content is reached, the dried seed is put into multiple aluminum packets. If it is new accession, the field label is put into one long-term storage pack and the pack is labeled with the accession number and date. It is then sealed. The rest of the seed is put into one or more bulk distribution aluminum packs (depending upon the quantity of seed remaining since no seed is discarded) and labeled inside and outside with accession number and date. It is also sealed.	Seed Processing Area
Step 7b.	When the required moisture content is reached, the dried seed is put into multiple aluminum packets. If the seed is from multiplication of a currently held accession, then seed is put into distribution packets; the field label is included in a pack, but all are labeled inside and outside with the accession number; and the packets are sealed.	Seed Processing Area
Step 8a	If a new accession, both the long-term storage pack and all the bulk distribution packs are assigned a location in the freezer. They use paper cartons in the upright freezers and plastic boxes in the chest freezers.	Seed Store
Step 8b	If is a multiplication of an existing accession, the bulk distribution packets are put with the current long-term pack and distribution pack in the assigned freezer and shelf or box.	Seed Store

Step	Description of activity	Location for activity in Figure 1
Step 9	The accession number, the freezer number and the shelf or box number are logged into the inventory on a data sheet that is stored as well as entered into the database.	Documentation Room
Step 10a	When seed is requested for a distribution or research, the distribution pack is used, and the seed is counted to meet the request. The packets are labeled with accession number by hand.	Seed Processing Area
Step 10b	Stakes from cassava or stem cuttings from the vines of sweet potatoes are harvested from field seedbank and shared with requestors	Field genebank
Step 11	The seed quantity of the distribution pack is monitored when seed is taken out and when the supply of seed is low, it is scheduled for multiplication.	Seed Processing Room
Step 12a	Seed is taken out of the distribution pack, packaged, labeled by hand, and laid out for planting.	Seed Processing Room
Step 13a	The multiplication plots are planted in various multiplication sites, depending upon the crop. This is done with the supervision of the seedbank staff at the field site	Multiplication Field Sites
Step 13b	Every two years, cassava stakes or stem cuttings from sweet potato vines are gathered from healthy plants for each accession and replanted in new field plots	Field genebank
Step 14a	Characterization of accessions can be done in the multiplication field if funds allow, by seedbank staff or by students for projects.	Multiplication Field Sites
Step 14b	Characterization can also be done as part of a funded research project by seedbank staff or by university students as part of a collaborative research effort.	Research Sites
Step 15	Data collected on the characterization traits in the field are recorded on sheets and these are stored in the documentation room	Documentation Room
Step 16	The plant material or seed from the multiplication site are received in and processes as described starting in Step 1.	Seed Processing Area

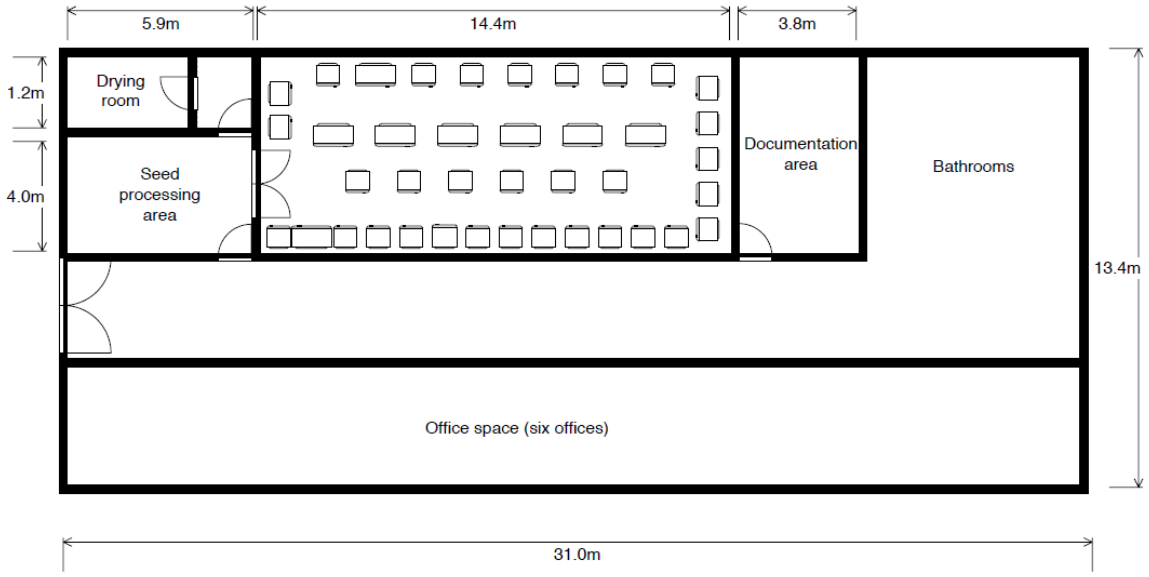
As reported in Table 3 for the baseline information on the performance indicators, the seedbank currently lacks key steps for the routine processes for germination testing, seed health determination, and determination of the number of seed conserved. They also do not have a routine process established for regeneration. Overall the steps in the flow of the routine operations, there is no secure management of the accession identity. Thus, the current processes are incomplete and inadequate to secure the conservation and use of the accession over the long term. This will need to be the focus for improvement in the upgrade. This improvement will be the focus for the establishment of the QMS and the development of SOPs recommended earlier.

The reviewers recognize that the lack of many of these processes has been due to the low level of annual funds for routine seedbank operations. This has resulted in gaps in essential equipment purchase, maintenance, and repair. The implementation of standard processes has also been hindered by the current set-up of the seedbank building where most of the limited operations have to be done in the seed processing room. This has also meant that the ‘dirty’ and ‘clean’ seed processes are mixed. This is a risk to both the seed health of the seed being handled but also to the staff health. These processes can only be separated with changes in the set-up of the seedbank building.

Short-term storage

Collections from regeneration or acquisition remain in cotton bags within the Seed Processing Area (Figure 1) for one to four weeks. The main risk is of seed deterioration while waiting to be dried and cleaned. Although the room has an air-conditioning unit which will help provided cooler, drier conditions, greater use of the drying room (once it is functioning – see below) would be advantageous.

Figure 1. Current seedbank layout



Seed cleaning

This process is carried out within the Seed Processing Area which has air-conditioning. Currently, there are sufficient good quality sieves available for cleaning. *However, it is felt that more might be needed if throughput is increased and the procurement of an additional set of sieves is recommended (Table 5 – item 16).* The facility lacks a seed aspirator / blower and hand-winnowing is practiced. *Purchase of an aspirator is recommended to improve the precision of this process (Table 5 – item 15).*

A significant risk when seed cleaning is the exposure of staff to irritant dusts or allergens. Two types of face mask (“gauze” and “gas mask”) are currently used though there is uncertainty about their efficacy or to what extent they are used. *Purchase of new masks is recommended (Table 5 – item 17) and regular cleaning of this room should occur to prevent dust accumulation. Also, the reviewers recommend the shift of this operation across the corridor and converting one of the offices (see comments under Packaging, below) and providing air-conditioning (Table 5 – items 2 and 9).*

The Seed Processing Room is rodent proof though insects could still get in. *The reviewers recommend that they establish a step in the seed handling process to utilize a hermetically sealed storage system (http://www.knowledgebank.irri.org/training/fact-sheets/postharvest-management/storage-fact-sheet-category/hermetically-sealed-systems-fact-sheet) to eliminate stored insect pest after initial seed cleaning*. There are various options available such as these from https://www.vestergaard.com/zerofly-hermetic-storage-bag or https://grainpro.com/solution-storing/.

Drying and moisture content determination

Seed moisture content is a key determinant of seed longevity and thus central to any seedbank operation. Within limits, a logarithmic decrease in moisture content leads to a logarithmic increase in seed longevity based on a straight-line relationship. For any given

species, moisture content is determined by relative humidity and temperature. Having control of these two parameters is essential in the seed drying process. NPGRC has a small drying room (internal l x w x h dimensions provided by NPGRC of 3.44 x 1.64 x 2.08 m) that was constructed in 2005. However, it is not functioning optimally at present due to problems with its control panel. Furthermore, there was no shelving in the room at the time of the visit.

Upgrades to get the drying room functioning is central to the whole operation. The first step is to get a refrigeration and air-conditioning consultant in to (a) determine the problems with the control panel and (b) determine the serviceability of the components (dryer, refrigeration, insulation, control panel and alarms) of this drying room (Table 5 – *item 2*).

The reviewers recommend a refrigeration and air-conditioning consultancy to address the need for technical advice across a range of equipment and facilities that need to be upgraded. Thus, the basis for the recommended basis for the terms of reference for the consultancy is to provide written specialist advice on:

- The status of the existing Munters dryer of the drying room (is it serviceable with a further five years lifespan?).
- The status of the chiller plan within the drying circuit of the drying room (is it serviceable with a further five years lifespan?).
- The status of the thermal and moisture insulation properties of the 2005 drying room. Repair or replacement of the control unit for the drying room.
- The status of air-conditioning in the seed store containing the deep freezers (is it sufficient for the task and is their sufficient spare capacity in the event of one unit breaking down?).
- Provision (if needed) of air-conditioning for the room selected to act as the germination room.
- Provision of 'outside of condition' alarms and external sounders for drying room and seed store.
- The required servicing of the equipment and the stock of spare parts that should be held.

Provisional costs for the recommended replacement of these different component parts have also been included in Table 5 – items 6-10 plus the provisional cost of their import into Zambia, transportation to site, installation and commissioning (Table 5 – item 5). It must be stressed that *items 2* and *5-10* are provisional with a fair margin for error and only some of the costs in *items 5-10* may actually be necessary.

Instead of replacing shelving within the room, *it is recommended that plastic fruit crates on purpose-built trolleys be used to hold the seed for drying (Table 5 – items 20 and 21).* This would allow for flexibility of configuration of samples within the drying room and permit good air circulation.

