

Genetic Resources Research Institute (GeRRI) Genebank Review 2020

Genebank reviewed	Genetic Resources Research Institute - Kenya Agricultural & Livestock Research Organization
Site visit dates	September 20 - 24, 2019
Review report date	24 April 2020
Institution and Crop Trust responses	
Place	Nairobi, Kenya
Genebank manager	Desterio Nyamongo
Review panel	Paula Bramel Simon Linington Bonny Ntare Milko Škofič
Crop Trust staff	Nora Castañeda

Nr.	Reviewers recommendation	Timeframe	Responses
1	Given the importance of performance measurement and indicators in both the KALRO and Crop Trust contracts, we recommend that KALRO modify their performance monitoring for GeRRI to include the performance targets in use by the Crop Trust to simplify reporting and ensure the long-term conservation and use of the accessions.	2020 – 2024	<p>GeRRI: Agree. GeRRI's performance targets are set through a negotiated process that ensures that the set targets are relevant and aligned with those of the organizational Performance Contract (PC). We agree that there is a need to harmonize GeRRI's reporting format with that of the Crop Trust. In this case, GeRRI will need to work with KALRO's performance contracting office to see how the revised targets align with KALRO's performance targets and effect changes where necessary. However, in case the reporting format/targets proposed by the Crop Trust will not have been developed by the time KALRO/GeRRI's PC is completed, these changes are likely to wait up to the next financial year (July 2021 – June 2022). In the meantime, GeRRI will be open to use any alternative reporting format as may be advised by Crop Trust.</p> <p>Crop Trust: The Crop Trust agrees with the recommendation and understands GeRRI's position. It is important that GeRRI's performance is monitored using indicators that adequately reflect the operations and role of the genebank in the long-term conservation and sustainable use of plant genetic resources.</p>

2	<p>We strongly recommend that GeRRI provide annual financial statements that are audited in line with international standards, with sufficient detail to enable the Crop Trust to annually review the financial situation of the genebank.</p>	2020 – 2024	<p>GeRRI: Agree. KALRO being a publicly funded organization, its resources, including financial accounts, are subjected to annual external audits. While the auditing of accounts is done at all levels within KALRO, the audited financial report is normally captured and reflects the financial position at the organizational level and it is not institute specific. It is nonetheless possible to engage a private external auditor to generate project-specific annual audit reports whenever such requirements and resources are provided for in the project agreement.</p> <p>Crop Trust: The Crop Trust supports both the recommendation and GeRRI's response. It is important that an annual financial audit and follow-up are conducted, as a means to support GeRRI in meeting the accounting standards required by the project.</p>
3	<p>We recommend the development of a long-term plan for the sustainable operation of the seedbank when the upgrade is completed, and a costing study of routine operations to help secure adequate annual funds for the conservation and use of the collections.</p>	Q2 2023	<p>GeRRI: Agree. We strongly agree that a long term funding plan/mechanism for GeRRI is critical to secure conservation and enhance utilization of the plant genetic resources it manages for production resilience and improved food security. A costing study of routine operations to inform development of the funding strategy for securing adequate annual funds for the conservation and use of the collections is a brilliant idea.</p> <p>Crop Trust: The Crop Trust agrees with the recommendation and GeRRI's response. To reach a steady state of operation it will be important to have well-established processes and to clear all backlogs.</p>
4	<p>Generally, the reviewers conclude that there is a need to invest into enhancing staff capacity for the long-term. They recommend:</p> <ul style="list-style-type: none"> ● 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 that have key knowledge of the collection or seedbank management. 	2020 – Q2 2023	<p>GeRRI: Agree.</p> <ul style="list-style-type: none"> ● There is a need to continually enhance the technical capacity of genebank staff through on-site training and exchange visits. This is particularly important for new staff and in case there are any technological advances in genebanking as it helps staff to stay abreast of those advances. GeRRI will develop a capacity building schedule for its staff by April 2021. ● We will initiate the process of identifying training needs by April 2021 and have bilateral arrangements with

			<p>international genebanks such as ICRISAT, IITA, and ILRI to have exchange visits by December 2021.</p> <ul style="list-style-type: none"> • Succession at the higher echelons of genebank management (Institute Director and Deputy Institute Director) is decided by KALRO Board of Management. GeRRI, through a board paper, will endeavour to bring to the attention of KALRO Board of Management the specialized nature of genebank operations and therefore the need to take into account knowledge, skills and experience during succession planning to ensure continuity. In the light of current staffing constraints, GeRRI has developed and submitted to KALRO management a human resource plan that should help to adequately address succession planning. <p>Crop Trust: The Crop Trust agrees with the recommendation. Training on technical aspects of germplasm collection management is needed to upgrade the operations of GeRRI. High-level support from KALRO and GeRRI 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 GeRRI on staff succession planning. It would be useful to share the human resources plan submitted to KALRO management.</p>
5	<p>Given the large number of accessions for some of the crops and the potential redundancy that was found between the collection held by GeRRI and other collections outside Kenya, it is recommended that a study is conducted to formally determine redundancy with other collections held by national and international institutions that were involved in joint collections with GeRRI or served as host sites for duplicates. The results of the study would allow for GeRRI to prioritize crops and accessions for long term conservation.</p>	Q2 2020	<p>GeRRI: Agree. There is certainly a possibility of some level of redundancy between GeRRI's collection and that of other genebanks, such as ICRISAT. The criteria to use for this exercise should be developed and agreed upon by all the genebanks involved. We note that there could be challenges in undertaking this exercise as some genebanks, may have dropped some data such as the original accession identifiers along the way. A study to elucidate the said redundancy is critical.</p> <p>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</p>

			urgent safety duplication. Special attention is advised to avoid unnecessary duplication. Based on the proposed study, we encourage GeRRI to select unique accessions of selected crops, which will be used to assess genebank management performance under the Seeds for Resilience project.
6	We recommend that GeRRI update the inventory of accessions of Annex 1 crops to reflect the current composition of the collection; clarify and record the MLS status for all accessions, including those of non-Annex 1 crops that were acquired from outside Kenya prior to 1992; add all available passport and characterization data; and share all the updated accession level information with users on their own website and Genesys.	Q4 2020	<p>GeRRI: Agree. An inventory list of all accessions conserved at GeRRI will be produced indicating Annex 1 materials and MLS status. This will be done by December 2020. While significant time and efforts might be required to sort, clean and organize characterization data before it can be shared on Genesys, it is important to note that around 90% of available passport data is already on Genesys. Efforts will be made to ensure continued updating of this information is achieved.</p> <p>Crop Trust: The Crop Trust agrees with the recommendation. 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. The Crop Trust encourages GeRRI to update the notification letter of material available in the MLS submitted to the ITPGRFA Secretariat.</p>
7	We recommend that GeRRI prioritize crops and accessions and arrange safety duplication of accessions not already duplicated at another location outside Kenya as well as the Svalbard Global Seed Vault.	2020 - 2023	<p>GeRRI: Agree; Safety duplication is an integral part of our conservation strategy. An inventory audit will be done for all the accessions, and a report produced to guide GeRRI on prioritizing safety duplication to Svalbard Global Seed Vault and other genebanks as appropriate. Investing resources to undertake multiplication of accessions with limited seed quantities to facilitate duplication is an essential venture. A safety duplication strategy will be developed by June 2022. It is important to note that, contrary to information presented in table 4 of the report, GeRRI has already duplicated a total of 4,185 accessions in other genebanks outside the country. This includes 1,314 accessions duplicated in Svalbard.</p> <p>Crop Trust: The Crop Trust supports this recommendation. We acknowledge the update to the baseline information presented in</p>

			table 4 of the full report. We encourage GeRRI to prepare a plan for all unique accessions to be safely duplicated in Svalbard.
8	We recommend that GeRRI 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	<p>GeRRI: Agree. GeRRI has standard operating procedures for a few genebank operations. These will be updated and new ones developed for those activities where they are not available. Efforts will then be made to convert the SOPs into an operation manuals which can be updated regularly.</p> <p>Crop Trust: The Crop Trust agrees with the recommendation and GeRRI's response. The Crop Trust will continue to provide technical support to GeRRI 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 GeRRI management.</p>
9	We recommend the implementation of the procurement plan in Table 6 with careful consideration of each item by GeRRI 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 this full review report.	2020 - 2023	<p>GeRRI: Agreed. GeRRI is in agreement with the proposed procurement plan. A team will be established by September 2020 to guide the procurement process and ensure smooth implementation of this plan. As much as possible, we recommend that the Trust undertakes the sourcing and procurement of the recommended items. We note that some critical items/equipment are missing in the procurement plan, such as irrigation infrastructure, incubators, and cold room protective gear among others. These will be critical in facilitating germplasm regeneration/characterization and viability monitoring; the two important components in which we currently have massive backlog. We thus request that they be included in the procurement plan</p> <p>Crop Trust: The Crop Trust supports this recommendation. We acknowledge GeRRI's priorities in relation to the additional items to be procured, however given the project budget restrictions, including more elements to the report procurement list is not feasible. Particular attention needs to be given to re-organizing the current layout of the genebank, in order to extend the area dedicated to germination testing and to conduct processes handling dirty and clean seeds in separate areas.</p>

10	<p>We recommend that GeRRI develop and implement a realistic plan to clear the backlog of initial seed viability tests as well as continuing viability retesting. Priority should be given to the oldest Annex I crop seed lots, aiming for at least 1,500 tests per year. As described in the full report, there could be a need to ensure all past and future seed viability test results are fully entered into GRIN-Global.</p>	2020 - 2023	<p>GeRRI: Agree. With availability of laboratory supplies and enough staff, this target is achievable. The head of seed technology will develop a schedule for the seed testing by December 2020. The schedule will target to have all the viability tests on annex 1 materials done by September 2022; and all other materials done by December 2023. Due to staff shortages, seed viability testing is currently largely being done by casual workers and volunteers. Considering the current low staffing levels, we will require engagement of interns to assist in seed viability testing and other conservation activities. All seed testing data will be documented on GRIN-Global.</p> <p>Crop Trust: The Crop Trust supports this recommendation. Kenya's response describing the shortage of staff is concerning. These essential operations need to be undertaken by well-trained and experienced staff. There needs to be some indication that GeRRI is investing in this. We encourage GeRRI to consider engaging laboratory technicians to conduct key genebank operations. Further details about the viability testing plan should be described in the project workplan.</p>
11	<p>We recommend that seed quantity is monitored against thresholds for all accessions by digitally recording seed weight per 100/1000 seeds and seed packet weight for every seed lot before sealing and storage.</p>	2020 - 2023	<p>GeRRI: Agreed. Digital recording of seed weights provides a systematic way of monitoring seed quantity. Such a system helps to promptly inform on the need for seed multiplication before seed quantities drop to unacceptably low levels. An inventory audit will be conducted and a seed storage SOP developed to guide on the number of seeds to be conserved per accession for every species. These SOPs will be in operation by December 2022. The use of GRIN-Global will also help in the monitoring of the seed quantities. GeRRI will however require a lot of support on GRIN-Global operationalization to enable us to realize these targets.</p> <p>Crop Trust: The Crop Trust supports this recommendation. We encourage GeRRI to record information on seed numbers directly in the genebank database and use it, together with viability test results, to decide when regeneration is needed.</p>
12	<p>To address the inadequacy in feedback on the use of accessions, we recommend that the GeRRI utilizes a routine</p>	2020 - 2023	<p>GeRRI: Agreed. Getting feedback from recipients of germplasm is critically important to not only improve GeRRI's operations but also</p>

