AfricaRice Genebank Review 2014

Programme: Genebanks CRP		
Genebank reviewed: AfricaRice	**Site visit Dates:**	05 May 2014 - 08 May 2014
	Review report Date:	23 Jun 2014
	Center and Crop Trust responses:	15 Nov 2014
Place: Cotonou, Benin		

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RESEARCH PROGRAM FOR Managing and Sustaining Crop Collections

CGIAR

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AfricaRice 2014 Genebank Review: recommendations and responses

	Recommendation	Responses by AfricaRice	Responses by Crop Trust
1. *Germplasm collecting and acquisition*	Under the institution-wide coordination of the GRU, conduct a systematic gap analysis in the acquisition and collecting of rice germplasm, including the extent of safety duplication of all NARS accessions at the GRU, and develop and implement a cohesive long-term plan for further targeted acquisition and collecting.	Agreed. AfricaRice will liaise with Dr Khoury Colin and Dr Nora Castañeda-Álvarez from CIAT, for information on the gap analysis process. We will also send questionnaires to all NARS partners in Africa and obtain the list of accessions collected in their countries in their Genebanks as well as accessions of Africa origin stored in IRRI Genebank and compare it with our data. We will ask for the seeds of missing accessions for conservation at AfricaRice's genebank. We will share this proposition with our partners during the next meeting of the Africa-wide Rice Breeding Task Force. The partners who have funds for collecting germplasm could request AfricaRice for technical assistance. Gap analysis will be completed by the end of April 2015.	The Crop Trust agrees with the recommendation and Africa Rice's response. We understand that the reviewers are suggesting that Africa Rice develop a strategic and long-term acquisition plan to fill gaps and support national genebanks. Africa Rice is responding that they will conduct gap analyses and consult with partners. Coordinating also with IRRI is important in this regard. There may also be other steps, for instance consulting with users, before Africa Rice develops an acquisition strategy.
2. Conservation facilities	It is recommended that GRU urgently reviews its germplasm conservation infrastructure and take immediate steps to ensure that the environmental conditions for its operations meet internationally agreed standards. Also, adequate threshing and temporary storage facilities for freshly harvested or collected material should be provided.	Agreed. AfricaRice is in the process of improving its germplasm conservation infrastructure: - 2 new condensing units with good cooling capacity (similar to that of GRC at IITA Ibadan) will be installed for the main MTS - A dehumidifier will be added to the MTS pre-room - Electronic temperature and humidity data-loggers will be installed in MTS, with a display screen outside - An alarm system linked to the temperature and humidity data loggers will be installed - Vacuum hot sealing machine will be introduced for storage in the LTS and safety back up at Fort Collins and Norway. - For seed multiplication in Ibadan, equipment for drying, threshing, winnowing, and short-term storage rooms are available. - In Cotonou, space and equipment for drying, threshing, winnowing, and temporary storage have to be allocated. AfricaRice is seeking fund for these.	The Crop Trust supports this recommendation. Africa Rice has taken very seriously the recommendation and has made a comprehensive reply. We would very much like to support Africa Rice in the review of its infrastructure and equipment needs and purchases in any way we can. We also encourage them to consider what support IITA, IRRI or other institutes can provide.
3. *Germplasm management procedures*	GRU should conduct a critical expert review of its chain of seed processing and storage activities that constitute the routine	Agreed. AfricaRice will hire a consultant to review its seed processing and storage activities and ensure these meet	Africa Rice is not alone in receiving this recommendation. The processes at Africa Rice may be in need of more overarching review given that they are