It is recommended that a routine service of the drying room's dryer, refrigeration and control panel should be implemented, and a set of spare parts held on site. *Between services, it is recommended that the bank staff should also check that the controls are properly calibrated and that the room is operating within the desired parameters of 15% (± 5%) relative humidity and 15°C (± 3°C) using a portable monitoring device (Table 5 – item 19) that should be useful for other operations on site*. This device will itself need regular calibration. With slight modification, it might also be used to monitor seed equilibrium relative humidity which might augment the testing referred to in the next paragraph.

When seeds have dried to equilibrium in the room (approximately after one month), samples should be checked to see that they really have attained the moisture content required for long-term storage. *This is done non-destructively using a Burrows DMC500 grain moisture meter. This method needs to be calibrated using a gravimetric method (oven and balance*).

Seed viability monitoring

Seed viability monitoring is the key measure of the seedbank's efficacy in conserving the material and knowing the conditions necessary to germinate a given accession are central to unlocking its potential for the user. According to the baseline information on the performance indicators, none of the seed of the accessions stored in NPGRC have been viability tested (Table 3). They indicated that in the past, viability testing was done by the National Seed Testing Laboratory but that was stopped some time ago. They did not indicate if the viability testing data from the past was available or in a database. They have not been able to find an alternative provider of seed germination testing nor have they been able to invest in the equipment and processes to test the seed viability in house.

We were told in the visit to SPGRC, that they have done baseline viability testing for all the accession they hold for NPGRC. About 57% of the accessions are stored in both NPGRC and SPGRC. The seed was sent to SPGRC from the current seed lot, so it is exactly the same but stored under different conditions. If the viability test results are shared with NPGRC, this would allow for the seedbank to focus on regeneration of accessions with known poor viability at SPGRC.

NPGRC has a Wagtech GC 401 germination chamber but it needs repairs to be carried out to its door. It is assumed that NPGRC will arrange for this. Because germination chambers and incubators appear to fail regularly where there are electricity fluctuations, it is recommended that one of the offices in the seedbank building (another is suggested for the seed cleaning) is converted to act as a germination room rather than investing in further germination chambers. This would require air-conditioning plus some form of temperature control plus the installation of suitable lighting (fluorescent or LED) on a timer and the installation of some benches. It could also house the repaired Wagtech chamber. Advice should be taken from the refrigeration and air-conditioning consultant for the drying room about the conversion of this room (Table 5 – *item 2). The cost of air-conditioning has been included in the Table 5 – item 9. It is assumed that lighting work would be covered under general costs for converting the room (Table 5 – item 1).*

Using one germination room rather than several incubators means that the bank will have to batch load its germination, changing the conditions appropriate to the material between batches. The specificity in germination conditions offered by incubators (e.g., alternating temperature regimes) will not be available with a room. Tests should be scored on a bench next to the window because staff would benefit from having natural daylight to examine the tests. *To this end, purchase of a stereomicroscope is recommended (Table 5 – item 14).* Germination tests benefit from the use of high-quality water. *Consequently, purchase of a water purification unit is recommended (Table 5 – item 13).*

If the entire collection (6,700 accessions) was to be regenerated over a five-year period (years 1-5), then 1,340 accessions will need to be tested in years 2-6, i.e., 112 accessions per month. This should be quite achievable in a facility of the size suggested.

Recommendation 8: The reviewers recommend that the significant backlog in testing for seed viability be addressed with the purchase of suitable equipment and lab setup to test viability, as well as through training to increase technical skills in permanent staff , aiming for a capacity to carry out seed viability tests at the rate of at least 1,000 accessions per year. While this capacity is being built, NPGRC should use the viability test results from SPGRC to prioritize regeneration and viability monitoring. An alternative will be to collaborate with SPGRC to use their facilities to help reduce the backlog.

Seed packaging

Once the seeds have been dried, it is essential that they remain that way during packaging and once sealed in the container. Dried seeds will readily imbibe moisture along a water potential gradient if the seal is ineffective and the storage environment is more humid. If there isn't sufficient space in the drying room, then accessions should be packaged very nearby and quickly. Ideally, the packaging area should have some air-conditioning. The Seed Processing Area would be appropriate as a working area if the seed cleaning (and hence the

dust and potential contaminants) were to be moved to a converted office across the corridor (see Seed Cleaning, above).

The foil bags currently used are of inferior quality and appear unsuitable for long-term storage. *An alternative heavier duty type of foil bag as used by some other large banks is recommended (Table 5 – item 23).* Although NPGRC has two foil bag sealers, only one is classified as being in good condition. *The purchase of a heavy duty and reliable bag sealer of a type used for many years by the Millennium Seed Bank in the UK is recommended (Table 5 – item 22).* The dwell-time for bag sealing must be calibrated to ensure that a bag sealed full of air when put under pressure (e.g., stamping by foot) splits away from the sealed edge. It is also essential that bags have a label on the inside as well as being marked externally.

Seed number determination

Currently, the seed number is not determined for monitoring seed quantity as indicated in the baseline performance assessment (Table 3). A new process needs to be established to monitor the number of seed available and conserved. This will require that a sample of seeds with a known number, usually 100 or 250 or 1000 seed depending upon the seed size, be weighted to establish a known number of seed per gram. This needs to be recorded in the seedbank management database and used as part of a new process for monitoring seed quantity for multiplication and regeneration. This is a significant backlog in a routine operation that needs to be addressed.

When an accession is introduced, the seed lot is split between a base pack that will be stored for the long term and a distribution pack that will be used for meeting distribution request and for multiplication. There can be one or more distribution packs, depending upon the quantity of seed. The quantity of the seed in the distribution pack is only monitored visually when seed is taken out for distribution. If the quantity is very low, then the accession is scheduled for regeneration. *This is not a very secure or efficient approach for monitoring, so the reviewers suggest that the weight for both the base and distribution packs be taken and documented in a seedbank management database.*

Recommendation 9: The reviewers recommend the adoption of a process to determine and monitor the number of seeds available per accession (e.g. systematically document baseline packet weights, distribution packet weights, and 100/1000 seed weights) to ensure that acceptable thresholds are maintained.

The seedbank currently has one new Elmor Seed Counter and several balances that could be used for packet weight and seed number determination. *The current equipment is adequate to fully implement a new process for determination of packet weights and seed number but there appears to be no routine calibration of the bank's equipment. This needs to change and the seed counter is a priority for regular calibration.*

Seed storage

NPGRC have adopted a storage system using domestic deep-freeze units as widely used by genebanks in the SADC region. They now have 32 deep-freezers and while a single cold storage room would be a more efficient approach given the volume, to convert now would be an expensive process and is probably unwarranted. Most of the freezers are Bosch and of varying ages (number and year of purchase): 17 (<2000), 4 (2004), 1 (2003), 10 (2015), 1 (2016), 1 (2018), 2 (2019) and 4 (unknown). According to NPGRC, of the eight that are chest deep freezers, five are among the oldest, while three were procured around 2011. Currently, there are 14 freezers that are less than five years old. All packs are put together in the same freezer for storage. This is a very risky strategy since the breakdown of a single freezer could significantly reduce the viability of all the seed for any accession. It is urgent to take actions to reduce this risk.

Recommendation 10: The reviewers recommend, as a priority, that the base pack of the most original seed lot for all the accessions be relocated into a base collection and conserved in freezers dedicated for long term storage, where the temperature can

be maintained in a constant and optimal range with minimal disturbance. Newly regenerated material should also be stored in base collection freezers. All the distribution packs should be stored in different freezers.

They also report that the two newest freezers are currently empty and there is the equivalent space of about a further two within the other freezers, i.e., a total space equivalent to four freezers. A stepwise process of replacing the oldest freezers should take place probably starting with the chest deep freezers. This will free up extra storage space allowing two (or more) upright deep-freezers in the space previously occupied by each chest deep-freezer. Upright freezers currently can hold 175 accessions compared to 250 in the chest ones. Replacing all eight chest deep freezers would therefore increase storage capacity by at least 800 accessions. Additionally, the room probably has the capability to hold at least four other upright freezers (a further 700 accessions) by closing up the space between existing upright freezers. This extra capacity should future-proof the bank for the next decade. If further expansion space is required at a later date, consideration should be given to converting the adjacent documentation area/computer room.

To allow a gradual turn-over (and thus not create one big replacement expense when eventually they in turn need to be replaced), it is recommended that this project purchases six upright deep-freezers in year 1 (Table 5 – item 24). The bank should then aim to cover the costs of replacing a further twelve with the following four years. *With more deep-freeze units required, the adequacy of the electrical circuitry in the building needs to be checked (Table 5 – item 3).* This is discussed further in the Building sub-section below. The estimated cost for any renovation of the circuitry is accounted for in Table 5 – *item 25*.

With so many deep freezers throwing out heat, it is essential that the Seed Storage Room has sufficient air-conditioning. The safety of the collection is dependent upon the functioning of the air-conditioners; too high a room temperature and the freezers will struggle to lose heat. *Because of this, it is recommended that spare air-conditioning capacity is provided for the room (Table 5 – items 2 and 9) and the room should be supplied with a high temperature alarm linked to an external sounder (Table 5 – item 10). In addition, a log should be kept recording the daily inspection to check for freezers failing to hold their -20°C temperature.*

Seed health testing

None of the accessions have known seed health status (Table 3). NPGRC does not have the capacity nor an established process for seed health testing. Seed-borne viruses/other diseases and pests can reduce seed longevity and increase the risk of loss of an accession when grown for regeneration. These are a risk to the genetic integrity of the accession. NPGRC also risks the distribution of disease through the seed to areas where it does not currently occur. Assessing the seed for all possible viruses or other diseases is not a feasible option so it will be necessary to develop a protocol to check if the seed is free from a few key known seed-borne pathogens/viruses/insects. This can be done with a limited checklist for field inspection and then seed inspection if needed. This will establish a protocol to monitor the incidence of pathogenic diseases and pests at regeneration and multiplication sites including field genebanks.