	<p>formal process for soliciting and using feedback from recipients to improve seedbank operations and enhance accession level information with actions such as to:</p> <ul style="list-style-type: none"> • Conduct routine user surveys on the use of the collections, delivery timelines, quality of seed received and other useful information. • Fully implement DOIs to better link to information generated on the accessions. • Develop a procedure for ensuring that information on the evaluation and use of the distributed germplasm is shared with GeRRI to enrich accession level data. 		<p>add value to the collection. GeRRI will adopt a routine follow-up process on its distributions by use of user surveys (online questionnaires and field visits) and the implementation of DOIs. A detailed SOP for this process will be adopted by December 2022. Feedback information on germplasm evaluation will be systematically documented to enrich information on our accessions. GeRRI will need support and guidance on the implementation and use of DOIs.</p> <p>Crop Trust: The Crop Trust supports this recommendation and GeRRI's response. Evaluation data should be published on Genesys whenever possible, according to the existing SOP.</p>
13	<p>We recommend that GeRRI implement a realistic plan to securely regenerate priority accessions, those which fall below seed viability and seed number thresholds, at two to three suitable sites, for the duration of the S4R project as well as in the longer term, with significant improvements in the regeneration protocols to increase cost effectiveness and security. In addition, there is a need to access a site near Nairobi (such as the fields of the University of Nairobi or other governmental organizations) for regeneration of seedbank accessions at high risk of loss. Regeneration and multiplication should prioritize older accessions with low seed viability and/or low seed numbers.</p>	2020 - 2023	<p>GeRRI: Agreed. A majority of our forage legumes and selected cereals may currently be threatened by low seed viability. These rank highly among our priorities for regeneration. For some taxa, we will recommend laboratory-based seed pre-germination before the seedlings are transferred to the screenhouse and finally transplanted to the field. Experience has shown us that this system works well in cases where direct seeding in the field poses a great risk of losing an accession due to poor viability. Support will be required to repair the screenhouse. GeRRI will develop a plan to regenerate prioritized accessions by April 2021. This plan will include short, medium and long-term schedule and targets. We will identify regeneration sites near Nairobi where ecological requirements are suitable for accessions at high risk of loss. An SOP for the same will also be developed to guide on all future regenerations.</p> <p>Crop Trust: The Crop Trust agrees with the recommendation. We acknowledge GeRRI's priority to repair the screenhouse, however, given the project budget restrictions, it is not possible to include such item in the report procurement list. It is important that the regeneration plan gives precedence to unique, threatened accessions of selected crops that fall below seed quantity and viability thresholds. Other materials may potentially be sourced from other genebanks. Further details about the regeneration plan should be described in the project workplan. We support GeRRI in</p>

			collaborating with other institutions in regenerating seed material, as appropriate.
14	We recommend that GeRRI organize facilitated meetings at agro-ecological zone level (2-3) with representatives of farmers' organizations, NGOs, local government agencies, research institutions/universities based in the zones, and local seed producers (max. 40 participants per zone). The reviewers also recommend that GeRRI constitutes a technical working group of breeders/researchers within KALRO, universities, and the private sector for characterization, evaluation and use of collections in crop improvement. In order to elevate the profile of the national seedbank and raise awareness on the importance of supporting it, the reviewers strongly recommend that GeRRI holds at least two facilitated high-level meetings with key policy makers during the implementation of the project.	2020 - 2024	<p>GeRRI: Agree. These kinds of meetings can help increase the visibility of GeRRI. GeRRI has always worked with breeders and researchers and is open to such collaborations and partnerships. Mechanisms of sustaining the technical working group beyond the project period need to be considered during the development of long term funding plan/strategy.</p> <p>Crop Trust: It is important that a structured communications plan is first developed, as this can guide GeRRI's efforts to enhance its communications with all users and other stakeholders, including genebank users. The Crop Trust will support GeRRI in designing and implementing a communications plan aiming to enhance the genebank's visibility.</p>
15	<p>To address the limited use of national collections to enhance crop diversity to mitigate the effects of climate change, the reviewers recommend that GeRRI facilitates technical support in the evaluation, characterization, and multiplication of accessions of underutilized and climate smart crops for direct use in the cropping system by:</p> <ul style="list-style-type: none"> ● Together with the technical working group of breeders/scientists, identify a core collection of underutilized and climate-smart crops for use in crop improvement. ● Multiply/bulk seed of selected accessions for distribution. ● Together with breeders/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. 	2020 - 2024	<p>GeRRI: Agreed. Understanding the potential genetic value of conserved germplasm in the face of climate change and strengthening linkages with germplasm users, particularly smallholder farmers, ranks highly among our priorities. GeRRI has been involved in joint scientist-farmer evaluation/characterization and conservation of crop diversity, based on important functional traits, using novel crowdsourcing and Information Communication Technologies. With support from the project, we intend to continue with this approach as it holds great potential for enhancing farmers' access to productive, adapted and genetically diverse climate resilient genotypes. We have also been involved in studies establishing phenotype-genotype relationships with the aim of identifying genetic markers associated with important functional traits. These would be useful in assisting the genebank manager to quickly identify accessions potentially possessing useful traits. Additional support may be required in enhancing the technical capacity of GeRRI staff in using crowdsourcing approaches in germplasm evaluation.</p> <p>Crop Trust: Given restricted resources we would prioritize:</p> <ul style="list-style-type: none"> ● The identification of promising landrace material through participatory field evaluation trials.

	<ul style="list-style-type: none"> • With breeders, 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). 		<ul style="list-style-type: none"> • 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. <p>It is important that GeRRI selects the most promising crop(s) for climate-change affected regions of Kenya, for which GeRRI 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!</p>
16	<p>The reviewers recommend that a detailed risk management matrix (such as Table 8) is agreed upon and used as the basis for monitoring risk for the seedbank on an annual basis with updates provided as needed by GeRRI to the Crop Trust.</p>		<p>GeRRI: Agreed. This is urgently required as GeRRI's risk assessment and management systems are in most cases inadequate. A risk management and mitigation team will be established at the institute and its role in monitoring and mitigating risks outlined.</p> <p>Crop Trust: The Crop Trust supports both this recommendation and GeRRI's response. Work on QMS will provide support to GeRRI to strengthen its risk management.</p>

Genetic Resources Research Institute – Nairobi, Kenya

External Review Report

April 27, 2020

Review Team:

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

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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 to assess the short term and long-term upgrade needs for the Genetic Resources Research Institute (GeRRI) to meet international seedbank standards to better secure conservation and use for the future.

The National Genebank of Kenya (NGBK) was established as a crop genetic resources center in the 1980's with financial and technical support from the German Technical Co-operation Agency (GTZ) of the then Federal Republic of Germany. The establishment was done in two phases that ran concurrently. The first phase involved the rehabilitation of short-term conservation facilities in various commodity research centers of the then Kenya Agricultural Research Institute (KARI). The second phase involved the establishment of the current long-term conservation facilities at the NGBK Muguga. The NGBK facilities became operational in 1988 with the initial acquisition of 6,763 accessions from the short-term conservation facilities of the commodity research centers. By 1989, the seedbank had 18,618 accessions. The NGBK operated as a program in the Kenya Agricultural Research Institute (KARI) until it was elevated to a semi-autonomous institute of the Kenya Agricultural & Livestock Research Organization (KALRO) and named the Genetic Resources Research Institute (GeRRI). The current mandate of the national seedbank of Kenya, operating under GeRRI, is to undertake efficient conservation of plant genetic resources and enhance their effective and sustainable use for enhanced agricultural productivity and food security. GeRRI is headed by an institute director who is assisted by a deputy institute director, both of whom double as research scientists. Within GeRRI, there are four operational units headed by section leaders. These are: seed science, technology and conservation; characterization, multiplication, regeneration and evaluation; germplasm exploration and collection; documentation and data management. The reviewers found a number of areas for improvement in key institutional issues such as financial processes, annual funding for routine operations, and longer-term staff capacity building.

GeRRI reported that they currently conserve a total of 51,117 accessions from 14 crop categories, with 75% of these classified as cereals, forage grasses, pulses, and forage legumes. They indicated that only 2,030 accessions had been acquired in the last 10 years. They reported that over the last few years, the seedbank, in partnership with local and international partners, has collected at least 10 species which have previously not been reported in science and therefore constitute an important resource.

The Crop Trust utilizes a set of indicators to monitor various aspects of a seedbank's performance. The baseline performance for GeRRI 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 Kenya; 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, cold stores, and field sites to meet the needs for secure, cost-effective, sustained conservation for the long-term. The various risks 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 as well as to enhance accession level information for future users. The level of engagement of GeRRI 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 GeRRI 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 GeRRI 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 recommendations 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: Given the importance of performance measurement and indicators in both the KALRO and Crop Trust contracts, we recommend that KALRO modify their performance monitoring for GeRRI to include the performance targets in use by the Crop Trust to simplify reporting and ensure the long-term conservation and use of the accessions.

Recommendation 2: The reviewers strongly recommend that GeRRI provide annual financial statements that are audited in line with international standards, with sufficient detail to enable the Crop Trust to annually review the financial situation of the genebank.

Recommendation 3: The reviewers recommend the development of a long-term plan for the sustainable operation of the seedbank when the upgrade is completed, and a costing study of routine operations to help secure adequate annual funds for the conservation and use of the collections.

Recommendation 4: Generally, the reviewers conclude that there is a need to invest into enhancing staff capacity for the long-term. They recommend:

- 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 that have key knowledge of the collection or seedbank management.

Recommendation 5: Given the large number of accessions for some of the crops and the potential redundancy that was found between the collection held by GeRRI and other collections outside Kenya, it is recommended that a study is conducted to formally determine redundancy with other collections held by national and international collections held by institutions that were involved in joint collections with GeRRI or served as host sites for duplicates sites. The results of the study would allow for GeRRI to prioritize crops and accessions for long term conservation.

Recommendation 6: The reviewers recommend that GeRRI update the inventory of accessions of Annex 1 crops to reflect the current composition of the collection; clarify and record the MLS status for all accessions, including those of non-Annex 1 crops that were acquired from outside Kenya prior to 1992; add all available passport and characterization data; and share all the updated accession level information with users on their own website and Genesys.

Recommendation 7: The reviewers recommend that GeRRI prioritize crops and accessions and arrange safety duplication of accessions not already duplicated at another location outside Kenya as well as the Svalbard Global Seed Vault.

Recommendation 8: The reviewers recommend that GeRRI adopt a quality management system (QMS), including the development and regular updating of standard operating procedures (SOPs) for current processes for their routine operations, as well as any new processes.

Recommendation 9: The reviewers recommend the implementation of the procurement plan in Table 6 with careful consideration of each item by GeRRI 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 this full review report.

Recommendation 10: The reviewers recommend that GeRRI develop and implement a realistic plan to clear the backlog of initial seed viability tests as well as continuing viability retesting. Priority should be given to the oldest Annex I crop seed lots, aiming for at least 1,500 tests per year. As described in this report, there could be a need to ensure all past and future seed viability test results are fully entered into GRIN-Global.

Recommendation 11: The reviewers recommend that seed quantity is monitored against thresholds for all accessions by digitally recording seed weight per 100/1000 seeds and seed packet weight for every seed lot before sealing and storage.

Recommendation 12: To address the inadequacy in feedback on the use of accessions, the reviewers recommend that the GeRRI utilizes a routine formal process for soliciting and using feedback from recipients to improve seedbank operations and enhance accession level information with actions such as to:

- Conduct routine user surveys on the use of the collections, delivery timelines, quality of seed received and other useful information.
- Fully implement DOIs to better link to information generated on the accessions.
- Develop a procedure for ensuring that information on the evaluation and use of the distributed germplasm is shared with GeRRI to enrich accession level data.

Recommendation 13: The reviewers recommend that GeRRI implement a realistic plan to securely regenerate priority accessions, those which fall below seed viability and seed number thresholds, at two to three suitable sites, for the duration of the S4R project as well as in the longer term, with significant improvements in the regeneration protocols to increase cost effectiveness and security. In addition, there is a need to access a site near Nairobi (such as the fields of the University of Nairobi or other governmental organizations) for regeneration of seedbank accessions at high risk of loss. Regeneration and multiplication should prioritize older accessions with low seed viability and/or low seed numbers.

Recommendation 14. The reviewers recommend that GeRRI organize facilitated meetings at agro-ecological zone level (2-3) with representatives of farmers’ organizations, NGOs, local government agencies, research institutions/universities based in the zones, and local seed producers (max. 40 participants per zone). The reviewers also recommend that GeRRI constitutes a technical working group of breeders/researchers within KALRO, universities, and the private sector for characterization, evaluation and use of collections in crop improvement. In order to elevate the profile of the national seedbank and raise awareness on the importance of supporting it, the reviewers strongly recommend that EBI holds at least two facilitated high-level meetings with key policy makers during the implementation of the project.

Recommendation 15: To address the limited use of national collections to enhance crop diversity to mitigate the effects of climate change, the reviewers recommend that GeRRI facilitates technical support in the evaluation, characterization, and multiplication of accessions of underutilized and climate smart crops for direct use in the cropping system by:

- Together with the technical working group of breeders/scientists, identify a core collection of underutilized and climate-smart crops for use in crop improvement.
- Multiply/bulk seed of selected accessions for distribution.
- Together with breeders/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 breeders, 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 16. The reviewers recommend that a detailed risk management matrix (such as Table 8) is agreed upon and used as the basis for monitoring risk for the seedbank on an annual basis with updates provided as needed by GeRRI to the Crop Trust.

Introduction to the external review

The Crop Trust has organized and facilitated a number of reviews to assess and monitor seedbank 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 was composed of:

- Paula Bramel: Chair of the review panel with experience in conducting seedbank reviews and expertise in institutional analysis, diversity assessment, and seedbank management.
- Bonny Ruhemurana Ntare: Operations and use expert. Supported the chair in the areas of general seedbank management and links with users.
- Simon Linington: Equipment and facilities expert. Assessed in detail equipment status and needs.
- Milko Skofic: Information systems expert. Assessed seedbank management data flows and software and hardware needs.