	Recommendation	Responses by AfricaRice	Responses by Crop Trust
	genebank operations, identify and remedy shortcomings in order to achieve a more effective and efficient work flow in keeping with international standards and also ensure that the entire collection is adequately characterized as soon as possible.	with international standards. Where processes need improvement AfricaRice will introduce these changes as part of the lab best practices. As specified during this review, germplasm characterizations are done at AfricaRice on a project basis. AfricaRice will complete characterization of the entire collection by end of 2017.	relatively new and less-practiced, and also given the slight complication of the LTS being situated in Ibadan. Africa Rice will certainly benefit from the work of Janny van Beem over the next 2 years, to improve the quality of documented procedures. She will be able to facilitate the transfer of excellent practices between CG genebanks. We would also like to emphasize that Fiona Hay's expertise would be very useful in providing inputs into procedures. We recognize the challenges of characterizing a collection of 20,000 accessions through project based work and fully support Africa Rice's efforts to complete minimum characterization by 2017.
4. *Within accession diversity management and conservation*	An institutional strategy for the management of genetic stocks such as pure lines descended from original accessions and which are used in breeding and/or research, including gene discovery and sequencing, should be developed and implemented.	Agreed. AfricaRice will develop a clear institutional strategy for the management of genetic stocks such as pure lines descended from original accessions by end of 2015.	The Crop Trust fully supports the recommendation and response from Africa Rice. The genebanks meeting in Arusha will be a good venue for the genebank manager to share her ideas with other genebank managers.
5. *Enhanced security of accessions through adequate storage*	It is recommended that GRU introduces samples of all AfricaRice germplasm holding as a matter of priority into LTS; review its operations regarding the materials under LTS at IITA, Ibadan, Nigeria with a view to greater monitoring of the status of the samples.	Agreed. AfricaRice will urgently develop a strategy to introduce all AfricaRice germplasm in MTS into LTS by 2017. An inventory of the accessions conserved in LTS in Ibadan was completed in July 2014. Up to date a total of 8293 accessions are conserved in LTS. Out of these, 5300 accessions stored before 2000 need to be monitored for their viability and repacked in aluminium foil with barcoded labels. An additional staff of one research assistant should be recruited and based in Ibadan for this activity.	This is an important point. We would like to clarify that our understanding is that Africa Rice will have all germplasm in LTS by 2017. Africa Rice's plans should be discussed with IITA to determine an efficient monitoring arrangement. In the review of procedures (R#3) it will be worth spending some time working out whether it would be more effective to test viability or carry out other operations on site in Ibadan rather than transfer the samples to Cotonou.
6. *Information management*	It is recommended that GRU, as a matter of urgency, uploads the available passport and characterization data onto ARGIS and to implement fully the barcoding system for all its operations as soon as practicable. GRU should also, based on a thorough evaluation of possible germplasm management systems (e.g. ARGIS, GRIMS	Agreed. GRU is working to finalize passport data of all accessions in MTS, and data will be uploaded into ARGIS and Genesys. Available data will now be uploaded by the end of 2014. AfricaRice will work to implement fully the barcoding system for all its operations by end of 2016.	The Crop Trust supports both recommendation and response. The question of what data management system to adopt remains pending. We understand that this may remain an open question until more feedback is provided on GRIN-Global. We would support open discussion on this point, particularly with close partners.