The reviewers recommend that a Seed Health Specialist consultancy to provide technical support on seed and plant health (Table 4- item 43) with the term of reference that includes: to establish seed health testing protocols: develop a handbook for the identification of key pathogens and pests of the crops in the collections: and provide capacity building with follow-up technical support on-site to institutionalize these processes.

The seedbank lacks an equipped seed testing laboratory for seed health testing. For the longer term, the seedbank will need to have a partnership with a lab with basic equipment for detecting the key pathogens and to initiate the screening of the plants in the field genebank and the seed for key viruses. This service could be supplied by the plant pathology laboratory in Zambia Agricultural Research Institute (ZARI). A very extensive list of equipment and chemicals needed by them to accommodate seed health testing was provided to the reviewers but no allocation is being recommended from this review. The seed

health specialist will advise on the need for any longer-term investment in the upgrade of the ZARI lab if it is to be used.

Distribution

In the last five years a total of 308 seed samples (53 within the institute, and 255 elsewhere in country) (Table 6) have been distributed nationally on request. In addition, 283 seed samples were distributed internationally. If each seed sample sent were a different accession, then only 9% of the overall accessions have been shared with users in the last five years. The proportion that have been distributed will be much less since there are likely to only be a few accessions which were distributed. Only seed has been distributed nationally or internationally. The main users nationally have been farmers (61%), researchers and breeders. Internationally, the main users have been other seedbank curators but there have been distributions to the seed industry and researchers. Clearly the level and breadth of use is inadequate if the national seedbank is to meet its key objectives in terms of contribution to agricultural development and food security as well as to the global system of conservation and use.

Table 6. Number of accessions distribute annually (2014-2019)

Recipients	**2014**	**2015**	**2016**	**2017**	**2018**
Within ZARI	11	13	9	3	17
Within Zambia (outside ZARI)	63	88	60	22	43
Outside Zambia	15	0	116	67	85

The low level of distribution is not surprising given the low knowledge users have of the composition of the collection, the limited access users have to accession level information, and the lack of characterization or evaluation data. The feedback from the seedbank staff and users was that most requests were for accessions for repatriation to farmers or for a general trait like drought tolerance. The identification of the accession to be sent was mainly determined by the seedbank staff. In some cases, for the national distributions, farmers or NGO's either requested accessions by coming to the seedbank directly or from the seedbank staff during attendance at agricultural shows. The recipients picked up the seed from the seedbank also.

The international users that the reviewers talked to also described the difficulty in getting information on the accessions they held and the length of time it took to actually receive the seed. Generally, seedbank staff have little experience with international users. International distributions are a challenge due to the need for additional packaging, phytosanitary permits, and shipping cost. The reviewers recommend that the seedbank establish clearer, more transparent protocols to meet distribution requests by both national and international users.

Recommendation 11: The reviewers recommend that NPGRC deploy a routine formal process for soliciting and using feedback from recipients to improve the use of the collection and seedbank operations with actions such as:

- **Conduct routine user surveys on the use of the collections, delivery timelines, quality of seed received and other useful information.**
- **Fully implement DOI to better link to information generated on the accessions. The seed sample for each accession at SPGRC is still the original seed from NPGRC. Thus, DOIs assigned to SPGRC for NPGRC should be the ones given for the accessions in Genesys rather than the ones that have currently been given to SPGRC.**
- **Develop a procedure for ensuring that information on the evaluation and use of the distributed germplasm is shared with the seedbank to enrich the accession level databases.**

Preparing samples for distribution or regeneration/multiplication would best be carried out in a room dedicated to packaging (see Seed Packaging, above). *Provision of some heavy-duty scales would prove useful in the dispatch of larger packages (Table 5 – item 18).*

Regeneration, multiplication, and characterization

Currently they have focused on multiplication to increase seed supply for distribution not to address any loss in seed viability. The accession is identified for multiplication when the quantity of samples in the distribution packets are reduced to two or three. The seed produced through multiplication is used to fill seed distribution packs but not to replace the basic seed pack. The base seed packs have not been regenerated. Thus, they have only done multiplication to increase seed for distribution and only 12% (754 accessions) have been multiplied in the last five years (Table 3). Consequently, they have routinely been multiplying slightly more than 100 accessions per year.

In the baseline survey, NPGRC indicated that regeneration has been planned for every 10 years to secure long-term conservation, but this has not been done. For the Annex 1 crops, 13% of the accessions are from original seed acquired in the 1980s and 50% are from 1990 collections. These are still the original seed lots stored in large bulk-packs. If the 2870 of the oldest accessions are taken as high priority for regeneration, at their current rate of 100 accessions per year, it will take nearly 30 years to regenerate them. There is thus a significant backlog in regeneration that will require regeneration of at least 600 accessions per year to address in the next 10 years. This will require a reconsideration of the site for regeneration, the methods for regeneration, and the proper handling of seeds through the seedbank. Regeneration will require improved processes to maintain the genetic integrity of the accession through secure field operations, better management of accession identity, pollination control, more standard operations for seed handing from field to seedbank with more efficient operations for cleaning, drying, and short-term storage, greater scheduling of drying and more secure monitoring.

Currently they can access field space for multiplication from three sub-stations, one in each agroecological zone. The field operations are managed by the station staff and using the station's equipment. The seedbank staff come to supervise the planting and return periodically to monitor the plots. Technical staff at the station manage the plots as needed. They will need to identify reliable field sites with irrigation where the seedbank staff can actively manage the field operation and the harvest.

They have access to the Nanga Research Station that has irrigation facilities installed but the station is a four-hour drive from Lusaka where it is essentially used for research on vegetables. The Nanga Research Station has issues with the distance from the seedbank, although there are facilities for seedbank staff to stay at the station during the season. The research farm is equipped with a pumping station with an electric generator drawing water from the River Kafue. The holding reservoirs are in dire need of rehabilitation. They also have a significant need for replacement of old pipes. Despite these constraints, it is still a good site for vegetable crop accession regeneration and characterization even in its current state and the station staff are very familiar with these crops. *The reviewers recommend that the renovation of the irrigation system at the Nanga station be undertaken as given in Table 5 – item 29*.

There is also limited space for regeneration at the ZARI HQ site, but the reviewers suggest they could solicit help from the breeding programs, especially for maize or sorghum. There are also a number of possible options to collaborate with other research organization that have field sites very near Lusaka. For example, SPGRC has 25 ha of irrigated fields that are under-utilized. This is land that was donated by ZARI to the regional seedbank. All of these sites are within Lusaka and offer the opportunity for seedbank staff to actively engagement in operations and management. It would also offer opportunities to hold field visits with ZARI scientists, university staff and students, as well as farmers and politicians to view the wide diversity of very important crops in Zambia.

Currently during multiplication, NPGRC do control crosspollination for crops such as maize and sorghum but they will need supplies of bags for the increased number of accessions to regenerate. They will need to construct isolation cages to control insect pollination but that

could be done locally. *The reviewers recommend that NPGRC contact ICRISAT in Kenya to get plans and gain help building mobile regeneration screen houses (Table 5 – item 28).*

Recommendation 12: The reviewers recommend that NPGRC develop and implement a realistic five-year plan to securely regenerate at least 600 accessions per year, giving priority to those that were collected in the 1980s and 1990s. Priorities for regeneration should be based on new data made available from seed viability tests and the seed counts carried out by NPGRC. While this data is being generated, NPGRC should use the viability test results from SPGRC to prioritize accessions for regeneration that are below acceptable viability and seed number thresholds. NPGRC should also engage with SPGRC and other local research organizations for help to address the regeneration backlog.

During regeneration they need to incorporate characterization in order to fill a significant gap in the knowledge available about the accessions. Although the current characterization data includes the full set of IPGRI descriptors, feedback from users indicates that there is a need to have more information available on the accessions that has relevance to the needs of germplasm users. The reviewers recommend that the seedbank collaborates with user groups to identify a set of minimal descriptors to be taken for key traits. This will reduce the effort required to characterize all accessions and also increase the usefulness of this accession level information. To enhance the characterization of the accessions, they should continue to develop collaborative arrangements with universities to encourage more graduate students to characterize and evaluate collections using molecular techniques as well. *The reviewers recommend that these collaborative arrangements include a data-sharing agreement so that the data generated in the study comes back to the seedbank to be shared with all subsequent users.*

Field genebank

One hundred cassava accessions are maintained in a field collection (Table 3), but they lack irrigation to sustain the collection during dry spells. They have already lost the entire collection of sweet potato and a local root crop, Livingston potato, to drought. All of these were accessions collected from Zambia that are not conserved in other institutes globally. In the longer term, there is also a need to fill a gap in the secure *ex situ* conservation for yams, *Musa* and other key vegetatively propagated crops in Zambia.

The cassava field collection is being threatened with the build-up of viruses with the continuous replanting using the current plants from this single site. They do not have the capacity for *in vitro* conservation to clean the accessions and provide safety back-up for the field seedbank. One option discussed during the site visit was to utilize the ZARI tissue culture facility, which is open for any staff to use for research purposes, to initiate a new process for introducing accessions into tissue culture, cleaning the accessions, and conserving in slow growth media. Expertise exists at IITA so they should be engaged in assisting in the establishment of *in vitro* processes and capacity building as needed. Another option will be to develop a partnership with IITA or others in the region to secure these *in vitro* services as well as cryopreservation for long-term conservation of these crops. ZARI needs to consider the options and develop a long-term approach for both conservation and use of these crops.

Recommendation 13: Urgently, the reviewers recommend that the current cassava collection in the field be secured with irrigation and safety duplicated with a CGIAR genebank. Collecting missions should be undertaken to reconstitute the local sweet potato landraces accessions that were lost.

For the longer term, there is a need to adopt a process to ensure the maintenance and health of field collections with safety duplication at a CGIAR or another international genebank.