The review took into consideration various aspects that affect the overall functioning of the seedbank, including technical, financial, organizational, regulatory, social, and environmental aspects. The exact term of reference for the review is 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 GeRRI from 20 to 24 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 for GeRRI 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 will then be 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 current mandate

The National Genebank of Kenya (NGBK) was established as a crop genetic resources center in the 1980's with financial and technical support from the German Technical Co-operation Agency (GTZ) of the then Federal Republic of Germany. The establishment was done in two phases that ran concurrently. The first phase involved the rehabilitation of short-term conservation facilities in various commodity research centers of the then Kenya Agricultural Research Institute (KARI). The second phase involved the establishment of the current long-term conservation facilities at the NGBK Muguga. The NGBK facilities became operational in 1988 with the initial acquisition of 6,763 accessions from the short term conservation facilities of the commodity research centers. By 1989, the seedbank had 18,618 accessions. GBK operated as a program in the Kenya Agriculture Research Institute (KARI) until it was elevated to a semi-autonomous institute of the Kenya Agricultural & Livestock Research Organization (KALRO) and named the Genetic Resources Research Institute (GeRRI). Its mandate expanded to include animal, aquatic and microbial genetic resources. The current mandate of the national seedbank of Kenya, operating under GeRRI, is to undertake efficient conservation of plant genetic resources and enhance their effective and sustainable use for enhanced agricultural productivity and food security. The main objectives are to:

- Secure plant genetic resources from imminent loss by conserving them using appropriate approaches.
- Promote sustainable utilization of crop genetic diversity to enhance agricultural resilience for increased production and improved food and nutritional security.
- Enhance the level of awareness among various stakeholders on the value of plant genetic resources and importance of sustainable conservation and utilization.

The Kenya Agricultural and Livestock Research Organization (KALRO) is composed of a secretariat and sixteen (16) semi-autonomous institutes headed by institute directors. The board of management was established by the Kenya Agricultural and Livestock Research Act of 2013. GeRRI is one of the semi-autonomous crops institutes within KALRO. GeRRI is headed by an institute director who is assisted by a deputy institute director, both of whom double as research scientists. The director of GeRRI reports to the KALRO deputy director general, crops. Within GeRRI, different operational units are headed by section heads who report directly to institute management:

- Seed science, technology and conservation.
- Characterization, multiplication, regeneration and evaluation.
- Germplasm exploration and collection.
- Documentation and data management.

Research scientists assisted by technical officers/assistants conduct research across the various technical operational units.

Institutional issues

The heads of programs or units (scientists) within GeRRI develop annual workplans and budgets for approval by the director general of KALRO through the institute director. Once the GeRRI budget allocation is approved, the heads of the operational units develop an activity schedule, and this is approved by GeRRI's director. GeRRI informed us that they fully operate within the KALRO regulations and processes. GeRRI's director has to approve all procurements and invoices before they are finalized. KALRO indicated that quarterly reports from all the departments and institutes are compiled and submitted to the director general's office.

The Government of Kenya has adopted a performance contracting system in the public service to measure output and ensure efficient service delivery to stakeholders. KALRO signs a performance contract with the board of management. KALRO indicates that it has “a transparent reporting system” on its website for these performance targets and some external bodies also monitor some of the targets and do occasional reviews. The targets are cascaded down to the institutes, which in turn cascades them down to centers and all scientists/employees. At GeRRI, the institute director signs a performance contract with KALRO’s director general. Some of the performance indicators for the seedbank are given in Table 1. Many of these are similar to those that will be required for the Crop Trust performance monitoring.

Table 1. Key performance indicators for GeRRI

Indicator	Measurement
Expansion of the conserved genepool	Number of accessions collected or received at the seedbank through donations
Determination of seed viability for the seedbank collection	Number of accessions whose viability is tested
Germplasm regeneration	Number of accessions regenerated during the year
Establishment and/or maintenance of field seedbanks	Number of field seedbanks established or maintained during the year
Establishment of genetic diversity or potential of conserved germplasm	Number of accessions evaluated or characterized using either morphological or molecular tools during the year
Publications such as number of technical publications and number of extension materials developed/updated and availed	Publications in refereed journals and conference proceedings Other publications
Qualitative assessment	Gender and disability mainstreaming, corruption prevention/eradication

The GeRRI performance indicators are very similar to those used by the Crop Trust for monitoring their long-term agreements but there are some key differences. For example, the Crop Trust has a key performance measure focused on the number of accessions that are currently available for distribution. This performance measure is a measure of the accession that have been viability tested, health tested, and with sufficient number of seed for immediate distribution. The current indicators for GeRRI only includes the number with viability test. The Crop Trust also has a key performance measure focused on the number of accessions that are conserved in long term storage and safety duplicated at 2 levels. There is no corresponding measure or indicator for GeRRI from KALRO currently. These are just two examples but there are a number of other performance measure that are not well aligned with the KALRO measure or indicators that are used in their performance contracts.

Recommendation 1: Given the importance of performance measurement and indicators in both the KALRO and Crop Trust contracts, we recommend that KALRO modify their performance monitoring for GeRRI to include the performance targets in use by the Crop Trust to simplify reporting and ensure the long-term conservation and use of the accessions.

GeRRI published the Kenya National Strategy on Genetic Resources within the Context of Climate Change (2016-2020) to guide management of plant genetic resources in a changing climate. It was developed in a consultative process with stakeholders and experts. The process led to the identification of five strategic objectives, including one focused on *ex situ* conservation. Each strategic objective identified key monitoring indicators. The strategy, while not being formally implemented due to inadequate resources, currently receives *ad hoc* implementation using resources from small grants and collaborative projects.

The institute uses several approaches to measure the impact of projects. A monitoring and evaluation team at KALRO HQ is in charge of measuring the impact of projects. It publishes an annual report which is primarily focused on communicating impact stories. Other publications which report on the impact of projects include the biannual KALRO Highlighter.

A database of all projects implemented by KALRO is being considered but is not yet operational. It is expected that this database will enhance the monitoring of project impact.

Finances and accounting

The seedbank’s financial allocation, budgeting and financial reporting are the responsibility of the director general. Budgets are developed at institute level in collaboration with heads of sections and scientists implementing the various activities. The accounting system allows for processing and reporting of accounting and financial information, disaggregated by project and activities for major projects developed by KALRO but not for smaller projects developed at GeRRI. Processing and reporting of financial information for these smaller projects is done using Excel spreadsheets. All expenditures must be recorded in the cash book which is held at the GeRRI Finance offices. Imprest surrender forms, payment vouchers and other accounting documents are physically filed and are available for perusal by authorized personnel.

The KALRO budgeting system allows monthly up-to-date expenditure reports for major projects that are managed by KALRO but not for small grants managed by GeRRI. In the latter case, the cash book is used to track and generate expenditure reports periodically. GeRRI only operates in Kenya Shillings (KES). KALRO does not have any procedures for annual cost recovery, but there are mechanisms to generate revenue from other sources. The institutional overhead is 15% of the total budget. The rate has been stable and is reported in the Financial Policy and Procedures Manual.

We received the report of the Auditor General on the financial statements of KALRO. We have not received financial statements for GeRRI and therefore were not able to fully assess the current financial position, cash flow and the view of the external auditors with respect to GeRRI specifically. While we understand that GeRRI has not been audited separate from KALRO, we would still expect GeRRI to have separate financial statements that would have been input into the KALRO external audit.

Recommendation 2: The reviewers strongly recommend that GeRRI provide annual financial statements that are audited in line with international standards, with sufficient detail to enable the Crop Trust to annually review the financial situation of the genebank.

Annual routine operational funds

Based on the estimates provided in the baseline questionnaire, total annual costs for the seedbank are approximately KES 91.8 million. The majority of activities are funded 60-100% from projects, except field collection maintenance and electricity that are funded 100% from the government-provided budget. GeRRI indicated that almost all the permanent staff salaries are funded solely by the government budget. When the annual budget is compared with these predicted costs, in only one year since 2014 has it met (and exceeded) the demands of the various activities. No estimates for the annual budget was given in the baseline questionnaire for 2016/2017 and 2017/2018. It is not yet clear if the missing budget information is due to the lack of appropriate records, or the absence of actual governmental support. It would seem as if maintaining the routine operations for the last 5 years has been difficult, even with the level of projects being implemented.

Table 2. Seedbank annual budget in KES, as reported in the baseline questionnaire.

2014/2015	2015/2016	2016/2017	2017/2018	2018/2019
31,858,279	54,270,145	NA	NA	121,027,616

GeRRI has had experience in leading as well as being a key partner in a number of projects in the last five years. In 2019, GeRRI was involved in six projects. Since 2012, they have been involved in 5 projects with a budget of over \$100,000. They have experience working with 12 different donors. Three of these projects were done with the Crop Trust.

Currently, the annual funds available for routine operations are inadequate and fluctuate widely annually. The focus for addressing the gaps in annual funds has been on obtaining more short-term projects to increase funds for routine operations. We were given no evidence of long-term planning to better meet the annual requirement by GeRRI. More strategic approaches must be made to ensure adequate resources 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 3: The reviewers recommend the development of a long-term plan for the sustainable operation of the seedbank when the upgrade is completed, and a costing study of routine operations to help secure adequate annual funds for the conservation and use of the collections.

Staff capacity for both long-term conservation and active use

According to the baseline survey, they have 15 professional staff. Six have a doctorate degree and 4 have a master's degree. Eighty-seven percent of the professional staff have more than 10 years of experience in their position. When staff turnover is assessed for the last five years, there have been 24 staff changes but 60% of these were staff who transferred in, so there were more staff gains than losses. Given the years of service for the staff, their level of training and expertise, GeRRI has qualified, experienced staff, but they do need to plan for the changes in key professional staff in the future. There is risk of losing skilled personnel and this may compromise the quality of work and thus the quality of seed conserved. The reviewers noted they had a few key positions where they needed to consider how to mitigate the impact on operations with their loss.

They currently operate with many short-term interns or temporary staff when funds are available in research projects. The need to expand operations to address the significant gaps in routine processes will challenge this approach. Currently, they need to increase efforts to ensure their capacity and this need will increase in the future. There is no up-to-date 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. The development of standard operating procedures (SOP) for the key routine operations will help to mitigate staff loss while the implementation of a quality management system (QMS) to address staff continuity for secure long-term conservation is required.

The professional staff has all received training to enhance their performance in their current positions and there is no need to consider gaps in this general type of capacity building in the upgrade. With all the suggested improvement in the processes and equipment in the following sections, it will be necessary to consider investments into enhancing specific skills of staff with expert-lead, hands-on training in conjunction with the upgrade in the processes.

Recommendation 4: Generally, the reviewers conclude that there is a need to invest into enhancing staff capacity for the long-term. They recommend:

- **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 that have key knowledge of the collection or seedbank management.**

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

In the baseline survey, GeRRI reported on the inventory of accessions they were conserving in the seedbank by crop groups and not by crop or genus separately. A total of 51,117 accessions from 14 crop categories was reported with 75% of these classified as cereals, forage grasses, pulses, and forage legumes. They indicated that only 2,030 accession had been acquired in the last 10 years. They reported that over the last few years, the seedbank,

in partnership with local and international partners, has collected at least 10 species which have previously not been reported in science and therefore constitute an important resource. It is also reported that in the last four years, the seedbank has collected species not previously represented in the seedbank.

We were also able to extract data for KEN212 (GeRRI's seedbank code as per FAO WIEWS) from the FAO-WIEWS database (<http://www.fao.org/wiews/en/>). When all accessions are considered, they currently conserve 1,002 species but many of these species' collections are made up of a small number of accessions, since only 32% of all the accessions are of the largest 10 genera. We also determined the number of accessions from Kenya of Annex I crops that were held by 76 other national and international seedbanks as shown in Genesys (2019; <https://www.genesys-pgr.org/>). This is also summarized in Table 3.

Table 3. Summary of the total number of accessions of Annex 1 genera as reported in FAO-WIEWS and Genesys.