	Recommendation	Responses by AfricaRice	Responses by Crop Trust
	and GRIN-Global), adopt and implement a robust system that ensures full compatibility with especially CIAT and IRRI rice germplasm information systems and permits the use of Genesys as gateway.		
7. *Quality Management System*	GRU should as a matter of urgency, complete, peer review and publish, both as hard copy and on the GRU website, the draft genebank operations manual. Furthermore, GRU is encouraged to work towards the establishment of a quality management system for all its routine operations.	Agreed. AfricaRice will urgently complete, review and publish its genebank operations manual by April 2015. The draft of the operational manual is available. With the full support of AfricaRice management, AfricaRice's genebank is seeking (a consultant) to work toward the establishment of a quality management system for all its routine operations. QMS will be completed by the end of 2015.	The Crop Trust supports the recommendation and response. Again Janny van Beem will provide support to Africa Rice for this, working towards the adoption of a minimal QMS by the end of 2016.
8. *GRU website*	GRU is urged to enhance the utility of its website by providing an information exchange platform for use by its rice genetic resources community of practice; performing regular update of the contents; and by making copies of all validated protocols, manuals, SOPs and other relevant documents available.	Agreed. AfricaRice's GRU is working with ICT to enhance the visibility and use of its website and will achieve by end of 2015.	The Crop Trust supports this recommendation. Some more clarification from Africa Rice of what might be achieved would be useful here. We trust more details will be provided in the submitted workplans.
9. *Plant quarantine, seed health and germplasm distribution*	It is recommended that the Plant Pathology Unit of AfricaRice conducts a comprehensive review of the best genebank practices for controlling seed-borne pathogens and to align its own practices with those of international genebanks of the CGIAR. Regarding the weak national capacities for plant quarantine, AfricaRice is urged to take steps to improve the situation, including the hosting of the staff of the national institution within the Centre's premises and to integrate this sensitive responsibility in its institutional QMS.	Agreed and the review of best practices is already being implemented and aligned to international rule. But we are considering situation of PQ system in Africa. AfricaRice will support the creation of a plant quarantine and seed health unit working with GRU, plant pathology and biotechnology units. This plant quarantine and seed health units will host staff from the national plant quarantine office in Benin, if the government of Benin agrees.	International rules are not necessarily clear or adequate on all aspects of genebank practice. We strongly encourage Africa Rice to exchange views within the community of genebanks, particularly IRRI and IITA, to ensure that they are benefiting from the long experience there in treating seed before and after storage. We support the plan for Africa Rice to continue to strengthen its routine seed health and quarantine work and to liaise closely with Benin quarantine authorities.
10. *Facilitating Use*	It is recommended that the Centre invests more resources into leveraging its extensive genebank collection, capacity in	Agreed. As expressed to reviewers during the site-visit, close collaboration with other sections has been in place, leading to high usage of GRU accessions. AfricaRice will	This is a recommendation to the Center management, which goes beyond the GRU. We understand that the spirit of the recommendation is to "make the most" of

	Recommendation	Responses by AfricaRice	Responses by Crop Trust
	molecular techniques and plant breeding to expand its pre-breeding activities in order to increase the chances for successfully generating well-adapted varieties to assist farmers cope with climate change.	keep this close collaboration. We do generate specialized genetic stocks and pre-breeding lines, when necessary, but these activities are beyond of GRU.	the collection. While the GRU has a good relationship with research and breeding programs and networks, there may be additional ways for the GRU to encourage use of the wider diversity in the collection such as the activities described in the R#11.
11. *Research and innovation*	It is recommended that AfricaRice GRU adopts the routine use of GIS-based tools, including FIGS, to identify putative donor candidates for climate change-related and other traits in order to reduce number of accessions for evaluation and in like manner, strengthen capacities for the increased use of novel efficiency-enhancing techniques for germplasm conservation and use, e.g. GBS and other tools for gene and allele mining.	Agreed. GRU and GIS units work together to develop integrative maps including germplasm information and climate change-related traits for optimum use of accessions in the collection. In addition, data and information acquired in projects related to climate change can be used to enhance GIS information. We will apply genomics tools to characterize accession conserved in AfricaRice genebank.	The Crop Trust supports the recommendation. It is not clear from Africa Rice whether what it describes in the response are project outputs or a systematic method to help manage and use the collection as the reviewers are suggesting.
12. *Capacity building and training*	It is recommended that AfricaRice acquires R&D capacity in seed physiology in order that its germplasm operations are evidence-based and to develop and implement a systematic plan for the structured training of GRU staff and, quite essentially, the NARS partners in the various aspects of rice germplasm management.	Agreed in principle. We agree with the evidence-based germplasm operation and management in GRU. However, since a seed physiologist is difficult to find, updated information will be gathered from literature survey. We do not see strong need for seed physiologist. We will also explore possible collaboration with IRRI to address this issue.	The Crop Trust agrees with the recommendation and understands that hiring a full-time seed physiologist may be a luxury that Africa Rice cannot afford. However, expertise may be brought in to help with specific questions, which are unlikely to be answered by a literature review. Collaboration with IRRI is important here.
13. *Human resources*	The Centre should strengthen the human capacity in information and data management and based on the outcome of the recommended review of the current regeneration of germplasm accessions in Ibadan, Nigeria, dedicate adequate staff strength to this activity.	Agreed in principle. Considering the current workload of information and data management related to accession in GRU, we recognize that one specialized staff is not sufficient, and we will try to recruit three additional staff link to data management depending upon availability of budget. AfricaRice will recruit one research assistant and two technicians, to strengthen information and data management activities, and one research assistant to support regeneration and characterization of germplasm accessions in Ibadan, Nigeria.	There are insufficient details for the Crop Trust to fully agree either with the recommendation or the response. It is not clear what specific capacity is lacking although it is clear that regeneration and data management may need strengthening for Africa Rice to reach performance standards. We await more information in the submitted workplan.
14. *Security and risk*	GRU is urged to implement a robust procedure, preferably electronic, to control	Agreed. AfricaRice is committed to implement at GRU a robust electronic access by March 2015.	The Crop Trust agrees with the recommendation and with Africa Rice's intentions to put in place a more