Documentation

In 2017, the genebank suffered a theft of all computers, and the server that hosted the SADC Documentation and Information System (SDIS). Since then, the seedbank has had to rely on staff-owned computers for data entry and on SPGRC for any update of passport and inventory information in their databases of SDIS. The computers and server have been replaced but the server is still not operating. In order to prevent any future thefts, the Documentation room where the equipment is stored has been secured but the building security also needs to be increased as discussed in the next section. To further reduce the risk of theft, any mobile computers, printers and readers should be stored in a reinforced cupboard. Given the importance of the documentation system, the reviewers recommend that risk mitigation measures need to be identified, implemented, and monitored to prevent the situation in which the genebank was unable to use its information management system for two years.

In 2015, NPGRC initiated the use of the SDIS, which was developed by the SADC Plant Genetic Resources Centre. SDIS is a web-based software that acts as a client-server system, the central module is hosted by SPGRC and collects all the information inputted by the countries. Each country manages its own information which is transmitted to the central node. This means that the server in NPGRC needs internet access in order to upload or enter data directly to the SPGRC node, effectively creating a second level backup. In the database, each national seedbank, such as NPGRC, has a national page that is solely managed and accessed by them. The SDIS administrator in SPGRC is the only one with any other authorized access. This software features modules for germplasm registration, genebank management information system, collecting missions, distribution management, passport and characterization data. The type of information recorded in SDIS, and its format, has been established through consultation with the national seedbanks.

The SDIS software was chosen to be the main tool to be used for managing information in NPGRC. So, while some of the elements of the SDIS database have been populated with data, such as passport, it is still not fully utilized by NPGRC. They now have to provide the Excel sheets to SPGRC for input into the system due to the lack of adequate internet. It is not searchable internally or externally to meet distribution requests, monitor seedbank operations, or facilitate management of the accessions.

Currently, they manage accession identity through the tag from the multiplication plot that is transferred with the seed lot through the processes to the final aluminum pack. The accession number is also written on the outside of the bag or packet. Currently, distribution and base packs are identified inside and outside by accession number and date, when the packets are sealed. This information is manually written using a marker felt pen. Location of accessions in the freezers is written by hand on inventory sheets and then entered into an Excel sheet. This is an error prone procedure and interpreting handwriting can become an issue. *The reviewers recommend the seedbank adopt a barcoding system with the purchase of five barcode readers, two portable barcode printers, and one fixed barcode printer (Table 5 – items 38, 39, and 40).* This would allow the use of resin thermal transfer labels that can be used on the exterior and interior of the accession bags and also used in field operations. Labels and their adhesive must be capable of withstanding prolonged low temperature and the ink must not fade through time. The barcode solution should prevent eventual errors and allow operators to read much more information from the sticker, without the need to query the database.

The server has already been made available to the genebank for documentation purposes. *The reviewers recommend that four workstations, along with monitors and uninterrupted power supply for each, be procured (Table 5 – items 30, 31, 32, and 33) to replace the staff-owned personal computers currently in use.* Workstations were chosen over laptops because they cost less and are less prone to theft.

To fully implement the seedbank information system, it will be necessary to create a local area network in which all the computers are connected together and with the server which should host SDIS and act as a common back-up. The LAN can be created a Wi-Fi network. *The reviewers recommend that a network router (Table 5 – item 34) with a Wi-Fi range that*

is powerful enough to cover a large area and connect all the required equipment. The important aspect of the LAN is that the server should be accessible by all data entry workstations in order to handle the two years backlog of information and allowing several concurrent data entry sources available to SDIS.

In the last two years, documentation and management of germplasm has been carried out using paper forms and Excel sheets, creating a considerable backlog of information that still needs to be digitized. All accessions had their passport data transferred from their collection forms into SDIS, and about 51% of them also have been characterized, however, none of this data has been entered either into Excel or in any database. There is a need to transfer all paper stored characterization data into SDIS.

Recommendation 14: There is a backlog of information stored on paper that needs to be digitized, but this must not be done at the expense of the other high priority routine operations, so the reviewers recommend that temporary staff be hired and dedicated to digitization activities.

Electronic tablets could be a good solution to replace paper forms. This would cut the transcribing step and result in less errors, speeding considerably the time needed between data acquisition and transcription into the database. The other advantage would be that workstations would not be needed for all data entry, allowing these to be used for reducing the data entry backlog. *The reviewers recommend the purchase and use of three tablets (Table 5 – items 36 and 37). The reviewers also recommend that a camera be purchased to allow for the greater incorporation of images into the accession level information (Table 5 – item 42).*

Currently, only the data in SPGRC is backed up: a safe backup strategy is required. The server should act, in the first place, as a file server, storing and sharing all the Excel sheets and files comprising the current management data. Later as the server host SDIS or GRIN-Global, so it will contain the live working database. *To enhance the security of the documentation system, the reviewers recommend the procurement of two rugged mobile hard drives (Table 5 – item 35) to store the contents of the server, enabling a full restore in the case of a failure.* The SDIS data will also be centralized in the SPGRC server, becoming a second level backup.

Recommendation 15: The reviewers recommend that all efforts are made by ZARI to enhance internet connectivity at the genebank to the server to allow for the full implementation of SDIS or other seedbank information systems such as GRIN-Global.

SDIS is not the only genebank management system available, there is GRIN-Global, a management system that also handles all aspects of germplasm information management. The reason the reviewers favor the continued use of SDIS is that the staff are already familiar with the software and that the organization responsible for the development of that software is located in the same city, Lusaka.

As soon as possible, the reviewers recommend a Seedbank Information System Specialist consultancy (Table 5- item 44) to work directly with staff in the seedbank to fully implement SDIS, or another system such as GRIN-Global, with the appropriate workflows and procedures established for more secure and effective management of routine operations. A final decision on the most appropriate seedbank information system can be made once the workflow is clear and the fit for either system can be assessed. The terms of reference for the Seedbank Information System Specialist consultancy would be essentially to guide current staff in rationalizing the activities, to correct or add eventual missing steps and to translate this into a workflow that integrates with the features of SDIS or GRIN-Global. The expert's experience in implementing that system should be tapped, so that the correct modules are covered in the right order, while the staff are trained on the tool using the actual data in the actual environment.

The expert must initially visit the seedbank and, in collaboration with the staff, analyze and implement all the steps necessary to standardize processes with the required documentation elements and procedures. The work of the expert will improve the current documentation

practices, enhance the capacity of the staff to utilize documentation software, and essentially establish a solid foundation for the management system that later will be installed and implemented. It is key that the expert work with the staff in the seedbank, operating in the same environment and conditions, guiding the staff as they implement new procedures and perform their daily tasks. This phase should precede the installation of SDIS and be undertaken with the *existing means* (paper and Excel sheets).

Once the management stages have been established, there is the need to install and implement SDIS or GRIN-Global for these seedbank management modules. The expert would work with the staff in the seedbank to implement the workflow into the software until SDIS or GRIN-Global is operational and running. This will require being available as a long distance 'help desk' for staff as well. The expert may need to work with the documentation specialist to organize the four workstations and the server into a local area network. It will also be necessary to fully accommodate bar coding and labelling on the SDIS system through collaboration with SPGRC or with GRIN-Global in collaboration with other international seedbanks which have adopted it.

Buildings including safety, security and services

In order to provide and expand the conditions necessary for some operations, NPGRC will need to consider re-assigning some space currently used for clerical work. Staff and collection safety need to be carefully reviewed and measures taken. The main building appears to be basically sound and is visited at night by a security patrol but due to an incomplete fence around the compound, theft continues to be a potential risk. Following earlier break-ins and theft of computer equipment, the windows are barred and the second exit at the back of the building has been blocked. This has now made any emergency exit only from a single external door in the front and this is a major safety risk. *The lock on the main entrance also needs to be improved (Table 5 – item 26).* The reviewers recommend that urgent attention needs to be paid to providing a secondary, well-marked, means of escape through a door openable only from the inside using a push-bar, i.e., not locked with keys. (Table 5 – *item 25*).

Furthermore, there are no alarms of any kind. *Consequently, provision of alarms covering smoke, rises in room temperature / humidity and intruders are required. Additionally, these need to be linked to external sounders audible to security (Table 5 – items 4, 10 and 12).*

The nearest fire station is 20 km away. Therefore, tackling any fire (if safe to do so) needs to be done locally by staff and security. Currently, there is only one fire extinguisher*. The reviewers recommend that sufficient fire-fighting equipment of appropriate type to deal with electrical and other fires needs to be provided (Table 5 – item 27) and staff and security trained accordingly. The reviewers recommend that a fire alarm consultancy (Table 5- item 4) with the term of reference to provide written specialist advice on the provision of fire alarms and external sounders as well as the required maintenance schedule.* It may be possible to combine this with the refrigeration and air-conditioning consultancy.

The electricity supply to the building is underwritten by a 16-year-old generator considered to be in good condition*. Unfortunately, the battery related to the automatic switch-over from the mains is faulty. This needs to be replaced (Table 5 – items 3 and 11).* Currently, the generator is only serviced when it breaks down. With so much of the bank dependent upon electricity, a regular maintenance regime needs to be instituted. Similarly, a set of spare parts should be held on site.

The reviewers recommend a generator and electrical consultancy (Table 5- item 3) to provide written specialist advice on:

- The status of the existing 2003 generator and the auto switch-over mechanism.
- The required maintenance schedule and stock of spare parts that should be held on site.
- The adequacy of the electrical circuitry in the building to accommodate more deep-freeze units and extra lighting for the germination room.

It may be possible to combine this with the refrigeration and air-conditioning consultancy.

As part of the development of a QMS, NPGRC needs to carry out a full analysis of the risks both to staff and the collection carefully considering the likelihood of events occurring (and pairs of events) and the potential severity of their effects. They then need to put measures in place to mitigate against these risks.

The facility has no power obtained from alternative sources, such as solar panels. With a costly and intermittent electricity supply in Zambia into the foreseeable future as well as the high cost of fuel for the generator, a longer-term aim should be to mitigate this risk for long-term conservation with increased energy efficiency and meeting a significant portion of their energy needs from electricity provided from solar or other alternate sources.