Genus	FAO-WIEWS			Genesys
	Introduced Total	Kenya Total	Kenya landrace or wild	Other
<i>Sorghum</i>	47	3817	2434	2447
<i>Phaseolus</i>	484	2305	1009	125
<i>Eleusine</i>	27	1918	1428	1360
<i>Vigna</i>	381	1126	421	576
<i>Zea</i>	12	1254	421	8
<i>Avena</i>	1156	12	0	3
<i>Oryza</i>	1	1122	567	287
<i>Cajanus</i>	151	442	358	320
<i>Pennisetum</i>	27	470	155	154
<i>Trifolium</i>	134	194	10	121
<i>Solanum</i>	3	236	209	254
<i>Triticum</i>	107	102	2	56
<i>Medicago</i>	134	37	73	4
<i>Brassica</i>	59	95	16	0
<i>Vicia</i>	52	57	20	3
<i>Lolium</i>	53	4	0	0
<i>Lupinus</i>	12	23	15	1
<i>Triticosecale</i>	16	19	0	0
<i>Melilotus</i>	6	26	20	1
<i>Festuca</i>	26	0	0	1
<i>Ipomoea</i>	0	26	25	16
Other	114	46	40	45
Total	3002	13331	7223	5782

In the project development phase, a study was done to identify the national collections to be supported, based upon the size and uniqueness of the accessions of Annex I crops conserved. That study concluded that GeRRI should be considered for support given its very large number of accessions, the number of priority crop collections and the diversity of accessions held for *Vigna*, *Eleusine*, *Pennisetum*, *Cajanus*, *Sorghum*, and *Ipomea*. In the review, we attempted to get a better understanding of the potential uniqueness of the accessions conserved by GeRRI. 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 76 other international and national seedbanks. The comparison of the number of accessions held can be seen in Table 3. Generally, GeRRI holds significantly more accessions collected from Kenya for *Phaseolus*, *Oryza*, and *Zea*. For those landrace and wild accessions with geographical coordinates, there is very little overlap for collection site in the case of *Brassica*, *Eleusine*, *Phaseolus*, *Solanum*, *Vigna*, and *Zea*. The overlap for wild accessions was least in the case of *Asparagus*, *Dioscorea*, *Ipomea*, and *Pennisetum*. These crop collections are anticipated to include many unique accessions within the global system as well as the large, diverse non-Annex 1 accessions.

This preliminary review of the uniqueness of the accessions across crops indicates that there is merit in securing the long-term conservation of this unique collection conserved by GeRRI that is of significant value to the global system. Despite the level of uniqueness in the GeRRI collection, the large overlap of collection sites and the large number of landrace accessions from Kenya held by seedbanks outside Kenya indicate that there is a high probability that there are duplicates and redundancies for accessions held by GeRRI and other seedbanks in the global system, especially for the very large collections of *Sorghum*, *Eleusine*, and *Cajanus*. For example, ICRISAT has done a number of joint collection missions with GeRRI for these crops and some of these could have been shared with other seedbanks so an in-depth analysis of the uniqueness of the accessions would lead to opportunities for rationalization by all collection holders. It would also give GeRRI an opportunity to recover accession that have been lost and are no longer found in their original collection site.

Recommendation 5: Given the large number of accessions for some of the crops and the potential redundancy that was found between the collection held by GeRRI and other collections outside Kenya, it is recommended that a study is conducted to formally determine redundancy with other collections held by national and international collections held by institutions that were involved in joint collections with GeRRI or served as host sites for duplicates sites. The results of the study would allow for GeRRI to prioritize crops and accessions for long term conservation.

Baseline Performance Targets

The Crop Trust utilizes a set of indicators to monitor various aspects of a seedbank's performance. Table 4 gives the current status of GeRRI's performance for these indicators. The current collection is comprised almost entirely of orthodox-seeded species.

Table 4. Baseline assessment of GeRRI for key indicators

Baseline criteria	Number of accessions	% of total accessions
Composition of collections		
Number of accessions in total	51363	
Number of seed accessions	51197	99.7%
Number of accessions conserved in vitro	0	0.0%
Number of Field bank accessions	166	0.3%
Availability		
Viable tested	11050	21.6%
Viability above 85%	6482	12.7%
Health tested	0	0.0%
Adequate seed number	Not reported	
Included in MLS	16332	32.0%
Regenerated or multiplied in last 5 years	19043	37.2%
Security		
Number of LTS	19544	38.2%
Safety duplicated outside country	2807	5.5%
Safety duplicated at Svalbard or other site outside country	0	0.0%
Field collection maintained in two site at least	0	0.0%
Distribution		
Total distributed nationally in last 5 years	7656	
Total distributed internationally in last five years	581	
Number of countries distributed	14	
Information		
Minimum passport data (online)	51197	99.7%
Minimum characterization data (online)	3246	6.3%
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	

About 32% of the accessions are from Annex 1 crops and about half of these accessions are landraces, farmers' varieties, or crop wild relatives collected in Kenya. There are ten crops that account for 90% of the Annex 1 crops (Table 3). Most of these were collected in joint missions with the CGIAR centers and about 45% were acquired or collected prior to 1999. All of the accessions from outside Kenya were acquired only up to 1995. Amongst the accessions which originated from outside Kenya, the largest group is of oats, a crop that is not cultivated in Kenya and cannot be regenerated. So, the current collection for Annex 1 crops is mainly made up of accessions from 10 crops which were acquired or collected more than 30 years ago.

Germplasm exchange is subject to institutional regulations for in-country research users and a SMTA for international users for Annex 1 crops. A review of the FAO-WEIWS database in Table 3 found that there were 490 accessions of Annex 1 crops which are not included in the MLS. Also, they have about 5,800 accessions of crops that are not included in the MLS currently but were acquired from outside of Kenya prior to 1992. Designating these to the MLS could increase the global value of their collection.

Recommendation 6: The reviewers recommend that GeRRI update the inventory of accessions of Annex 1 crops to reflect the current composition of the collection; clarify and record the MLS status for all accessions, including those of non-Annex 1 crops that were acquired from outside Kenya prior to 1992; add all available passport and characterization data; and share all the updated accession level information with users on their own website and Genesys.

The lack of safety duplication risks loss of genetic variation for the many unique accessions of important global and national crops and wild species that they conserve. Currently they only have 8.2% of the accessions duplicated elsewhere, mainly black box type storage in Svalbard Global Seed Vault Norway and at the Royal Botanic Gardens Kew, UK.

Recommendation 7: The reviewers recommend that GeRRI prioritize crops and accessions and arrange safety duplication of accessions not already duplicated at another location outside Kenya as well as the Svalbard Global Seed Vault.

In the baseline, they indicated written operational manuals are available for all seedbank operations except for *in vitro* conservation and disease detection. They were last updated in January 1992 except for safety back-up that utilizes Seeds for Life Best Practice Protocol from 2004. These manuals were not shared with the reviewers during the visit. These serve more as guidelines for the operations than anything. Since many temporary interns are utilized for key operations, there is a need to establish or update Standard Operating Procedures (SOPs) for current operations as a priority. There is need to implement the key aspects of a Quality Management System (QMS) for the conservation of the collections. There is also a need to plan for staff succession in key roles, such as the head of sections, the maintenance engineer, and others.

Recommendation 8: The reviewers recommend that GeRRI adopt a quality management system (QMS), including the development and regular updating of standard operating procedures (SOPs) for current processes for their 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 at the seedbank, seed storage, regeneration/multiplication and characterization until it is finally received 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 change required with the upgrade. The essential equipment was reviewed based on baseline information requested prior to the visit and the visit to the seedbank. Table 5 lists the flow of seed or plant material through the various steps and its location in the two main work areas of the seedbank that is given in Figure 1 for the seed conservation unit and Figure 2 for the seed processing area. In general,

the reviewers found that the GeRRI seedbank has many of the essential elements for ensuring the secure conservation and use of the accessions but has the need for the key elements of investment in facilities, equipment and expert services.

Recommendation 9: The reviewers recommend the implementation of the procurement plan in Table 6 with careful consideration of each item by GeRRI 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 this full review report.

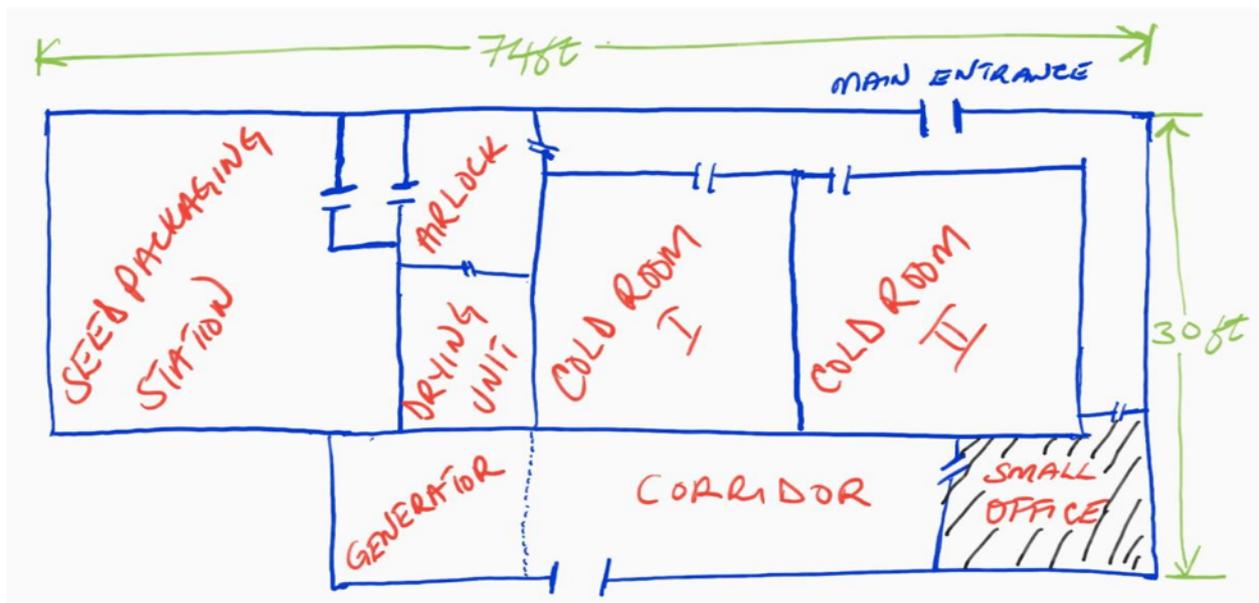
Table 5. GeRRI Flow chart for operations

1. Receive seed or plant material from multiplication/regeneration site or from collection.
2a. If seed, then winnow in work area in front of building
2b. If panicles or inflorescences, then thresh and winnow in area in front of building
2c. If fruit, ripen in growth room and extract seeds
3a. If seed is known not to have dormancy, initial germination test made as well as moisture content taken
3b. If seed is known to have dormancy, use appropriate method to break dormancy and then initial germination test made as well as moisture content taken
3c. If seed behavior for species is unknown, then research on degree of dormancy and methods to break it before initial germination test made as well as moisture content taken
4. Fully clean seed lot by manual picking or use of seed blower or sieves
5. Seed lot put into cloth bags is labeled inside and outside
6a. If space in drying unit, then bags put in drying unit
6b. If no space in drying unit, then put in air lock shelving until space in drying unit
6c. If insect infestation, then seed put into hermetically sealed barrels until space in drying unit
7. Relative humidity of dryer monitored, and seed lot moisture content monitored until 5-7%
8. Seed lot transferred from cloth bag to aluminum pack. Packet weight and 100/1000 seed count/weight recorded on data sheets that are transferred to documentation unit
9. Packet is sealed to put in long-term storage. Label from inside cloth bag transferred to aluminum pack and label written on outside by hand
10. Distribution when requested from long-term storage packs. When seed supply is noted to be low, accession is scheduled for regeneration/multiplication
11. If resources are available, arrangements are made with KALRO field sites for grow-outs
12. Seed is packaged and labeled by hand
13. Field plots set-up and taken to site to supervise field layout, planting, and labeling
14. Characterization done by new temporary staff that are trained
15. Field plots monitored regularly by seedbank staff visits
16. Material harvested according to accession maturity or as needed from middle rows of plots
17a. Plant material dried down, bundled and sent back to GeRRI for steps 1 to 9
17b. Plant material dried down and threshed. Seed sent back to GeRRI for steps 1-9
17c. Fruits harvested and sent back to GeRRI for steps 1-9
18. All characterization data sheets given to documentation unit for data entry

Short-term storage

Currently the seedbank lacks an adequate crop work area for post-harvest handling of seed and for short-term storage. Uncleaned collections are placed on shelves in the airlock (Figure 1), or if insufficient space, within the drying unit itself (which mixes dirty and clean work). Bruchids are a problem in the airlock and even in the drying unit. Additionally, the seed packaging station is not completely rodent proof.

Figure 1. Current sketch of conservation unit (as provided by GeRRI)



The crop work area (labelled seed laboratory and seed cleaning in Figure 2) is used for both seed cleaning and germination testing. This mixes the clean and dirty work areas and allows for contamination. It is also being used for storage of obsolete equipment. The seed pathology office (labelled office in Figure 2) is currently used as a storage room for consumables and some equipment and serving as an office for the seed technology and conservation section manager.