	Recommendation	Responses by AfricaRice	Responses by Crop Trust
management	access to the genebank facilities. A risk management plan specifically for the GRU which would include detailed emergency measures for possible hazards and threats should constitute part of a business continuity plan.	GRU will liaise with other CGIAR GRU units to establish an appropriate access system that is related to risk management plan.	robust access system. The reviewers also suggest that Africa Rice develops a GRU-specific risk management plan, a recommendation that is fully supported by the Crop Trust. Janny's work on QMS will provide support to Africa Rice to strengthen its risk management.

Review of AfricaRice Genebank, Cotonou, Benin Republic,

05 – 08 May 2014

Final report 15 Nov 2014

Jan Engels and Chikelu Mba

Abbreviations and acronyms

ARGIS	AfricaRice Genebank Information System
CG	CGIAR
CGIAR	Consultative Group on International Agricultural Research
CGN	Centre for Genetic Resources, The Netherlands
CIAT	International Center for Tropical Agriculture
CRP	CGIAR Research Program
FAO	Food and Agriculture Organization of the United Nations
FIGS	Focused Identification of Germplasm Strategy
GBS	Genotyping by Sequencing
GIS	Geographic Information System
GPG2	The Collective Action for the Rehabilitation of Global Public Goods in the CGIAR Genetic Resources System – Phase 2
GRIMS	Genetic Resources Information Management System
GRIN-Global	Germplasm Resources Information Network - Global
GRU	AfricaRice Genetic Resources Unit
IITA	International Institute of Tropical Agriculture
IRRI	International Rice Research Institute
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
NARS	National Agricultural Research System
LTS	Long-term storage
MTS	Medium-term storage
QMS	Quality management system
RH	Relative humidity
RP	Review Panel (as commissioned by the Trust)
SOP	Standard Operational Procedure
Smc	Seed moisture content (either dry weight or fresh weight based)
SMTA	Standard Material Transfer Agreement

STS	Short-term storage
Trust	Global Crop Diversity Trust
USDA	United States Department of Agriculture

Executive summary

One of the 16 CGIAR Research Programs (CRPs), known as 'Managing and Sustaining Crop Collections' (or the Genebanks CRP), brings together the work of the 11 genebanks that safeguard the crop genetic resources that are held *in-trust* for the international community by CGIAR centres. The genebank of the AfricaRice Centre, managed by its Genetic Resources Unit (GRU), is one of these genebanks. This CRP is coordinated by the Global Crop Diversity Trust (the Trust) which commissioned a review of the AfricaRice genebank as coordinator of the CRP.