In the short term, the reviewers recommend that energy efficiency is considered in all equipment purchases. To facilitate this shift to energy efficiency and alternative energy sources, the reviewers suggest that a solar energy consultancy be done (Table 5- item 45) with the task of conducting an energy audit, recommend investment into energy efficiency and an alternative energy option with the full cost as well as provider. It is thought that there was local expertise available given the significant investments being made in solar energy options for companies and households in Lusaka.

Table 5. List of recommended infrastructure, equipment, supplies, and services to procure in upgrade. (Table excludes most consumables.)

Item	Proposed purchase	Potential supplier	Est. item cost (Euro[2])	No. items	Est. shipping & import cost (Euro)	Total cost (Euro)	Comment
1. Germination Room	Room conversion	(a) Local	2,000	-	-	2,000	Including benches
2. Refrigeration and air-conditioning consultancy[3]		(a) Club Refrigeration, RSA (though uncertain about generator and alarms) (b) Various potential RSA Refrigeration companies online	8,500	-	-	8,500	Assume return scheduled SAA flight RSA to Zambia = GB£ 461 = Euro 512; travel in-country = Euro 100; per diems x 4 nights = Euro 150 x 4 = 600; consultancy charges = Euro 1,000 per day x 7 days = 7,000. Total = Euro 8,212 say 8,500. Could visit other banks as well – one contract (more cost-effective)
3. Generator and electrical consultancy		(a) Local	500	-	-	500	Potentially *may* be coverable by Refrigeration and air-conditioning consultancy

[2] Exchange rate assumptions: Euro 1 = US$ 1.11; Euro 1 = GB£ 0.86; Euro 1 = CDN$ 1.45

[3] Some of economies of scale may be possible if some items will be purchased for all five banks.

Item	Proposed purchase	Potential supplier	Est. item cost (Euro[2])	No. items	Est. shipping & import cost (Euro)	Total cost (Euro)	Comment
4. Fire alarm consultancy		(a) Local	500	-	-	500	Potentially *may* be coverable by Refrigeration and air-conditioning consultancy
5. Installation costs of following 6 items		(a) Club Refrigeration (b) Various potential Refrigeration companies in RSA	100,000	-	-	100,000	Notional sum including shipment of items
6. Munters unit	Model TBC (small model – presumed like-for-like)	(a) Club Refrigeration, RSA (b) Munters RSA	5,000	1	-	5,000	Dryer looks in good condition in photo. Notional sum included for replacement. Depends on advice received
7. Insulated Drying Room structure		(a) Club Refrigeration, RSA (b) Various potential Refrigeration companies in RSA	100,000			100,000	Depends on advice received
8. Dryer panel	Model TBC	(a) Club Refrigeration, RSA (b) Various potential Refrigeration companies in RSA	1,000	1	-	1,000	Notional sum shown. Depends on advice received
9. Air-conditioners	Model TBC	(a) Club Refrigeration, RSA (b) Local	**1,500**[4]	3	-/Local	**4,500**	Depends on advice received. Local purchase

[4] Figures in bold have greater degree of certainty.

Item	Proposed purchase	Potential supplier	Est. item cost (Euro[2])	No. items	Est. shipping & import cost (Euro)	Total cost (Euro)	Comment
10. 'Outside of condition' alarms and sounders for Drying Room and Seed Store	Model TBC	(a) Club Refrigeration, RSA (b) Various potential Refrigeration companies in RSA	500	-	-	500	
11. Generator auto switch-over	Model TBC	(a) Local (b) Club Refrigeration, RSA?	1,000	1	-	1,000	Notional sum shown. Depends on advice received
12. Fire / smoke alarms and sounders	Model TBC	(a) Local	500	-	-/Local	500	Depends on advice received. Local supplier
13. Water purification unit	E.g., SLS Lab Pro 20T3 PurA-Q3 Reverse Osmosis + 35l storage	(a) SLS, UK (b) Try VWR / Avantor (but for different model)	**4,000**	1	1,000	5,000	Requires given water flow and pipe fittings. Also electricity supply.
14. Stereomicroscope	Nikon SMZ445	(a) Nikon Instruments Europe BV, NL (b) Try VWR / Avantor	**1,000**	1	250	1,250	May require light source within stand
15. Aspirator	Agriculex CB1 Oregon Seed Blower	(a) Agriculex, Canada (b) Hoffman, USA	**3,500**	1	1,000	4,500	Export to Africa? Do they require the CB-3 for larger seeds? Hoffman machine is cheaper at US$1,950
16. Sieves	Endecott	(a) SLS, UK (b) Endecotts, UK (RSA distributor)	**100**	10	1,000	2,000	Sieve dimensions / pore size to be advised
17. Face masks	Model TBC	(a) 3M, UK (b) Local	30	20	200	800	Preferably re-usable half masks with replaceable filters

Item	Proposed purchase	Potential supplier	Est. item cost (Euro[2])	No. items	Est. shipping & import cost (Euro)	Total cost (Euro)	Comment
18. Heavy-duty scales	Model TBC	(a) Local	**750**	1	Local	750	Assume local purchase
19. RH / Temperature logger	Gemini Tiny Tag View 2 TV-4500	(a) Gemini Data Loggers, UK (RSA distributor) (b) tbc	**200**	1	50	250	
20. Stackable crates	E.g., 600x400x154 ventilated HDPE	(a) Schoeller Allibert, NL (b) Local or regional supplier?	**15**	50	200	950	Freight may be prohibitively expensive and >>Euro 200 given quantity
21. Trollies for crates	600x400	(a) Schoeller Allibert, NL (b) Local or regional supplier?	**45**	5	150	375	Similar comments to above
22. Foil bag sealer	HM305CTD	(a) Hulme Martin, UK (b) ?	**1,250**	1	250	1,500	Do they export? 10.7 kg DHL cost (up to 12 kg) £139
23. Foil bags	7k each of 105x150 mm 150x210 mm Type 321/04 (Moore & Buckle)	(a) Moore & Buckle, UK (b) ?	4,000	-	500	4,500	Notional
24. Upright deep-freezers	Bosch	(a) Local	**900**	6	Local	**5,400**	Institute has recently purchased 2 Bosch freezers locally at US $1k each.
25. Building and electrical work	Extra doors – need secondary exit to building and changed access to Seed Store. Extra circuitry work for building.	(a) Local	3,000	-	Local	3,000	Notional
26. Security locks	TBC	(a) Local	1,000	-	Local	1,000	Notional

Item	Proposed purchase	Potential supplier	Est. item cost (Euro[2])	No. items	Est. shipping & import cost (Euro)	Total cost (Euro)	Comment
27. Fire extinguishers	TBC	(a) Local or regional supplier	100	4	Local	400	
28. Isolation cages	Locally built	(a) Local	1,000	-	Local	1,000	Notional
29. Irrigation equipment	TBC	(a) Local?	**60,500**	-	Local	60,500	Ref email from Graybill – irrigation for Nanga regeneration site (US$67k). Assume local purchase
30. Workstation	Dell Vostro Desktop 3471 Intel Core i7-9700 8Cores/8Threads 4.7GHz 12MB Cache 8 GB DDR4 2,666 MHz RAM 1 TB 7200 U/min HD		620	2		1,240	Data entry and application hosting workstations (Excel, Access, and other office applications); also potential servers. Minimal configuration: I7 Processor, 8GB RAM, and 1TB HD

Item	Proposed purchase	Potential supplier	Est. item cost (Euro[2])	No. items	Est. shipping & import cost (Euro)	Total cost (Euro)	Comment
31.Workstation	Dell Vostro Desktop 3670 MT Intel Core i5-9400 8Cores/8Threads 4.1GHz 8 GB DDR4 2,666 MHz RAM 1 TB 7200 U/min HD		500	2		1,000	Data entry and application hosting workstations (Excel, Access, and other office applications). Minimal configuration: I7 Processor 8GB RAM 1TB HD The alternative could be 2 laptops, but they would be more expensive and a risk for theft.
32.Monitor	Dell 24 Monitor		100	4		400	Monitors for workstations.
33.Uninterrupted power supply	Eaton Ellipse ECO 800 USB UPS AC 9230 V (500W)		150	4		600	To power workstations during electricity outages. Should handle at least 500W.

Item	Proposed purchase	Potential supplier	Est. item cost (Euro[2])	No. items	Est. shipping & import cost (Euro)	Total cost (Euro)	Comment
34.Router	Nighthawk X4S AC2600 WiFi VDSL/ADSL Modem Router		330	1		330	Local Area Network router. The important feature is that it has a long communication range. A cable based LAN is also an option, but it might be costlier and less flexible as a solution.
35.Backup Hard Drives	Silicon Power Armor A60 IPX4 Shockproof/Waterproof 2.5 USB 3.0 Military Grade Portable Hard Drive – 2TB.		120	2		240	What is important is that the model is rugged, it should be water and shock proof. At least 2TB of storage to be twice the size of the hard drive to back up.
36.Electronic tablet	Zebra TC75		3000	2		3,000	For use as mobile data input devices. These devices could be used when the genebank management system is operational, thus the model depends on the compatibility with the

Item	Proposed purchase	Potential supplier	Est. item cost (Euro[2])	No. items	Est. shipping & import cost (Euro)	Total cost (Euro)	Comment
							management software.
37.Electronic tablet	Zebra ET50		3500	1		3,500	For use as mobile data input devices with more complex input forms.
38.Barcode reader	Zebra Symbol LS2208		100	5		500	To be used to read barcoded labels.
39.Barcode portable printer	Zebra Series ZQ500		600	2		1,200	Use direct thermal printing for short term usage indoors.
40.Barcode printer	Zebra Series ZT410		1,200	1		1,200	Use thermal transfer resin labels for long term storage or field use.
41.Printer/Scanner	Brother DCP-L5500DN DCP A4 Mono		300	1		300	Multifunction monochrome laser printer. To print forms that will be filled, then transcribed on the computer, for scanning and archiving documents, for general printing necessities.
42.Camera	Nikon Coolpix W300 Digital Camera (16 MP, 5x Optical Zoom/7.6 cm (3 Inch) LCD Display, 4K UHD Video, Image Stabilization, GPS)		350	1		350	To use when collecting and characterizing, to add images to germplasm information.