The reviewers recommend that a renovation of the crop work area, the seed cleaning room, and maybe the old seed pathology office with the construction of an interior wall to separate the seed cleaning from the clean work area, the establishment of a short term storage room for freshly harvested and threshed seed, and the establishment of a germination room with the incubators (Table 6- item 1).

This is feasible in the current space. This would allow one room of the crop work area to be used for seed handling, cleaning, and sorting while the other used for short-term storage using sealed drums against infestation. Providing enough air-conditioning in this room would be a wise precaution (Table 6 – items 2 & 8). Increasing the covered work area in front of the building to allow some seed processing might also be advisable.

Figure 2. Current sketch of seed processing area (as provided by GeRRI)



Seed cleaning and seed quantity determination

There is one large high-quality zig-zag blower and two other small seed aspirators of unknown quality. *The purchase of a heavy-duty bench-top aspirator is recommended (Table 6 – item 14).* Some good quality sieves are also available. *However, with increased throughput anticipated, the purchase of some more sieves is recommended (Table 6 – item 15).*

A significant risk when seed cleaning is the exposure of staff to irritant dusts or allergens. With the face masks of unknown quality, *it is advised that suitable face mask against seed dust are purchased (Table 6 – item 16).* Regular cleaning of the room that is ultimately designated for seed cleaning should occur to prevent dust accumulation.

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 (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.

The drying unit is approx. 3 x 6m and was constructed in 1983 and is fitted with shelving. Drying is provided by a Munters dryer purchased in 1988 and connected to the room via ductwork. The dehumidifier unit has not been working properly since it was last maintained and repaired. It is uncertain how air temperature is controlled in the room since there is only a large thermometer on the outside of the dryer room. There is no monitor for temperature or RH within the drying unit.

The drying unit is probably at the end of its serviceable life as the insulation may no longer be effective and the dryer is 31 years old (which even for this reliable make, is a venerable age). Ideally, this room would be replaced but given the uncertain state of the building (see below) in which it sits that might be unwise investment at this time. *Because of the importance of seed drying, the reviewers recommend that a refrigeration & air-conditioning consultant (Table 6 – item 2) provides specialist expertise on getting the drying unit working, the need to replace the dryer and controls, the provision of temperature control and the provision of an outside of condition alarm; they should also test the efficacy of the insulation.* They should also advise on spare parts that need to be held and a maintenance schedule.

The costs of replacing the dryer are included in Table 6 (item 7). It is advised that as and when the drying unit is replaced, stackable plastic fruit crates and trolleys are used instead of trolleys as this will lead to much greater flexibility in configuring samples within the room.

Even if the control panel is made functional, GeRRI needs to ensure that the drying unit is operating within the desired parameters of 15% ($\pm 5\%$) relative humidity and 15°C ($\pm 3^\circ\text{C}$) *using a portable monitoring device (Table 6 – item 21) 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 need to be checked to see that they really have attained the moisture content required for long-term storage. Currently, this is done non-destructively using a Rotronic eRH workstation. It is confirmed that this device is calibrated regularly. The facility has three ovens of unknown age all marked as being in 'poor' state and no two-decimal place balance. Because gravimetric moisture content determinations using balances and ovens are a useful adjunct to equilibrium relative humidity monitoring, *recommended purchases include a two-decimal place balance (Table 6 – item 18; a 2018 four-decimal place is on site) and a new ventilated oven is recommended (Table 6 – item 20).*

Seed viability monitoring

In the baseline, they indicated that they intend to do viability testing every 10 years, as per seedbank standards, but clearly this has not been done routinely. Overall, 22% of the accessions have been viability tested, while 13% have >85% seed viability overall (Table 4). When only the Annex 1 crops are considered, 35% had viability above 85% with a range of 99% for wheat and 64% for finger millet to 2% for *Avena* and *Solanum*. They concluded in the baseline assessment that although they had not viability tested as planned for all accessions, they were encouraged that in those that had been tested, the viability had not declined significantly.

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. The current facilities are inadequate considering the backlog of almost 40,000 accessions with no viability testing. Handling this is an enormous task that is currently limited by staff, equipment and clean workspace. There needs to be greater clarity on where the priorities for seed viability testing lie with respect to the backlog. Even the monumental task of testing 5,000 accessions per year would mean that the backlog would take 8 years to clear (and there would be an additional need for retests). Since 54% of the accessions are more than 30 years old, there is also an urgent need to monitor these more closely. There is a significant gap in this routine operation that was attributed to inadequate human, infrastructure, and operational resources. We would agree and will focus on addressing these constraints in the following sections. There is a high risk of loss of accessions with the loss of viability and a loss of genetic integrity with regeneration.

Recommendation 10: The reviewers recommend that GeRRI develop and implement a realistic plan to clear the backlog of initial seed viability tests as well as continuing viability retesting. Priority should be given to the oldest Annex I crop seed lots, aiming for at least 1,500 tests per year. As described in this report, there could be a need to ensure all past and future seed viability test results are fully entered into GRIN-Global.

Five LMS incubators are not being used since they cannot hold temperature within acceptable range. These need to be thoroughly checked and if not repairable, they should be disposed of. There is one cooled LMS incubator (2017) marked as "excellent". Some of these incubators are in the seed cleaning room (mix of dirty and clean work) and need to be shifted to a dedicated germination room (see comments under short-term seed storage). Additionally, there are two Jacobsen germination tanks available. Both date to 1984 and although being used, one is no longer automatic. A growth room of approx. 6m² is operating but it uses an air conditioner to cool the room with no temperature control. This growth room is currently being used for germination test of accession in plastic boxes.

Assuming that the seed pathology office (marked 'office' in the second building) can be used as a germination room then the conversion would require the provision of air-conditioning plus 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 two Jacobsen germination tanks and the 2017 incubator. *Advice should be taken from the refrigeration & air-conditioning consultant about the conversion of this room (Table 6 – item 2). The cost of air-conditioning has been included in Table 6 (item 8). It is assumed that lighting work would be covered under general costs for converting the room (Table 6– item 1).* Germination incubators at this facility have a poor history (in common with several other banks) and the room conversion offers a way forward (as used at IITA). Using one germination room rather than several incubators means that the bank will have to batch load its germination tests, 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 (see Procurement Plan – item 13).*

As an additional resource, the refrigeration & air-conditioning consultant should be asked to advise on an upgrade of the growth room so that it can be securely used for germination

tests. This will likely require a new air conditioner, temperature control and monitoring, and LED lights for all the shelves (Table 6 – item 10).

Germination consumables will need to be purchased but it is assumed that these will be picked up under GeRRI's general running costs.

Packaging and quantity determination

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 unit then accessions should be packaged very nearby and quickly. Ideally, this should be in the seed packaging station (but note comments of concern over the use of this room noted under buildings below).

During the site visit it was noted that the three envelope sealers were not working, incapable of ensuring a good seal and unsafe to use. *Purchase of a rugged pedal-operated foil bag sealer is recommended (Table 6 – 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.

The foil bags are of an uncertain quality and may be unsuitable for long-term storage. The CWR Project provided some high-quality foil bags but these have been used for a very small proportion of the collections (97 accessions). Currently there are 51,000 accessions. If we assume these accessions are eventually represented in both long-term and medium-term storage (currently they are exclusive), 102,000 bags would need to be purchased. Although there is economy with a large purchase, there could be problems of storage prior to use. *Consequently, a notional sum for the purchase of 20,000 medium-sized bags has been included in Table 6 (item 23)* which should easily cover work over the next few years. Bags are labelled inside and out with handwritten labels. The only label printer is not working.

Seed counts and weight of seed packages are taken before sealing but there is clearly a backlog. The data shared for sorghum accessions indicated that 36% had no data taken, 8% had less than 3,600 seeds, so only 56% had adequate seed number. The lack of monitoring of the number of seeds available for distribution or multiplication risks the loss of an accession when the sample size falls below the number required to securely regenerate an accession.

GeRRI has a seed weighing balance and a Shimadzu AUWU220D both of unknown age. The latter appears to be a 4 decimal place balance with a maximum weight limit of 200g. The balances are confirmed to be calibrated regularly. An extra two-decimal place balance has been recommended (see Moisture Content Determination, above). *An additional seed counter is also recommended (Table 6 – item 19)*.

Recommendation 11: The reviewers recommend that seed quantity is monitored against thresholds for all accessions by digitally recording seed weight per 100/1000 seeds and seed packet weight for every seed lot before sealing and storage.

Seed storage

The genebank has two cold rooms both with the capacity for long term storage (-20°C). Currently, cold room I is used for long-term storage (-20°C) and cold room II is for medium-term storage (+5.0). Both are approximately 5 x 7m and installed in 1988. They are maintained by an on-site technician. Refrigerant R12 was replaced by R134a in 2018. They may need new compressors since they are the originals from 1988.

As with the drying unit, these cold rooms must be towards (probably beyond) their useful life and the insulation may now be of limited effect. Similarly, the ideal would be to replace these rooms but given the uncertain state of the building in which they sit (see below) that might be an unwise investment at this time.

Consequently, in order to safeguard what is there, *it is recommended that the refrigeration & air-conditioning consultant (Table 6 – item 2) assesses the status of the compressors and controls; they should also test the efficacy of the insulation. Advice on spare parts that need to be held and the required service regime would also be sought. The concerns over the generator and electricity supply are detailed under buildings (below).*

The reviewers recommend a refrigeration and air-conditioning consultant (Table 6 - item 2) to provide specialist expertise on resolving the issues for the drying unit, cold rooms, germination room, growth room, any short-term storage, generator, alarms, and sounders that is described in this section. The basis for the recommended ToR of the refrigeration and air-conditioning consultancy is to provide written specialist advice on:

- The status of the existing Munters dryer of the drying unit (is it serviceable with a further five years lifespan?).
- The status of air cooling within the drying unit.
- The status of the refrigeration plant for the cold rooms (is it serviceable with a further five years lifespan?).
- The status of the thermal and moisture insulation properties of the drying unit and cold rooms.
- The status of the control units for the drying unit and cold rooms.
- Provision (if needed) of air-conditioning for the room selected to act as the germination room.
- Provision (if needed) of air-conditioning for the area selected for seed reception / short-term storage.
- The status of the growth room and what would be required to make it serviceable with controlled temperature.
- Provision of 'outside of condition' alarms and external sounders for drying unit and cold rooms.
- If possible, to advise on the status of the generator and on the provision of fire alarms and sounders.
- The required servicing of the equipment and the stock of spare parts that should be held on site.

There is inadequacy in monitoring of temperature in the cold storage units. The current paper-based system is not working for the long-term storage and there is no monitor for the medium-term storage. *Monitoring using a downloadable device is recommended (Table 6 – item 21).*

At the point at which the current building housing the cold rooms proves to be repairable or is completely replaced, a project to fund new cold rooms will probably be necessary and should be part of the long-term plan in Recommendation 2. The cold rooms are described as being “fairly full”. However, the 10% per annum increase in collection size maybe unrealistic and, in any case, would involve mainly non-Annex 1 species. Consequently, a small expansion is envisaged, and this could probably be accommodated within the footprint of the existing building. However, the fact that the long-term and medium-term storage collections are exclusive to one another means that a much larger footprint would be required if every accession was to be in both stores.

Plant health testing

There are no accessions with documented health status. In the past, there was a pathologist in the seedbank, but that position is vacant, so the only health testing occurs when the accession is to be distributed internationally. Seedborne viruses and other diseases can reduce seed longevity and risk the genetic integrity of the accession. There is also the risk of distribution of the disease through the seed to areas where it does not currently occur. Assessing the seed for all possible viruses or diseases is not a feasible option given the very significant backlog so it will be necessary to develop a protocol to check if the seed is free from a few key known seedborne pathogens or pests. This can be done with a limited

checklist of pathogens and pest for field inspection and then seed inspection if needed. This will establish a protocol to monitor pathogenic and/or quarantine diseases incidence at regeneration and multiplication sites including field seedbanks. In the future, they will need to initiate the screening of the plants in the field seedbank and the seed for key viruses.

The reviewers recommend that a Seed Health Specialist consultancy be done to provide technical support on seed and plant health (Table 4- item 36) 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.

Currently there is no laboratory nor staff to do seed health testing. In the future, they will need to initiate the screening of the plants in the field and the seed for key pathogens and viruses. This might require a partnership with a pathologist in another KALRO Institute. At that time, there will be a need to consider facilities and equipment for the testing.

Distribution

On average, 1,134 accessions were distributed as seed per year within the institute and 400 within the country during the last 5 years (Table 7). Within the country, the main requesters were from universities for students’ research work. There has been very limited distribution of accessions outside the country: only 581 samples in the last 5 years. There is very limited knowledge of the accessions conserved by the seedbank internationally as well as their availability for distribution. The KALRO website has a page for the seedbank but it has no specific information on the accessions held and their use. There are links to repositories for publications, but these are very limited for genetic resources.