After studying background materials (reports and other relevant documents) and conducting a survey of the clients, partners and stakeholders of the genebank, the two-person Review Panel implemented a 4-day site visit to the Cotonou, Benin Republic campus of AfricaRice during which it interacted with personnel of the Centre, observed activities and toured the facilities. Overall, the impressions gleaned were very positive with the salient observations being that:

1. AfricaRice had established a functional, well-run genebank with well-maintained facilities in the intervening period since its hasty relocation from Cote d'Ivoire less than ten years previously;
2. GRU staff appeared to be a team of knowledgeable, motivated and dedicated personnel who carried out their tasks at a commendably high level of proficiency;
3. Support staff appeared empowered and communication within GRU and with other units was adjudged excellent;
4. GRU, the functional unit responsible for the genebank, enjoyed the support and confidence of the Centre senior management who seemed to consider the genebank a valued asset that was critical to the success of the Centre;
5. GRU appeared to be well integrated into the overall operations and programs of AfricaRice and there was ample evidence that mutually beneficial working relationships had been developed and nurtured with other units especially, plant breeding; and
6. The prominent display of flowcharts of operations in GRU facilities was indicative of a recognition of the importance of quality control.

Also, it was observed that there existed some room for improvement and the following 14 actionable recommendations were proposed for addressing the identified areas.

Introduction

AfricaRice is one of the 15 International Agricultural Research Centres (IARCs) that constitute the Consultative Group on International Agricultural Research (CGIAR) Consortium and is uniquely also an intergovernmental association of 25 African member countries[1]. Established in 1971 as the West Africa Rice Development Association (or WARDA), it is mandated with research, development and partnership activities aimed at increasing the productivity and profitability of rice agriculture in the continent. The Centre is staffed with scientists, other professionals and support personnel who operate from its headquarters in Cotonou, Benin Republic and from the research hubs in Senegal, Nigeria, Tanzania and Côte d'Ivoire. The Centre executes its mandate through four programs, Genetic Diversity and Improvement; Sustainable Productivity Enhancement; Policy, Innovation Systems and Impact Assessment; and Rice Sector Development.

The Genetic Resources Unit (GRU) which is located within the Genetic Diversity and Improvement Program operates the genebank of rice genetic resources at the IITA-owned and AfricaRice managed campus in Cotonou, Benin. The genebanks contains the world's largest genetic diversity of African rice species, *Oryza glaberrima,* which numbers about 2,500 accessions; the genebank also stores over 17,000 *O. sativa* accessions that were largely collected from African countries as well as samples of related wild *Oryza* species, all together obtained or collected from approximately 85 countries. These accessions are held *in-trust* for the international community under an agreement with the International Treaty on Plant Genetic Resources for Food and Agriculture (the International Treaty) of the Food and Agriculture Organization of the United Nations (FAO). As part of this agreement, AfricaRice has agreed (a) not to claim legal ownership over the designated germplasm, nor seek any intellectual property rights over germplasm or related information, (b) to manage and administer the designated germplasm in accordance with internationally accepted standards, including ensuring the material is duplicated for safety, and (c) to make small quantities of germplasm and related information 'readily available for the purpose of scientific research, plant breeding or genetic resource conservation, under a standard Material Transfer Agreement (SMTA)' that is used by the CGIAR for all *in-trust* materials.

The major funding for the operation of GRU has been received from the Genebanks CRP as well as from the Governments of the Federal Republic of Germany and Japan.