Item	Proposed purchase	Potential supplier	Est. item cost (Euro[2])	No. items	Est. shipping & import cost (Euro)	Total cost (Euro)	Comment
43. Seed Health Specialist consultancy				1		16500	
44. Seedbank Information System Specialist consultancy				1		16500	
45. Solar energy consultant				1		3000	
Total						**382,035**	

Distribution, communication, and use of accessions and linkages with its users

Stakeholders and staff are interested in generating more information on the accessions and facilitating their use. Users do not fully appreciate the positive effect they could have if they were to more openly share information and research results with the seedbank. Users are willing to share data or results to help build up information on the accessions, but this was not solicited by the seedbank.

To better promote the use of the accessions with key local and national users as well as to address the apparent inadequacy in engaging with stakeholders, it is essential that NPGRC fosters an enabling environment to create stronger collaborations with users and other relevant national stakeholders. To address the limited use of accessions, NPGRC needs to take steps to increase the knowledge about the accessions being conserved and available for use nationally**.** For all users, the reviewers recommend that accession level information be published online and updated regularly in a searchable database on the seedbank website and/or Genesys as discussed in the section on the baseline indicators. In addition, the reviewers recommend greater efforts be made to increase national awareness of the seedbank and the accessions conserved through key actions such as:

- With support from Crop Trust, prepare a standard presentation on all aspects of the national collection conservation and use to be presented at various fora.
- Develop awareness materials and communication pathways tailored to different user groups including farmers/NGOs, seed producers at agroecological level; researchers and scientists; policy makers.
- Share information on accessions in both print and electronic media that is tailored more to the users' needs.
- Compile a list of key journalists to be contacted to write stories about the seedbank services and diversity available, for publication in local media.
- Prepare a calendar of agriculture-related events where the national seedbank can be presented, and its services and seeds showcased.
- Develop a mobile phone app that recommends seed material to users (e.g. farmers, NGOs, breeders) according to local agro-ecological conditions and availability.
- Ensure an online presence via social media, such as Facebook, Twitter and Instagram.

Effective collaboration with other conservers

Current collaboration with international stakeholders is only through SPGRC based in Lusaka. There are missed opportunities in not collaborating directly with other conservers such as the CGIAR seedbanks. It is highly desirable to initiate new partnerships with other conservers, especially CGIAR centers to enhance information exchange through a framework for mutual interactions and organizing learning exchange visits among the different seedbanks. The reviewers recommend that NPGRC engage more formally with the CGIAR centers and other national conservers that conserve accessions collected from Zambia to better secure conservation and to identify gaps for joint collection trips.

Engagement with stakeholders at local, national, and international levels in an effective manner

ZARI is involved in a number of partnerships with regional and international networks, including crop networks facilitated and supported by CGIAR centers such a CIAT, CIMMYT, IRRI, IITA and ICRISAT. The national seedbank is part of the SADC Plant Genetic Resources Centre (SPGRC) network. Zambia is a party to the ITPGRFA, having ratified in 2006, and actively participates in its deliberations and programs.

National users include researchers from ZARI, universities, and the private sector, as well as smallholder farmers. Seedbank staff view themselves as the intermediary between the smallholder farmers who have provided the seeds and research users. They do accept that

they have a role to meet farmers' requests for seed, but they perceive this as a secondary task. This results in a challenge when farmers or NGOs come to visit them or otherwise request seeds or information.

ZARI and seedbank staff do not fully appreciate the benefit of expanding their outreach to global users or stakeholders. They currently see these as a secondary priority. They would value these new opportunities more if they resulted in more projects and partnerships to generate accession-level information from evaluation or genotypic characterization. ZARI and the seedbank will need to resolve the challenges if there is a significant increase in demand by international stakeholders for access to seed and information.

We noted limited routine, audience-appropriate communications at the local and national level. Biodiversity fairs, local seed fairs, national and regional agricultural shows, field days and occasional on-station visits by groups or individuals are the main avenues used to promote accessions with a diversity of local and national users. Engagements with the various stakeholders such as researchers, breeders, universities, NGOs and farmers are generally *ad hoc*. Although, NGRC is integrated in ZARI we noted limited engagement with decision makers. These inadequacies limit national support, visibility and use of the collection.

There is no formal involvement of users in the activities of the seedbank, except for the annual meeting with all ZARI scientists. At least some users would be willing to provide feedback, and be more involved, but the staff of the seedbank have not done much to follow-up on this. Users want to know more about the accessions held in the seedbank and to be able to access information more readily. The staff recognize a need to promote the seedbank to farmers and researchers but not necessarily provide information on individual accessions. They have an interest to meet the objective to have greater use of the seedbank, but there is no clear communication strategy with users or other stakeholders.

To enhance the engagement of the seedbank with stakeholders at the national, international, and local levels, the reviewers recommend the development of a participatory and cost-effective communication strategy to facilitate dissemination of appropriate information suited to each users group.

- Enhance collaboration and engagement with national and international stakeholders, including the private sector and CGIAR centers that are located in Lusaka.
- Participate in regional events/shows related to plant genetic resources and climate change.
- Active engagement with regional and international plant genetic resources networks/platforms

Discussions with a limited number of users indicate that there are no formal mechanisms to solicit feedback although users were willing to provide feedback and it was indicated in the SMTAs and MTAs, where applicable. Non-research users indicate they had issues with the multiplication of the accessions received because they did not receive any information that would have helped them as farmers. Limitations in seedbank operations could lead to distribution of poor-quality seed with limited knowledge about the growth or use of the collections. Likewise, seedbank staff have not had an opportunity to take a more proactive role in facilitating information exchange by requesting feedback, research results and data. The seedbank is widely viewed, even by the staff themselves, as simply providing a service on request.

Recommendation 16: The reviewers recommend that NPGRC organize facilitated meetings at agro-ecological zone level (2-3) of representatives of farmers' organizations, NGOs, local government agencies, research institutions/universities based in the zones, and local seed producers (max. 40 participants per zone). In order to elevate the profile of the national seedbank and raise awareness on the importance of supporting it, the reviewers strongly recommend that ZARI holds at least two

facilitated high-level meetings with key policymakers during the implementation of the project.

The objective of the first meeting could be to:

- increase awareness about national seedbank and activities (e.g. the seed material adapted to the agro-ecological zone and available for distribution; process to request and obtain seed samples)
- identify farmers' "repatriation" needs
- identify crops and varieties of interest for multiplication
- identify opportunities for collaboration among the stakeholders
- identify mechanisms for registering farmers varieties
- identify collecting gaps (e.g. unique seed material available in farmers' fields but not yet conserved in the seedbank)
- articulate the information needs and feedback mechanisms for each agro-ecological zone
- agree on the *modus operandi* of each agro-ecological zone user group for information sharing and feedback.

Other key activities that should be considered include:

- Multiply/bulk seed of accessions of identified crop portfolios for distribution
- Conduct participatory multi-location (2-3 sites in each zone) trials to identify farmer-preferred and climate-smart accessions for direct use in the cropping system.
- With support from NGOs, organize field days to expose a larger number of farmers to diverse accessions
- Provide technical support in the registration of selected accessions for large scale use
- Provide technical support to development projects to enhance use of accessions and conservation services by smallholder farmers.
- Provide technical support to programs engaging farmers in participatory evaluation and multiplication of local landraces for direct use.
- Participate in any annual biodiversity fairs in each agroecological zone.
- Engage researchers at research stations or adjacent areas to review germplasm being regenerated at the stations.

As noted earlier, NPGRC needs to establish formal processes to obtain feedback on the use of the germplasm in the breeding programs and to increase collaboration with national agricultural research institutions and private seed companies in the country. It is also essential to institute a formal agreement with researchers to share results and data for inclusion in the database. The reviewers also recommend that NPGRC constitutes a Technical Working Group of researchers/scientists within the institute and universities for characterization, evaluation and use of collections in crop improvement.

We propose at least one annual meeting of this Technical Working Group to convene around 10-15 key researchers and scientists from national agricultural research institutes, universities and any other institution conducting plant breeding in the country. The objectives of this user-group should be to:

- obtain direct feedback on minimum traits that breeding users need to make decisions on seed material requests
- identify data needs
- identify candidate seed material of interest to breeders
- identify opportunities to create core collections
- to collaboratively introgress new genes in crop improvement
- coordinate participation in multi-location diversity and participatory plots
- identify opportunities for joint germplasm evaluations

- publish results from joint activities

Contribution to climate change adaptation and resilient seed systems

There is a recognition of the significant contribution of diverse national collections to enable adaptation to climate change and create resilient seed systems. There is increased interest by users in local germplasm adapted to drier conditions. The users were all very interested in using germplasm more effectively but lacked knowledge on the accessions to better target accessions. The NGOs and farmers also found the limited number of seeds they could receive from the seedbank hampered their evaluation of the accessions. Reduced crop diversity renders cropping and seed systems less resilient to climate change. The low level of knowledge and use of the collection is not conducive to long-term adaptation to the changes in climate.