Table 7 Number of accessions distribution to national users 2014-2019 by GeRRI

Recipient	2014	2015	2016	2017	2018
Within GeRRI and KALRO	203	1,434	248	798	2,980
Within Kenya (excluding KALRO)	4	291	687	729	282
Outside Kenya	172	0	7	382	20

In the baseline questionnaire, GeRRI reported that no formal requests were made for information/data on the usefulness of the accessions sent; type of traits or characteristics found in the material; and published research results based on the characterization, evaluation or use of the accessions. They only utilized an informal approach to solicit feedback from recipients on the quality of the seed received. Feedback from recipients is critical to reduce the risk of distribution of poor-quality seed that did not meet the needs of the requester or was not received on time. It also enhances the knowledge and use of the accessions by capturing data and results generated by other users.

Recommendation 12: To address the inadequacy in feedback on the use of accessions, the reviewers recommend that the GeRRI utilizes a routine formal process for soliciting and using feedback from recipients to improve seedbank operations and enhance accession level information with actions such as to:

- **Conduct routine user surveys on the use of the collections, delivery timelines, quality of seed received and other useful information.**
- **Fully implement DOIs to better link to information generated on the accessions.**
- **Develop a procedure for ensuring that information on the evaluation and use of the distributed germplasm is shared with GeRRI to enrich accession level data.**

Provision of some heavy-duty scales would prove useful in the dispatch of larger packages (Table 6 – item 17).

Regeneration, multiplication, and characterization

In the last five years, the seedbank has multiplied 19,043 accessions. This amounts to about 4,000 accessions per year. This would indicate they could still have a significant backlog of about 60% of the accessions that would potentially have not been multiplied recently. The backlog in the number of accessions that require regeneration due to poor viability is less

clear. Addressing the backlog for regeneration could require doubling the current rate, considering that the 60% of accessions are only conserved in medium-term conditions.

We also noted the difficulty in timely regeneration in the current field sites scattered across all agroecological zones with limited staff capacity to supervise and monitor field operations and post-harvest handling. At the seedbank, there is lack of access to facilities or land for regenerating accessions with very low viability or those difficult to regenerate species. The current approach to multiplication and regeneration has significant constraints with the high cost for staff travel; enormous logistical challenges; limited local staff capacity to adequately supervise pre-and post-harvest operations; and transportation of harvested seed or plant material to GeRRI.

The seedbank uses KALRO experimental research centers in the different agroecological zones of Kenya based on the adaptability of the different crop species. For example, the field site visited that is targeted for regeneration and multiplication of cereal and cowpea is a 5-6 hr. drive from Muguga (where the seedbank is based), and without qualified staff in handling of accessions stationed at the site, it must be difficult to adequately supervise all pre- and post-harvest operations and transport harvested material back to the seedbank for further seed handling. Thus, the reviewers recommend that GeRRI identifies two to three suitable sites where the majority of crop species can be regenerated with more secure monitoring.

GeRRI should explore the use of fields located near Nairobi that are owned by the University of Nairobi and other government institutions for regeneration of seedbank accessions with very low seed viability, number of seeds, or those difficult to grow. Depending upon outcome of site choice, the purchase of irrigation equipment may be required. The details of potential suppliers might be obtained from ICRISAT.

Currently, isolation cages are not being used for regeneration of insect-pollinated outcrossing species. Recommended isolation distance is not being used either. The harvesting of the middle of the plots is not adequate for regeneration. There are significant risks from the current approach with the cost for staff travel; enormous logistical challenges; limited local staff capacity to adequately supervise pre-and post-harvest operations, and transport of harvested seed or plant material to GeRRI. There is a high risk of loss or change in genetic integrity for accessions with poorly established and managed regeneration. This includes the impact of significant cross pollination from ineffective control of insect pollination. GeRRI needs to construct isolation cages that are mobile (Table 6- item 26). ICRISAT is utilizing a large screened cage that can be produced locally. This should be considered for the Kenya seedbank as well.

Recommendation 13: The reviewers recommend that GeRRI implement a realistic plan to securely regenerate priority accessions, those which fall below seed viability and seed number thresholds, at two to three suitable sites, for the duration of the S4R project as well as in the longer term, with significant improvements in the regeneration protocols to increase cost effectiveness and security. In addition, there is a need to access a site near Nairobi (such as the fields of the University of Nairobi or other governmental organizations) for regeneration of seedbank accessions at high risk of loss. Regeneration and multiplication should prioritize older accessions with low seed viability and/or low seed numbers.

Field Genebank

Currently, GeRRI does have small field collections of yams, sweet potatoes, avocados, and guava as well as an *in vitro* facility that the reviewers did not visit. There is no documentation on any of these accessions but in some case such as yams, these can be recovered. Also, the sweet potato collection is located at KALRO in Kakemega where it's status and composition are unknown to GeRRI. An *in vitro* facility was established at GeRRI in 2014 and was used for yam conservation but it no longer operates, and the yam accessions were transferred to ILRI or IITA. The use of this facility for securing the longer-term conservation of vegetatively propagated or recalcitrant crops needs to be considered for the future. There is a need to assess the security of the current collections of vegetatively-propagated crops held

by GeRRI and other institutions and if not adequate, this needs to be considered for upgrades with a more comprehensive understanding of the future for conserving local diversity that is threatened by climate change and land use changes. The reviewers recommend KALRO develop a long-term plan for the conservation of vegetatively-propagated crops currently held by GeRRI and other KALRO institutions or those to be acquired in the future to secure local crop diversity that is threatened by climate change and land use changes in Kenya.

Documentation

GeRRI indicated that they had 100% accessions with multi-crop passport descriptor (MCPD) data in a searchable database in the documentation unit but none is shared internally but some of the accessions have had passport and characterization data shared online in Genesys. When accession level information is needed, the documentation scientist queries the database and responds to the request. Only 11% (5,831 accessions) have been characterized with key morphological descriptors while only 6% are digitized into the database and none is shared internally or externally with users (Table 4). The reviewers recommend that GeRRI captures minimum characterization traits of priority crops during multiplication/regeneration and include it in the database.

Collecting data follows the MCPD standards but does not include the extra information that can be found on standard collecting forms (only location coordinates are recorded). Both collection and characterization data are recorded on paper forms and then digitized in the documentation unit. GeRRI is preparing to adopt GRIN-Global which will facilitate the digitization of the characterization data and the sharing of all accession level information.

The documentation system at GeRRI is largely manual: data is first recorded on paper forms and then it is brought to the documentation unit where it is digitised. Germplasm collecting is documented using the MCPD standard, only geographical information is added to the database. Once the material has reached the seedbank, it goes through a processing phase, while the collecting data is digitised. After the processing phase there is a registration process in which the accession number is issued. After that, the accession goes through seed testing where the testing information is recorded. Then the material goes through the storage process where the storage location is recorded. During storage, the material undergoes viability monitoring, duplication, characterisation and distribution.

GeRRI uses a Microsoft Access database to store information electronically. The database does not have a user interface for input: data is directly stored into its tables and there are no automated data validation procedures. Using a database to manage everyday processes of a seedbank is a good way forward, however, doing so without an interface that safely guides users through each step is not a sustainable option for a number of reasons. First of all, storing information directly into database tables is a delicate operation that can only be done by somebody who is very familiar with data management and databases. It is not something that can be expected from a staff member who is not an IT specialist. The other problem is that data validation is done as data is transcribed from paper, which doesn't provide the security and reliability automated data validations and quality checks offer. Finally, Microsoft Access is a single-user database, which means that, while several users can read information at the same time, only one user can add information.

The documentation unit has three workstations, one server and a printer in the documentation room. Paper forms are all brought to that room to be digitised and any request for information has to go through that room. This, along with the fact that only one staff member can input data at one time into the database, makes the current documentation workflow limited and inefficient.

For the above reasons, GeRRI has been investigating how the current data management activities could be transferred to GRIN-Global. So far, the IT manager has attended one training session in Nairobi and has been working closely with the CIMMYT team which helped migrate some data under that management system. The server has been fitted with Microsoft SQL and the GRIN-Global software. Users, lookup tables and taxonomic tables

have been loaded so far in the software. During the evaluation process the first idea had been to transfer information in bits, since the current database tables are structured in a similar way as GRIN-Global modules. However, GRIN-Global combines some of this information, so this became a slow and complicated process. It is expected that by next mid-year passport and storage data should be migrated into GRIN-Global.

GRIN-Global will provide an environment featuring workflows which will help staff perform their tasks with less errors and more data. It will also allow passport and characterisation be published automatically on Genesys. Adopting GRIN-Global is certainly the right solution to solve the current documentation bottleneck and to ensure data quality. While passport and storage information have already been added to the system, GRIN-Global strengths lie more in handling management data such as seed viability, seed availability, last regeneration date, seed packet weight.

The database manager was sent to one training session, but this is not sufficient to successfully implement the software and migrate current procedures. GRIN-Global is a powerful but complex system which it takes time and effort to understand its structure, how to take advantage of its power and how current activities can be migrated. This task is very demanding, because the institute is relying on one staff member to handle routine documentation duties while migrating the documentation system. This results in long interruptions of the migration activities, which require the staff to familiarise themselves with the system when returning again to configure GRIN-Global. Migrating a documentation system is a full-time task. Time needs to be dedicated into understanding how the new system works, its capabilities and, at the same time, rationalise current documentation activities so that the migration does not disrupt the current workflow. It is only with experience that it becomes possible to plan a documentation system migration without resorting to trial and error, attending one training makes this neither easy nor obvious, given the complexity of GRIN-Global.

The reviewers recommend that an expert in seedbank operations and GRIN-Global visit the seedbank and analyse with the staff the current workflow and documentation practices to migrate the current activities under GRIN-Global. The role of the expert 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 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. Thus, the reviewers recommend a GRIN-Global Specialist consultancy with an expert who is also familiar both with seedbank operations and GRIN-Global to work directly with GeRRI (Table 6- item 37) with the following term of reference to:

- Rationalize the responsibilities of the various units to create a working environment that matches the features and organisation of GRIN-Global
- Facilitate the full implementation of GRIN-Global.

As current germplasm management workflows are being analysed and rationalised, these should be optimised and enriched with missing data, correcting dysfunctional practices, and only then migrated in GRIN-Global. For instance, collecting data follows only the MCPD standard, but does not include the extra information that can be found on standard collecting forms. Standard operating procedures should be produced and updated during the assessment phase, in particular relating to documentation activities under GRIN-Global: access to data will no more be constrained to one staff member. It is important that these SOPs be available to anyone who needs to manage information.

Another aspect which should be tackled is the reliance on paper forms. One of the most burdening phases of documentation is germplasm collection and characterisation: the information is first recorded on paper, then it has to be transferred on the computer. This takes a long time, because trying to correctly interpret handwriting can be difficult and error prone. There is a backlog of information stored on paper that needs to be digitised, but this

must not be done at the expense of the documentation system migration, so the reviewers recommend that temporary staff be hired and dedicated to those activities.

The reviewers recommend that three electronic tablets (Table 6- item 28 and 29) should be purchased to reduce reliance on paper forms. The institute had been thinking in the past of using tablets in the field and it is something that is still in the pipeline: GRIN-Global could make that happen, since it is compatible with such devices. *The reviewers also recommend that a digital camera be procured (Table 6- item 34) to allow for the capture and storage of images to enhance accession level information.*

The institute has also been thinking about implementing a barcoding system in the very near future. This system should be set-up to be compatible with GRIN-Global. *The reviewers recommend the purchase of five barcode readers (Table 6, item 28 and 29), two portable barcode printers for short-term usage (Table 6, item 31), and a fixed barcode printer (Table 6, item 31) for longer-term usage.*

Currently, germplasm bags are labelled inside and outside with handwritten labels. *The reviewers recommend that one fixed printer/scanner (Table 6, item 33) should be purchased to replace the current label printer which does not work.*

Currently one of the partitions of the server is used for backups and back-ups are performed manually by copying data into a portable disk and flash disk which are stored in separate locations. *The reviewers recommend that a couple of portable rugged hard drives (Table 6- item 35) could be used to back up the entire contents of the server, allowing it to be fully restored in the event of a failure.*

Buildings including safety, security and services

The seedbank comprises two separate buildings. The one containing two large cold rooms and a small seed drying unit (Figure 1) has a number of concerns with respect to both staff and collection safety. It has a heavy asbestos tiled roof which if disturbed in any way, is of concern regarding staff health. Ideally, it should be carefully and expertly removed and replaced with a more suitable material. The weight of this roof is causing damage to the walls of the building though the extent of that damage is uncertain.