One mechanism that the CGIAR has adopted for delivering on its mandate is the alignment of the work of its constituent 15 IARCs and their partners into multidisciplinary programs. There are 16 of such multidisciplinary entities known as CGIAR Research Programs (CRPs). The CRP on 'Managing and Sustaining Crop Collections' (or the Genebanks CRP), empaneled in 2012 and which brings together the work of the 11 genebanks, including the plant genetic resources held *in-trust* for the international community by CGIAR Centres. Based on a 5-year duration agreement between the Global Crop Diversity Trust (the Trust) and the CGIAR Consortium, the former coordinates this CRP which AfricaRice participates in. The Trust is "an independent international organization working to guarantee the conservation of crop diversity"[2]. In addition to the CRP, the Trust is providing in-perpetuity funding for the conservation of the genetic

[1] http://www.warda.cgiar.org/warda/aboutus.asp#
[2] http://www.croptrust.org/content/who-we-are

resources of the world's 15 most important crops, edible aroids and forages that are maintained in international genebanks.

The overarching aim of the Genebanks CRP is "to conserve the diversity of plant genetic resources in CGIAR-held collections and to make this diversity available to breeders and researchers in a manner that meets high international scientific standards, is cost efficient, is secure, reliable and sustainable over the long-term and is supportive of and consistent with the International Treaty on Plant Genetic Resources for Food and Agriculture[3]". It is under the auspices of this CRP that the Trust – as its coordinator – commissioned the Review Panel (RP)[4] to "assess the efficiency and effectiveness of the genebank operation as a whole, and the status of the genebank within the context of the global system for the conservation and use of the crops in question[5]". This review and the outputs therefore feed into the monitoring mechanism of the CRP and contribute to the longer term objective of creating sustainable genebank operations in the CGIAR.

The review consisted of a study of materials relevant to the management of rice genetic resources by AfricaRice – which included reports, work plans and project documents; a survey of clients and partners of the genebank; extensive consultations with staff of the Trust; and finally, a 4-day site visit to the Cotonou, Benin Republic campus of AfricaRice by the RP (5-8 May 2014)[6]. During the site visit, the RP, through interactions with management and staff of the Centre; observations of operations of the genebank; extensive tour of the facilities (genebank storage laboratories, screen houses, fields) specifically reviewed: 1) the operations and activities of the genebank; 2) the roles, services and use of the genebank, and the linkages with users and partners both within and outside the CGIAR; and 3) the status of the genebank and individual collections within it, in the context of a global system for long-term conservation and use of the rice crop in question.

Aims of the Review

This review was aimed at assessing the efficiency and effectiveness of the genebank operation as a whole, and the status of the AfricaRice genebank within the context of the global system for the conservation and use of rice genetic diversity, especially of *O. sativa* and *O. glaberrima*. The terms of reference of the review (Annex 1) included the following:

- Assess the operations and activities of the genebank;
- Assess the roles, services and use of the genebank, and the linkages with users and partners both within and outside the CGIAR;
- Consider the status of the genebank or individual collections within it, in the context of a global system for long-term conservation and use of the crop(s) in question;
- Assess any outcomes or impact specific to the provision of the long-term grant;

[3] http://www.cgiar.org/our-research/cgiar-research-programs/cgiar-research-program-for-managing-and-sustaining-crop-collections/
[4] Consisting of Messrs Johannes Engels (Chair) and Chikelu Mba
[5] Annex 1 to this Report: Terms of Reference to the Review Panel
[6] RP was accompanied by staff of the Trust: Mss Charlotte Lusty and Amanda Dobson

- Review the general appropriateness of current expenditures for the routine operations of the genebank with reference to the Costing Study estimates;
- Provide actionable recommendations related to all of the above.

Review Methodology

The RP consisted of two scientists with expertise in the fields of genebank management, seed storage, use of plant genetic resources in crop improvement, research collaboration and research management (for their backgrounds, please see Annex 2). The RP commenced the evaluation process by studying a number of relevant background documents pertaining to AfricaRice Centre, rice genetic diversity, the Genebanks CRP and several reports and work plans that had been prepared by GRU (Annex 3) that had been provided by the Trust. Also, with the facilitation of the Trust, the RP, through a survey, solicited the feedback of a wide array of individuals that had interacted with the GRU, especially with regard to the request and receipt of germplasm samples. The target survey respondents were broken down into two braid groups: the AfricaRice researchers (23 scientists) on one hand and external counterparts on the other (52 scientists). The RP subsequently conducted a site visit to AfricaRice and its GRU facilities from May 5thto 8th, 2014 in order to interact first hand with the staff members, observe operations and tour the genebank facilities. The detailed program of the visit is appended to this report as Annex 4 while a list of the persons interviewed is provided as Annex 5.