Recommendation 17: To address the limited use of national collections to enhance crop diversity to mitigate the effects of climate change, we recommend that NPGRC and ZARI facilitate technical support in the evaluation, characterization, and multiplication of accessions of underutilized and climate-smart crops for direct use in the cropping system by the following actions:

- **Together with the Technical Working Group of researchers/scientists, identify a core collection of underutilized and climate smart crops (e.g. Bambara, finger millet, sorghum, popular vegetables landraces and some CWR) for use in crop improvement**
- **Multiply/bulk seed of selected accessions for distribution**
- **Together with scientists/researchers, conduct phenotypic/genotypic characterization for climate-smart traits**
- **With user groups, provide technical support in the evaluation of characterized accessions for climate-smart traits with researchers and NGOs that can then facilitate access to seed and knowledge to farmers.**
- **With researchers, undertake introgression and genetic enhancement with selected accessions to develop diversified populations**
- **Conduct participatory selection with farmers to identify preferred resilient varieties (medium-term)**
- **Seek the registration and seed multiplication of selected varieties**
- **With support from NGOs facilitate access to seed and knowledge to farmers (long-term).**

Comprehensive risk management

Currently, there is no formal risk assessment and management plan at NPGRC or at ZARI. Assessment and management of environmental, health, safety, and social risks at both ZARI and NPGRC levels is weak but the World Bank funded APPSA project did build some capacity in this respect. Two staff were trained as “safeguards”. In the annual planning meeting, the Zambia Environmental Management Agency contributes to the planning of institutional projects. The internal audit unit also works with this agency to monitor compliance. ZARI maintains records of incidents and compliance and does annual reports to the Zambia Environmental Management Agency. Internal audit also reports on this to ZARI’s director. There is no clear focal point for risk assessment, monitoring, and management at ZARI or NPGRC. Risk seems to be mainly managed at the project level if required by the donor or *ad hoc* if there are incidents.

The human resources unit organizes a meeting with staff when they join and as needed. They have staff manuals and booklets that are given to staff when they join. There was no visible communication with staff on social and environmental standards, such as posters, notice boards, or brochures. There seems to be little effort made to raise awareness among staff on risks and the steps needed to mitigate risks, except for fire. Formal risk assessment should include the status of implementation of regulations for the management of significant

environmental, safety, health, and social risk. ZARI should make every effort to fully mitigate against these risks as required. In particular, ZARI and NPGRC need to ensure that there is proper staff training regarding fire, fieldwork (including operation of machinery and chemical spraying) and seed processing operations (e.g. preventing inhalation of dust). Safety equipment needs are referred to in sections above. Staff trained should include the out-of-hours security staff.

It was noted that the seedbank facilities are vulnerable to a range of threats such as fire, freezer breakdown, unreliable power, theft, etc. A practical risk management plan to mitigate the primary risks needs to be developed as an urgent action. A number of the recommended actions are given in the previous discussions and was the basis for determining the priority upgrades. The review team has identified significant risk in Table 7 with level of risk before and after mitigation, suggested mitigation actions, likelihood of successful mitigation, and who is responsible for the risk management. These risks fall into a few key categories that are given in the Table 7. These are risks that are external to ZARI, NPGRC, and the seedbank. There are risks that are internal to the institute such as issues related to finance, administration, and policy. Finally, there are risks that are related to the facilities, routine operations of the seedbank and its links to users. The suggested mitigation actions have also been taken into account in the development of the upgrade recommendation by the reviewers.

Recommendation 18. The reviewers recommend that a detailed risk management matrix (such as Table 6) is agreed upon and used as the basis for monitoring risk for the seedbank on an annual basis with updates provided as needed by NPGRC to the Crop Trust.

Table 7. Risk Management Matrix

Source of risk	Level of risk	Mitigation actions	Level of risk after mitigation	Likelihood of successful mitigation	Responsibility for risk management
External to NPGRC					
Loss of crop diversity in farmers field and in the wild	Medium	· Long-term planning for collecting plant germplasm · Secure conservation of accessions ex situ	Low	Medium	Crop Trust and ZARI
Increased incidents of drought	High	· Access to irrigation in field seedbanks and in regeneration sites Enhance testing and use of accession with drought tolerant traits for researchers and farmers	Low	High	Crop Trust and ZARI
Inadequate electricity supply	High	· Greater investment into energy efficiency and alternative energy through projects and government support · Safety duplication of accessions to seedbank outside Zambia	Medium	High	Crop Trust and ZARI
High cost of fuel	High	· Greater investment into energy efficiency and alternative energy through projects and government support · Safety duplication of accessions to seedbank outside Zambia	Medium	High	Crop Trust and ZARI
Insecurity in Lusaka and in stations	High	· Fencing of the perimeter of seedbank complex · Increased movement of security staff around perimeter · Secure building with strong locks and/or keypad access · Use of secure SPGRC regeneration fields with irrigation · Access to irrigation and secure fields in ZARI sites	Low	Medium	Crop Trust, ZARI, and SPGRC
Institutional administration, finance, and policy					

Source of risk	Level of risk	Mitigation actions	Level of risk after mitigation	Likelihood of successful mitigation	Responsibility for risk management
Inadequate and inconsistent annual government spending for ZARI and seedbank	High	· Ensure government funding obligation in the Seeds for Resilience project agreement and any future agreement · Increase visibility for the seedbank and its annual funding needs to Ministry of Agriculture and Parliament	High	Medium	Crop Trust and ZARI
Poor planning for long-term support for crop conservation and uses within ZARI	High	Strategic planning for seedbank with 10-20 year plan for implementation with key performance indicators developed by ZARI with stakeholders	Medium	Medium	Crop Trust and ZARI
Unclear financial situation of ZARI and the seedbank within ZARI due to the absence of externally audited yearly financial statements	High	· Establish and publicly share external audits of financial statements for both ZARI and the seedbank on a yearly basis.	Medium	Medium	Ministry of Agriculture and Treasury
Inadequate internal monitoring of spending	Medium	· Quarterly financial monitoring and annual audit of account · Clear terms and conditions in project agreement on disbursement of funds and replenishment · Capacity building for ZARI accounts department at project initiation	Low	High	Crop Trust
Inadequate management of key assets of project	Medium	· Clear terms in project contract on management of assets procured, maintained, or repaired by project · Clear terms for donation of assets to seedbank within ZARI at end of project · Regular scheduled maintenance with record keeping in logbook · Repair when required in a timely fashion	Low	Medium	Crop Trust and ZARI
Bureaucratic procurement process	High	· Crop Trust to handle project procurement directly · Project agreement specifies custom clearance process for procurement, especially the payment of duties	Low	High	Crop Trust and ZARI

Source of risk	Level of risk	Mitigation actions	Level of risk after mitigation	Likelihood of successful mitigation	Responsibility for risk management
		· Procurement includes cost for shipping and custom clearance			
Inconsistent implementation and monitoring of compliance with environmental, human safety, and social risk according to government policy	Medium	· Risk management plan for seedbank with annual monitoring and updates	Low	Medium	Crop Trust, ZARI, and Government of Zambia
		· Clear documentation and implementation tools regarding compliance with operational (e.g., procurement, health and safety, etc.) and ethical (e.g., anti-terrorism, sexual harassment, financial irregularities, etc.) requirements utilized at ZARI and the seedbank level, including awareness raising among staff, defining ownership of reference documents, defining responsibilities, setting up processes to ensure compliance, defining ownership of these processes, ensuring annual reporting and updating			
		Restricted access to the cold rooms with keypad access			
Links to users					
Inadequate engagement with stakeholder for long-term support for crop conservation and uses	Medium	· Long-term plan (10-20 years) for crop seedbank with implementation monitored transparently by key users and stakeholders	Low	High	NPGRC, ZARI, and Crop Trust
		· Increased collaboration with other ZARI researchers, universities, NGOs, and private sector to link to smallholder farmers and communities			
		· Increased collaboration with communities to support conservation and promotion of genetic resources			
Inadequate communication on the seedbank, its accessions and any impacts to users and other key stakeholders	Medium	Communication strategy with implementation plan and key performance indicators	Low	High	Crop Trust and ZARI
Inadequate feedback to and from user	Medium	Establish formal process to solicit feedback from recipient of accessions	Low	High	ZARI

Source of risk	Level of risk	Mitigation actions	Level of risk after mitigation	Likelihood of successful mitigation	Responsibility for risk management
		Establish process to feedback value of accession back to the donors and users of germplasm			
		Monitoring the impact of the use of conserved accessions			
		Greater engagement with users through stakeholder meetings or through advisory group for the seedbank			
Inadequate accession level passport, characterization and evaluation information available and shared online	Medium	Recovery of data generated by accessions recipients	Low	Medium	ZARI
		Formal agreements with research recipients on sharing research results and data with seedbank for inclusion in seedbank information system			
		Collaboration with universities to increase opportunities for student projects Publishing accession level information on Genesys and updating as required			
NPGRC Facilities					
Freezer outage or breakdown	High	Maintain dedicated long-term conservation freezers for base packets of all accessions	Medium	High	ZARI and Crop Trust
		Maintain secure internal monitoring of freezer conditions			
		Maintain secure external monitoring of freezer condition with external alarms and sounders			
		Regular maintenance of freezers and air conditioners			
		Ensure adequate spare freezers for urgent replacement if needed			
		Ensure secure, safe power supply for freezers and air conditioners for 24 hours and 7 days a week.			
Fire	High	Adequate firefighting equipment	Medium	High	ZARI and CropTrust
		Internal and external alarms and sounders			
		Adequate fire safety training			

Source of risk	Level of risk	Mitigation actions	Level of risk after mitigation	Likelihood of successful mitigation	Responsibility for risk management
Theft and vandalism targeting ICT equipment, laboratory, conservation facilities, and seed samples	Medium	Increased security of building with external locks, alarms, and sounders	Low	High	ZARI and Crop Trust
		Restricted access to the seed store with keypad access			
Insecure long-term access to appropriate land resources for regeneration, multiplication, and other field related activities for the seedbank	High	· Ensure clear commitment by ZARI and other relevant governmental agencies to make available appropriate land resources for long-term use by seedbank	Medium	Medium	ZARI and Ministry of Agriculture
		· Provide sufficient resources to ZARI, its stations, and the seedbank to maintain land resources and ensure seedbank access for the long-term			
Routine Operations					
Inadequate staff numbers, capabilities, and planning for replacement	Medium	Strengthening the staff composition	Low	Medium	ZARI and Crop Trust
		On site capacity building and exchange visit to other key seedbanks			
		Staff succession planning for the replacement of key staff			
		Adequate remuneration to retain qualified staff			
Conservation and distribution of seed with unknown viability or germination potential	High	Upgrade facilities, equipment and processes to document seed germination routinely	Low	High	ZARI and Crop Trust
Conservation and distribution of seed with unknown seed health, especially for seed-borne diseases or virus.	High	Upgrade facilities, equipment, and processes to monitor and document the plant and seed health status routinely	Low	Medium	ZARI and Crop Trust
Inadequate monitoring of seed quantity	High	Upgrade facilities, equipment, and processes to document 100/1000 seed weight and packet weight	Low	High	ZARI and Crop Trust
		Initiate processes to document any change in seed quantity with distribution			
Loss or change in genetic integrity for accessions with poorly established and managed regeneration sites.	High	Implement standard operating procedures for regeneration for a range of mating types	Medium	High	ZARI and Crop Trust
		Develop five-year plan to regenerate at least 600 accessions per year securely			