The building's recently built seed packaging station is a particular concern with respect to staff safety. Its sole evacuation route in the event of a fire involves moving through four doors. Furthermore, it has no windows. Some of these should be installed, direct access to the outside provided and the removal of the secondary airlock is recommended subject to the structural survey (see next paragraph).

The reviewers recommend a structural survey consultancy (see Table 6 – item 5) to provide written advice on the structural soundness of the conservation unit and the installation of external door(s) and windows in the seed packaging station. Should the advice be that the building is unsafe, then additional funding should be sought to carry out remedial works or to replace it since such costs will lie outside of the scope of the S4R project.

There are no functioning alarms within the current building which is a particular concern with respect to fire. The reviewers recommend a fire alarm consultancy (see Table 6 – item 4) to provide written specialist advice on the provision of fire alarms & external sounders and the required maintenance schedule.

Further concerns are the building's security locks (though it is in a secure compound and there is night security) and the potential impact damage from vehicles parked adjacent to the building. Similarly, there is a fuel tank right up against the building that is a serious fire risk that needs to be moved urgently. *These can be addressed through simple building works (Table 6 – item 24).* Without the above changes, investment in new cold rooms or drying units within this building would be unwise.

The power situation is a main constraint for the seedbank. Currently they experience long periods of power outage from the grid. Thus, they have had to depend upon the ageing 1987 generator and expensive fuel. Furthermore, GeRRI do operate the generator outside working

hours but if it is a prolonged outage, the generator has to be turned off to cool down due to its old age. This results in having to leave the cold rooms and the facility without power sometimes. The generator also covers the entire facility, not just the cold rooms. It is only currently serviced on break-down. The facility has no power obtained from alternative sources, such as solar panels. With a costly and intermittent electricity supply in Kenya 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 as well as meeting a significant portion of their energy needs from electricity provided from solar or other alternate sources. This should allow for a shift to utilize the generator for securing the essential equipment, such as the cold rooms, with the use of solar or other alternative for the rest of the laboratories and documentation group.

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 6- item 38) 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 providers.

Table 6. Recommended procurement plan for GeRRI upgrade

Item	Proposed purchase	Potential supplier	Est. item cost	No. items	Est. shipping & import cost (Euro)	Total cost (Euro) ¹	Comment
1. Germination room	Room conversion	(a) Local	2,000	-	-	2,000	
2. Refrigeration and air-conditioning consultancy		(a) Club Refrigeration, RSA; (b) Various potential RSA Refrigeration companies online	9,400	-		9,400	Assume return scheduled SAA flight RSA to Kenya = GB£ 1,391 = Euro 1,617; 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 9,317 say 9,400. Could visit other banks as well – one contract (more cost-effective)
3. Fire alarm consultancy		(a) Local	500	-	-	500	Potentially <i>may</i> be coverable by Refrigeration and air-conditioning consultancy
4. Structural survey		(a) IITA	1,000	-	-	1,000	Travel and subsistence only. Will there be a charge?

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

Item	Proposed purchase	Potential supplier	Est. item cost	No. items	Est. shipping & import cost (Euro)	Total cost (Euro) ¹	Comment
5. Installation costs of following 5 items		(a) Club Refrigeration; (b) Various potential RSA Refrigeration companies online	20,000	-	-	20,000	Notional sum including shipment of items
6. Munters unit	Model tbc	(a) Club Refrigeration, RSA; (b) Munters RSA	10,000	2	-	20,000	Depends on advice received. Notional sum
7. Air-conditioners	Model tbc	(a) Club Refrigeration, RSA; (b) Local supplier	1,500²	2	-/Local	3,000	Depends on advice received. Local purchase
8. 'Outside of condition' alarms for drying room, cold rooms and growth room	Model tbc	(a) Club Refrigeration, RSA; (b) Various potential RSA Refrigeration companies online	500	-	-	500	
9. Upgrade of growth room		(a) Club Refrigeration RSA; (b) Various potential RSA Refrigeration companies online	5,000		-	5,000	
10. Generator	Model tbc	(a) Local	20,000		Local?	20,000	Notional figure only. Depends on advice received

² Figures in bold have greater degree of certainty.

Item	Proposed purchase	Potential supplier	Est. item cost	No. items	Est. shipping & import cost (Euro)	Total cost (Euro) ¹	Comment
11. Fire / smoke alarms & sounders	Model tbc	(a) Local	500	-	Local	500	Depends on advice received. Local purchase
12. Stereomicroscope	Nikon SMZ445	(a) Nikon Instruments Europe BV, NL; (a) Try VWR / Avantor	1,000	1	250	1,250	May require light source within stand
13. 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
14. Sieves	Endecott	(a) SLS, UK; (b) Endecotts, UK (RSA distributor)	100	10	1,000	2,000	Sieve dimensions / pore size to be advised
15. Face masks	Model tbc	(a) 3M, UK; (b) Local	30	20	200	800	Preferably re-usable half masks with replaceable filters
16. Heavy-duty scales	Model tbc	(a) Local	750	1	Local	750	Assume local purchase
17. 2-decimal place balance	Ohaus PX3202/E	(a) Fischer Scientific, UK; (b) Try VWR / Avantor	1,000	1	250	1,250	3,200g x 0.01g
18. Seed counter	Contador	(a) Pfeuffer, Germany; (b) Hoffman, USA	8,000	1	250	8,250	16kg; Check seed sizes required

Item	Proposed purchase	Potential supplier	Est. item cost	No. items	Est. shipping & import cost (Euro)	Total cost (Euro) ¹	Comment
19. Ventilated oven	Genlab ME200/SS/DIG	(a) Genlab (Kenya) (b) Try VWR / Avantor (but different make)	2,000	1	500	2,500	
20. RH / Temperature logger	Gemini Tiny Tag View 2 TV-4500	(a) Gemini Data Loggers, UK (RSA distributor); (b) tbc	200	2	50	450	
21. Foil bag sealer	HM305CTD	(a) Hulme Martin, UK; (b) tbc	1,250	1	250	1,500	Do they export? 10.7kg DHL cost (up to 12kg) £139
22. Foil bags	Type 321/04 (Moore & Buckle)	(a) Moore & Buckle, UK; (b) tbc	12,000	-	1,500	13,500	Notional
23. Building work	Extra door, move fuel tank, create impact-prevention barriers etc	(a) Local	5,000	-	Local	5,000	Notional
24. Security locks	tbc	(a) Local supplier	1,000	-	Local	1,000	Notional
25. Fire extinguishers	tbc	(a) Local or regional supplier	100	4	Local	400	
26. Isolation cages	Locally-built	(a) Local	1,000	-	Local	1,000	Notional
27. Equipment for seed health	Unspecified	(a) Various	?	-	?		Unspecified at present

Item	Proposed purchase	Potential supplier	Est. item cost	No. items	Est. shipping & import cost (Euro)	Total cost (Euro) ¹	Comment
28. Electronic tablet	Zebra TC75		1500	2		3000	For use as mobile data input devices. These devices could be used when the seedbank management system is operational, thus the model depends on the compatibility with the management software.
29. Electronic tablet	Zebra ET50		3500	1		3500	For use as mobile data input devices with more complex input forms.
30. Barcode reader	Zebra Symbol LS2208		100	5		500	To be used to read barcoded labels.
31. Barcode portable printer	Zebra Series ZQ500		600	2		1,200	Use direct thermal printing for short term usage indoors.
32. Barcode printer	Zebra Series ZT410		1,200	1		1,200	Use thermal transfer resin labels for long-term storage or field use.

Item	Proposed purchase	Potential supplier	Est. item cost	No. items	Est. shipping & import cost (Euro)	Total cost (Euro) ¹	Comment
33. 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.
34. Digital camera	Nikon Coolpix W300 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.
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. Seed Health Specialist Consultancy				1		16500	
37. GRIN-Global Specialist Consultancy				1		16500	
38. Solar energy consultant				1		3000	
Total						177,340	

Distribution, Communication, and Use of accessions and linkages with its users

The standard engagement used by the seedbank is through a range of annual activities such as field days, seed fairs, hosting visitors to the seedbank, and radio talks. There is, however, significant involvement in regionally funded projects which is an indication of effective international engagement. There are no clear linkages among local and national stakeholders which limits the extent to which the collections are used to contribute to agricultural development in the country. This will also limit national support for the seedbank in the long-term.

Most of the national users are researchers within KALRO and universities for evaluation and in some cases characterization for specific traits; but data from such activities is not incorporated into the database. One of the mechanisms used to share information is policy briefs but their wide accessibility was not clear. Further, the content and length of these briefs are rather more of a technical nature than policy briefs which are usually shorter. We believe that limited use of accessions risks the future of agricultural development based upon the use of these valuable genetic resources.

To enhance engagement with all users, the reviewers recommend that accession level information is published online and updated regularly in a searchable database on the seedbank website and Genesys as discussed in the section on the baseline indicators. In addition, the reviewers recommend greater efforts are 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.
- Further develop awareness materials and communication pathways tailored to different user groups including farmers/NGOs, seed producers at agroecological level; researchers/scientists; and 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.
- Develop 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 suggests seed material to users (e.g. farmers, NGOs, breeders) according to local agroecological conditions and availability.
- Maintain an online presence via social media, such as Facebook, Twitter and Instagram.

Effective collaboration with other conservers

GeRRI has included its Annex 1 materials into the MLS, sharing this material with an SMTA. It has also conducted various stakeholder training and awareness workshops on the ITPGRFA. Draft regulations to implement the ITPGRFA have been prepared and are waiting to be finalized by stakeholders. The seedbank has partnered with other institutions to implement projects supported under the Benefit Sharing Fund of the ITPGRFA. The seedbank is a member of the Open Source Seed Systems Network and has collaborated with the CGIAR Seedbank Platform and Seeds for Life Project family.

GeRRI has had collaborative activities with ICRISAT in joint collections of crops such as pigeon pea, finger millet, sorghum, and pearl millet. They also have collaborated with the Millennium Seed Bank (MSB) in the collection of crop wild relatives. Effective engagement at the international level or with international organizations enhances the visibility and support for the seedbank. This also provides opportunities for capacity building in new innovations in genetic resources research. Thus, the institute should strengthen collaborative activities with other conservers.

More effort should be made to identify redundancies and gaps in global collection of accessions from Kenya with CGIAR Centers for their mandate crops and with other national seedbanks to better target new collection trips. Enhanced engagement with CGIAR Centers with offices or headquarters in Nairobi on genetic resources conservation and use is highly desirable.

The reviewers recommend that GeRRI engages more formally with the CGIAR centers and other national conservers that conserve accessions collected from Kenya 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

The seedbank has had limited opportunities to engage with a diversity of users, such as smallholder farmers, in the evaluation of accessions for traits of preference. Most of its partners and users are researchers. Experience with farmers are development efforts in the multiplication of seed for distribution as well as multiplication and characterization plots, demonstrations, and seed fairs. Smallholder farmers are the custodians of local landraces and should be seen as a target group for accession level information sharing. Thus, the seedbank should increase engagement with NGOs and other key stakeholders. Limited knowledge about the value of the collections amongst various user's risks reduced demand and support for the conservation of the collection.

The reviewers can identify three distinct user/stakeholder-groups that can contribute to increasing the use of accessions and visibility of GeRRI, and ultimately contribute to a more climate-change resilient agriculture. These include: direct users group representing all stakeholders operating in different agroecological zones; breeders/researchers' group which includes breeders and researchers from national and international agricultural research institutes and universities interested in using accession level diversity to develop new varieties; and the policy-makers -user group comprising of decision-makers such as directors of other key institutions, representatives from the government and donors where possible, relevant to increasing general awareness of the value of the national seedbank. Implementation of a tailored communications strategy will facilitate effective linkages with the various user/stakeholder-groups as recommended in previous section.

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 address the apparent inadequacy in effective engaging with stakeholders, it is essential that GeRRI fosters an enabling environment to create stronger collaborations with users and other relevant national 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. This includes:

- Enhance collaboration and engagement with national and international stakeholders, including the private sector and CGIAR Institutes.
- Participate in regional events/shows related to plant genetic resources and climate change.
- Actively engage with regional and international plant genetic resources networks/platforms.

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 GeRRI fosters an enabling environment to create stronger collaborations with users and other relevant national stakeholders.