Two staff members of the Trust, Mss Charlotte Lusty (Scientist, Genebanks GRP Coordinator) and Amanda Dobson (Finance Assistant) accompanied the RP on this site visit. The latter reviewed the Centre's financial transactions related to the CRP. On the last day of the visit the preliminary conclusions and recommendations were presented to GRU staff and other Centre staff, especially the plant breeders, molecular biologist and plant pathologist. These preliminary findings and conclusions were also presented to, and discussed with, the Leader of the Genetic Diversity and Improvement Program and the Deputy Director General.

Findings of the Review

Generally, the RP was very impressed by the significant progress the GRU has made since its relocation from Bouaké, Cote d'Ivoire to Cotonou, Benin in 2005 on account of the Ivorian civil war. The genebank facilities were impressive; there was evidence of continuing upgrade of equipment; the infrastructure and equipment appeared well maintained and the workstations seemed adequate and orderly. The RP was also highly impressed by the manifest high level of motivation and strong dedication to its assigned duties demonstrated by the GRU staff and management who appeared quite knowledgeable in the subject matters relevant to their work. The RP concluded that the GRU demonstrated several positive signs of an effective team. Support staff seemed empowered; a number of them were pursuing advanced academic studies with the active encouragement of management; and communication both within GRU and with other units seemed excellent. Different staff members presented overviews of the different aspects of the genebank's work under their charge and seemed aware of how the individual interventions contributed to the overall goal of conserving the germplasm and making them available to users.

Particularly noteworthy was the obviously strong integration of the genebank activities into the overall institutional programme of work, especially with the crop breeding, plant pathology and molecular biology activities. Also, based on interactions with the echelons of the AfricaRice management, it was also evident that a healthy channel of communication existed between the GRU and the Centre's management. Overall, the RP was left with the impression that the leadership of AfricaRice seemed to take pride in the genebank, was cognizant of its unique worth, strove to foster linkages between its activities and those of other functional units in the institute, and provided adequate support. The recent change in the leadership of the GRU did not appear to have had a discernible negative impact on the operations of the genebank.

The RP's overall excellent impressions with regard to the management of the genebank is reflected by the commendably overall high levels of satisfaction expressed by the users of the genebank collection who responded to the survey questionnaire. Nonetheless, it was also evident that there existed some room for improvement, especially so that the genebank lives up to its billing as a centre of excellence that sets the standards for the management of rice genetic resources in Africa. To this end, the RP decided on 14 actionable recommendations which cover the full gamut of the operations of the genebank and how it may foster linkages that enhance the use of the conserved materials. These are presented below.

Specific Observations and Recommendations

Below are the areas that the RP considers as deserving of improvements and therefore proposes that the GRU, with the support of the AfricaRice management and the Trust, address.

1. *Germplasm collecting and acquisition*

The Global Strategy for the *ex situ* conservation of rice genetic resources[7] involves, *inter alia,* "the identification and filling of gaps in the conserved genepool and associated knowledge". The Review Panel was gratified to note the planned collecting missions to Central African Republic (CAR), Democratic Republic of Congo and Burundi for 2014. Furthermore, the successfully implemented collecting and characterization/evaluation of accessions in Senegal that had been recently carried out by a team of Centre's plant breeders in search of germplasm to aid breeding for climate change adaptation, convincingly demonstrated the great potential of such efforts in identifying useful and even new genetic diversity. To reap the maximum benefits and to ensure an optimal collaboration between the various programs within the Centre it is suggested that the GRU is the sole responsible entity to coordinate collecting as well as acquisition efforts. It is a matter of regret that with the ongoing civil strife in CAR, the planned activities in that country may have to be postponed indefinitely. Sadly, this is not an isolated incident; the rice growing regions and areas where the crop's wild relatives are endemic may not be the only such areas in the continent that cannot be safely accessed for germplasm collecting for a variety of reasons. Whole germplasm collections, including those of rice, have been lost in some countries also.