Source of risk	Level of risk	Mitigation actions	Level of risk after mitigation	Likelihood of successful mitigation	Responsibility for risk management
		Upgrade irrigation facilities at field sites			
		Utilize isolation cages for insect pollinated accessions			
Inadequate safety duplication	High	Prioritize unique accessions by crop and arrange for safety duplication with institutions outside of Zambia to serve as a primary black box	Low	High	ZARI and Crop Trust
		Continue to dispatch seed to Svalbard to fill gaps for accessions that are not deposited through SPGRC			
Lack of management and monitoring of significant virus and disease issues of vegetatively propagated accessions	Medium	Initiate a long-term plan to utilize an *in vitro* conservation system to complement the field genebank for the secure conservation	Low	High	ZARI and Crop Trust
		Implement protocol to monitor for viruses in cassava collection in partnership with researcher in ZARI or at other organization			
Insecure and inefficient routine management of conservation of accessions	High	Upgrade facilities, equipment, documentation, and processes for key routine operations	Low	High	ZARI and Crop Trust
Lack of a secure, dedicated seedbank information system to manage accession identity, facilitate secure and cost-effective routine operations, and enhance access by users to accession level information	High	Upgrade facilities and equipment for documentation	Low	High	ZARI, SPGRC, and Crop Trust
		Install and fully utilize a seedbank information system such as SDIS or GRIN-Global			
		Ensure secure back-up of documentation			
		Update data in Genesys and own website as required			

Annex 1

Terms of Reference

National seedbank review

The Global Crop Diversity Trust (Crop Trust) commissions the review of national and international genebanks as part of the process to assess their needs for upgrading and their eligibility to receive long-term support from its endowment fund. This review provides direct inputs to the development of subsequent seedbank upgrading workplans.

This initial national seedbank review is an activity of the "National Seeds Collections for Climate-Resilience Agriculture in Africa – Seeds for Resilience" project. "Seeds for Resilience" is funded by the Federal Republic of Germany, and its goal is to:

Empower national seed collections, by safeguarding them in perpetuity through an endowment fund, documenting and managing them appropriately for conservation and use, and promoting their use, to serve as a basis for climate change adaptation of vulnerable African cropping systems.

This review will take into consideration various aspects that affect the overall functioning of the seedbank, including technical, financial, organizational, regulatory, social and environmental aspects.

The objectives of the review are to:

- Determine the institutional arrangement and organizational capacity of the seedbank.
- Assess the basic organizational structure of the seedbank and its parent institute.
- Identify risks and constraints that prevent the seedbank from fulfilling its main objectives.
- Assess the seedbank's environmental, social, health and safety risks and procedures.
- Determine the main funding sources of the seedbank and the proportion dedicated to germplasm conservation activities.
- Determine the number of potentially viable, available and safety duplicated accessions, disaggregated by species and crops.
- Determine the uniqueness of the collection in the context of the global system for long-term conservation of plant genetic resources for food and agriculture.
- Review the adequacy of the facilities, equipment and field sites for both long-term conservation and active use of the collections.
- Assess the capacity of the seedbank staff to carry out activities for both long-term conservation and active use.
- Assess written and actual procedures as demonstrated by staff and determine if the level of operation is adequate for long-term and active use of the collections.
- Assess the level of use of each crop collection and existing linkages with its users.
- Provide the Crop Trust with key findings, actionable recommendations actions for priority and suggestions for mitigating risks of all of the above.

The review is to be conducted in five preselected national seedbanks, prioritized according to the importance and potential uniqueness of their collections, and for being part of the donor's "One world – no hunger" initiative.

Review implementation

A panel of external consultants, with relevant experience in the region and the aspects to be addressed in the review, will be appointed for the review. The project manager will facilitate the review providing background information from each seedbank, coordinating the development of the agenda, the execution of the overall review and assist the chair of the

review panel in any aspects of the review and the completion of the final report. The Crop Trust will not take part directly in the formulation of the review report and recommendations.

The review comprises three phases:

I. General background and literature review

The reviewers will aid in the preparation of questionnaires to be sent to each national seedbank considered in the review. These questionnaires will aim to gather baseline information about the seedbank and its parent institute.

The reviewers will be provided with:

- The responses to the questionnaires.
- Genebank website and related materials.
- Relevant past reviews of the genebank commissioned by the Crop Trust.
- Any other materials provided by the genebank as background for the review.

All review panel members and the seedbank manager will be involved in the development of the agenda for the site visit. This is an important process during which specific issues and questions are identified for review and relevant stakeholders and users within and outside the Centre are identified for consultation.

At least two calls will take place in advance of the site visit, between the panel members and Crop Trust staff.

II. Site visits and seedbank review

The panel members will conduct a site visit of the seedbank following the agreed agenda. Usually the site visit involves interactions between the panel members and senior management, researchers and the full genebank staff. There will also be at least one visit to field stations. The panel members should determine the scale of these interactions in the development of the agenda.

Given that discussions during the review are usually intensive, panel members may wish to review together the findings at the end of each day. There may also be a need to make adjustments to the agenda in order to pursue certain issues in greater detail. The draft recommendations will be presented to the seedbank staff and management on the last day of the site visit.

III. Completing the report and presenting the recommendations

The review panel will follow the agreed review checklist and complete the report format, including a report of the evidence provided by the seedbank for each checklist item, compliance of the seedbank/host institute to standard policies and guidelines, and a statement to indicate how any recommendations should be closed. Any additional reporting should be limited and justified.

A response will be solicited from the seedbank by the Crop Trust. The Crop Trust will provide its own response to the recommendations. In the event of a lack of endorsement by the seedbank or the Crop Trust to a recommendation, further discussions may be necessary between the Crop Trust, panel members and the seedbank staff. If necessary, the other specialist bodies may be consulted

Content of the report

The chair of the review panel will lead the preparation of an individual report of no less than 4,000 words per seedbank. The report will include the analysis of the various objectives of the review and key findings will be highlighted. The review panel is expected to make recommendations for the future management of the seedbank and its collections that should be actionable by the management of the seedbank, the Crop Trust, and the project.

Use of the review report

The report will be submitted to the Crop Trust for initial review to ensure completeness and clarity. A response will be solicited from the seedbank's host institute. The Crop Trust will provide its own response to the statements and recommendations with the agreement of the host institute and reviewers.

The reports will be used specifically to inform the project with regards to the final selection of national seedbanks to continue with the upgrading phase and provide a basis for preparing recommendation action plans, workplans and activities to be considered during the upgrading phase.

Annex 2

Seeds for Resilience

September 16 - 18, 2019
Lusaka, Zambia

Agenda

Time	Session	Items to be addressed	Participants	Facilitators
DAY 1: September 16				
09:00 - 09:30	Brief presentation by the Review Panel Chair and Q&A to all genebank relevant staff.	Introduction to the review panel and to the objectives of the review.	Head of genebank, genebank staff, review panel, Crop Trust project manager	Chair of review panel/Crop Trust project manager
09:30 - 10:00	General introduction to the genebank	Introduction to the history of the genebank, current activities	Genebank staff, review panel, Crop Trust project manager	Head of genebank
10:00 - 15:00	Tour of the genebank facilities and its operations	Getting to know the genebank and the people who work there. Introduction to all genebank operations by the staff responsible and review of the basic operations and main activities of the past 5 years. Include (but not restricted to): - Acquisition unit - Storage unit - Viability testing unit - Seed health unit - Distribution unit - Field operations (greenhouse unit) - Data management unit - In vitro (if available) - Characterization unit	Genebank staff, review panel, Crop Trust project manager	Genebank staff
15:00 - 16:00		Call with Equipment and Facilities reviewer		

16:00 - 17:00	Risk management & quality management system	General discussion on risk measures, implementation of a quality management system		
DAY 2: September 17				
09:00 - 10:30	Meeting with SPGRC	Introduction to the project and the review. Reviewers to understand synergies and partnerships between SPGRC and Zambian national genebank.	Head of genebank, review panel, Crop Trust project manager, SPGRC representatives	Chair of review panel/Crop Trust project manager
10:30 - 12:30	Meeting with ZARI senior management	Reviewers are provided a description of the overall research strategy and where the genebanks fits into ongoing or planned research. Reviewers will address various aspects related to the institutional and management arrangement of the institute.	ZARI senior management: Director General, Head of budgets/finances, Governance official, Director of research, head of genebank Review panel, Crop Trust project manager	Chair of review panel/Crop Trust project manager
12:30 - 13:30	Lunch			
13:30 - 15:30	Review of any outstanding issues with genebank staff		Genebank staff	Review panel
15:30 - 17:30	Review panel wrap-up		Genebank staff, review panel, Crop Trust project manager	Chair of review panel
DAY 3: September 18				
07:00 - 13:00	Visit to regeneration site		Head of genebank, review panel, Crop Trust project manager	Head of genebank
13:00 - 14:00	Lunch			
14:00 - 16:00	Review panel wrap-up presentation	Presentation of preliminary recommendations and wrap-up	Senior Management staff, genebank staff, review panel, Crop Trust project manager	Chair of review panel/Crop Trust project manager