Recommendation 14. The reviewers recommend that GeRRI organize facilitated meetings at agro-ecological zone level (2-3) with representatives of farmers' organizations, NGOs, local government agencies, research institutions/universities based in the zones, and local seed producers (max. 40 participants per zone). The reviewers also recommend that GeRRI constitutes a technical working group of breeders/researchers within KALRO, universities, and the private sector for characterization, evaluation and use of collections in crop improvement. In order to elevate the profile of the national seedbank and raise awareness on the importance of supporting it, the reviewers strongly recommend that EBI holds at least two facilitated high-level meetings with key policy makers 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 agroecological 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 on information needs and feedback mechanisms for each agroecological zone
- agree on modus operandi of each agroecological zone user group for information sharing and feedback.

Other key activities that should be considered include:

- Multiply/bulk seed of accessions of identified crop portfolio 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.

The reviewers also recommend that GeRRI constitutes a technical working group of breeders/researchers within KALRO, universities, and the private sector for characterization, evaluation and use of collections in crop improvement. We propose at least one annual meeting to convene this working group of around 10-15 key breeders and scientists from KALRO, 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
- 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

In the last five years GeRRI has been engaged in a 4-year (2016-2019) regional project promoting open source seed systems for beans, forage legumes, finger millet and sorghum for climate change adaptation in Kenya, Tanzania and Uganda; and a 3-year project (2014-2016) on mainstreaming plant genetic resources conservation into climate change adaptation strategies. Use of the conserved crop diversity directly by farmers, especially for the crops with limited crop improvement efforts contributes to the resilience and productivity of the cropping system with the challenges of climate change. Testing and use of accession for improving climate smart varieties will enhance the adaptation of crops to these challenges. More efforts are needed in this domain.

There is a recognition of the significant contribution of diverse national collections to adaptation to climate change and resilient seed systems, but the low level of knowledge and use of the collection is not conducive to long-term adaptation to the changes in climate.

Recommendation 15: To address the limited use of national collections to enhance crop diversity to mitigate the effects of climate change, the reviewers recommend that GeRRI facilitates technical support in the evaluation, characterization, and multiplication of accessions of underutilized and climate smart crops for direct use in the cropping system by:

- **Together with the technical working group of breeders/scientists, identify a core collection of underutilized and climate-smart crops for use in crop improvement.**
- **Multiply/bulk seed of selected accessions for distribution.**
- **Together with breeders/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 breeders, 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

Risk assessments, management plans, and monitoring are the responsibility of safety committees. For KALRO, a safety committee has been appointed by the director general. At the seedbank level, the safety committee is still not operational, and there is no clear focal point. The staff did not report any specific issues related to failure to manage risk in the past.

Risks that involves human health and safety are managed by the HR Section, which is responsible for sensitizing all KALRO employees on the policies and procedures. Staff can file complaints through complaint boxes posted throughout KALRO and each is handled by special committees. These include reporting suspected corruption and mismanagement. GeRRI indicated that staff have been filing complaints that are leading to changes. KALRO and GeRRI are managing environmental, health, and safety risk but not social risk.

The primary threats to the collection that GeRRI recognized in the baseline survey are:

- Intermittent power supply or power cut-off for extended periods of time.
- Breakdown of equipment and facilities, such as cold room and drying room malfunction.
- Lack of funds to undertake regeneration.
- Information Communication Technology (ICT) software and hardware malfunction. ineffective data back-up, inadequate ICT skills, ineffective data and documentation system
- Theft and vandalism targeting ICT equipment, laboratory, conservation facilities, and seed samples
- Fire.
- Loss of seed samples due to loss of viability and vandalism.
- Human errors leading to misidentification of accessions, misplacement, mislabeling, mixing, and incorrect recording of data emanating from various operations.
- Lack of effort to test for disease/pathogens in the collection due to lack of capacity.

A practical risk management plan for the seedbank to mitigate the primary risks needs to be developed as an urgent action. The review team has identified significant risks in Table 8 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 8. These are risks that are external to GeRRI 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 been taken into account in the development of the upgrade recommendation by the reviewers.

Recommendation 16. The reviewers recommend that a detailed risk management matrix (such as Table 8) is agreed upon and used as the basis for monitoring risk for the seedbank on an annual basis with updates provided as needed by GeRRI to the Crop Trust.

Table 8. 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 GeRRI					
Loss of crop diversity in farmers field and in the wild	High	Long-term plan for collection of crop diversity with identification of priority gaps	Medium	Medium	GeRRI and Crop Trust
		Secure conservation of accessions ex situ			
		Rationalize current collection to manage redundancy with other conservers			
Increased incidents of drought	High	Access to irrigation in field seedbanks and in regeneration sites	Low	High	KALRO and GeRRI
		Enhance testing and use of accessions with drought tolerant traits by researchers and farmers			
Inadequate electricity supply	High	Greater investment into energy efficiency and alternative energy through projects or government support	High	Medium	GeRRI, Crop Trust, and KALRO
		Safety duplication of accessions in seedbank outside Kenya			
High cost of fuel	High	Greater investment into energy efficiency and alternative energy through projects or government support	High	Medium	GeRRI, Crop Trust, and KALRO
		Safety duplication of accessions in seedbank outside Kenya			
Insecurity in Kenya	Medium	Secure building and cold rooms with strong locks and/or keypad access	Low	High	KALRO and GeRRI
		Increased monitoring of regeneration sites			
Inadequate and inconsistent annual government spending for KALRO and GeRRI	High	Ensure government funding obligation in the project agreement	Medium	Medium	Crop Trust and GeRRI
		Increase visibility for the seedbank, its value, and its needs by KALRO to Ministries and Parliament			
Institutional administration, finance, and policy					
Inadequate planning for long-term support for crop conservation and uses within KALRO and Ministry	High	Long-term plan (10-20 years) for seedbank with implementation monitored transparently by KALRO with key users and stakeholders	Medium	High	KALRO and GeRRI

Source of risk	Level of risk	Mitigation actions	Level of risk after mitigation	Likelihood of successful mitigation	Responsibility for risk management
Unclear financial situation of GeRRI due to the absence of externally audited yearly financial statements	Medium	Establish and publicly share external audits of financial statements for both KALRO and GeRRI on a yearly basis.	Low	Medium	KALRO
Inadequate reporting and replenishment of funds	High	Quarterly financial monitoring and annual audit of account	Low	High	Crop Trust and GeRRI
		Clear terms and conditions in project agreement on disbursement of funds and replenishment schedules			
Inadequate management of key assets of project	Medium	Clear terms in project contract on management of assets procured, maintained, or repaired by project	Low	High	GeRRI and Crop Trust
		Clear terms for donation of assets to seedbank within GeRRI at end of project			
		Regularly scheduled maintenance of equipment			
		Timely repair when needed			
Bureaucratic procurement process	High	Crop Trust to handle project procurement of capital items directly	Low	High	Crop Trust and GeRRI
		Project agreement specifies custom clearance process for procurement, especially the payment of duties			
		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	High	KALRO and GeRRI
		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 KALRO and GeRRI, 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			
Links to users					

Source of risk	Level of risk	Mitigation actions	Level of risk after mitigation	Likelihood of successful mitigation	Responsibility for risk management
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	Medium	High	GeRRI
		Increased collaboration with other KALRO Institutes, NGOs, and private sector to link to smallholder farmers and communities			
		Increased collaboration with communities to support conservation and promotion of genetic resources			
Inadequate feedback to and from user	Medium	Establish a formal process to solicit feedback from recipient of accessions	Low	High	GeRRI
		Monitoring the impact of the use of conserved accessions on production, crop diversity and resilient seed systems.			
		Greater engagement with users through stakeholder meeting or through advisory group for the seedbank			
Inadequate communication on the seedbank, its accessions and any impacts to users, policy makers, and other key stakeholders	Medium	Communication strategy with implementation plan and key performance indicators	Low	High	GeRRI
Inadequate accession level passport, characterization and evaluation information available and shared online	Medium	Recovery of data generated by recipients of accessions in the past	Low	Medium	GeRRI, KALRO, CGIAR Centers, and Universities
		Formal agreements with research recipients on sharing research results and data with seedbank for inclusion in seedbank information system			
		Collaboration with universities and others to increase opportunities for student projects			
		Access to accession level information increased with Genesys and GeRRI webpage within KALRO website			
		Clear the backlog for the digitalization of all information held on paper			
GeRRI Facilities					
Design and construction of the seed storage building	High	Determine structural soundness of the Conservation Unit and if found unsafe, then	Low	Medium	KALRO, GeRRI, and Crop Trust

Source of risk	Level of risk	Mitigation actions	Level of risk after mitigation	Likelihood of successful mitigation	Responsibility for risk management
		additional funding should be sought to carry out remedial works or to replace it			
		Installation of external door(s) and windows into the Seed Packaging Station.			
		Relocate fuel tank			
Age of the drying and storage facilities.	Medium	Repair or replace insulation, dryer, and controls as needed if seed storage building is sound	Low	Medium	KALRO, GeRRI, and Crop Trust
		Repair or replace insulation, compressors, and controls for cold stores when funds are available and seed storage building is sound.			
Fire	High	Adequate firefighting equipment	Medium	High	KALRO, GeRRI, and Crop Trust
		Internal and external alarms and sounders			
		Adequate fire safety training			
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	KALRO, GeRRI, and Crop Trust
		Restricted access to the cold rooms with key pad access			
Routine Operations					
Increased backlogs in routine conservation operations with increased focus on expanded mandate for GeRRI and shift to more project-based funding	High	Priority given to efficient, cost effective routine operations for conservation in annual workplans and performance contracts	Medium	High	GeRRI and Crop Trust
		Clear costing for routine operations			
		Annual transparent reporting and monitoring for key performance indicators by Crop Trust and other stakeholders			
Insecure and inefficient routine management of conservation of accessions	High	Upgrade facilities, equipment, documentation, and processes for key routine operations	Low	High	GeRRI and Crop Trust
Conservation and distribution of seed with unknown viability or germination potential	High	Upgrade facilities, equipment and processes to document seed germination routinely	Low	High	
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	GeRRI and Crop Trust
Inadequate monitoring of seed quantity	High	Upgrade facilities, equipment, and processes to document 250 seed and packet dry weight	Low	High	GeRRI and Crop Trust

Source of risk	Level of risk	Mitigation actions	Level of risk after mitigation	Likelihood of successful mitigation	Responsibility for risk management
		Initiate information system processes to monitor 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 crops with a range of mating systems	Medium	High	KALRO, GeRRI, Crop Trust
		Develop 5-year plan to regenerate at least those accession with very low viability			
		Utilize isolation cages for insect pollinated accessions			
Insecure long-term access to appropriate land resources for regeneration, multiplication, and other field related activities for the seedbank	Medium	Ensure clear commitment by KALRO and other relevant governmental agencies to make available appropriate land resources for long-term use by GeRRI	Low	High	KALRO, GeRRI, Crop Trust
		Provide sufficient resources to KALRO, its stations, and GeRRI to maintain land resources and ensure seedbank access for the long-term			
Inadequate safety duplication	High	Prioritize unique accessions by crop and arrange for safety duplication with institutions outside of Kenya to serve as a primary black box	Low	High	GeRRI and Crop Trust
		Dispatch seed to the Global Seed Vault in Svalbard as a secondary site			
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	Map workflow with documentation needs for the key routine operations	Low	High	GeRRI and Crop Trust
		Upgrade facilities and equipment for documentation			
		Install and fully utilize a seedbank information system such as 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 20 - 24, 2019

Nairobi, Kenya

Agenda

Time	Session	Items to be addressed	Participants	Facilitators
DAY 1: September 20				
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	<p>Getting to know the genebank and the people who work there.</p> <p>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):</p> <ul style="list-style-type: none"> - 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 21				
07:00 - 13:00	Visit to regeneration site		Head of genebank, review panel, Crop Trust project manager	Head of genebank
	Travel back to Nairobi			
DAY 4: September 23				
08:30 - 11:00	Review of any outstanding issues with genebank staff		Genebank staff	Review panel
11:00 - 13:00	Risk management & quality management system	General discussion on risk measures, implementation of a quality management system		
13:00 - 14:00	Lunch			
14:00 - 15:00	Travel to KALRO HQ			
15:00 - 16:30	Meeting with KALRO senior management	<p>Reviewers are provided a description of the overall research strategy and where the genebanks fits into ongoing or planned research.</p> <p>Reviewers will address various aspects related to the institutional and management arrangement of the institute.</p>	<p><u>KALRO senior management:</u> Director General, Head of budgets/finances, Governance official, Director of research, head of genebank</p> <p>Review panel, Crop Trust project manager</p>	Chair of review panel/Crop Trust project manager
DAY 4: September 24				
09:30 - 12:00	Review of any outstanding issues with genebank staff			
12:00 - 13:00	Risk management & quality management system	General discussion on risk measures, implementation of a quality management system		
13:00 - 14:00	Call with IT reviewer			
14:00 - 14:30	Travel to hotel			
15:00 - 16:00	Reviewers to meet with ICRISAT			