Therefore, while the further collecting of rice germplasm based on empirically determined gaps – as indicated in the Global Rice Conservation Strategy – is certainly of global importance, the largely sub-optimal national capacities for the collecting and safeguarding of crop germplasm in sub-Saharan Africa raises the stakes even higher for AfricaRice and the continent. The planned

[7] http://www.croptrust.org/documents/cropstrategies/Rice%20Strategy.pdf

and implemented activities alluded to above seem too *ad hoc* and opportunistic to serve as effective means of attaining the imperative of a comprehensive need-based germplasm acquisition and collecting as envisaged. For instance, no plans for acquisition and collecting were indicated amongst the Centre's 2016 targets. It was also unclear as to what extent the national germplasm holdings of the AfricaRice Center's catchment countries were systematically safety duplicated at the Centre. Clearly therefore, in the spirit of the Global Rice Conservation Strategy, a thorough gap analysis (both geographic and genetic) to provide the basis for a long-term germplasm collecting and acquisition action plan for cultivated rice and wild relatives must be carried out. Existing partnerships, including the very active Rice Breeding Task Force as well as collaboration with other international collecting initiatives should be effectively leveraged in this regard.

Recommendation 1

Under the institution-wide coordination of the GRU, conduct a systematic gap analysis in the acquisition and collecting of rice germplasm, including the extent of safety duplication of all NARS accessions at the GRU, and develop and implement a cohesive long-term plan for further targeted acquisition and collecting.

2. *Conservation facilities*

Over the past 43 years, AfricaRice has acquired and/or collected a total of almost 20,000 rice accessions covering the two cultivated rice species (*O. sativa* and *O. glaberrima)* and 5 wild related species. Over the past year or so, the Centre developed a draft genebank operations manual and was planning to develop a genebank quality management system as at the time of the site visit. With the sudden evacuation of AfricaRice from Cote d'Ivoire in 2005, a new genebank facility was established in Benin the year after. This consists of a MTS room, a drying room and laboratory facilities for seed viability testing (including two fully automated germination cabinets) and seed processing. Arrangements were made with IITA to use space for Africa Rice accessions in its LTS facility in Ibadan, Nigeria.

The current conservation facilities consist of a temporary storage room of approximately $35m^2$ which is set to operate at 20°C and currently contains breeders' materials. No system for controlling the RH was installed in the room. The seed samples were stored in plastic boxes in which plastic bags or other smaller jars containing seeds were kept. The MTS room of approximately $200m^2$ equipped with fixed shelves was set to operate at 5°C and 35% RH. Here, plastic bottles were being used as seed storage containers. An adjoining drying room of approximately $35m^2$ was set to operate at 18°C and 20% RH (which corresponds to a seed equilibrium moisture content of 6.9% for rice).

During the site visit, the temperature and RH readings at one end of the MTS cold room were 7.4^0C and 27.1%, respectively while at the other end, the corresponding readings were 6.4^0C and 20%, respectively. The temperature of an MTS environment should not exceed 5^0C while the maximum RH should be 15±3%. The high temperature and RH and their variation within the MTS environment and the reported fluctuations are sources of concern that ought to be addressed urgently. These deviations from the norm can have grave implications for the longevity of the seeds. Similarly, though the temperature of the drying room, about 18^0C, was close to optimal, the RH of 37% deviated substantially from the recommended maximum of 20%. The

GRU management was apprised of these concerns. Discussions held subsequently between the RP, GRU management and the facility maintenance unit indicated that these conditions in the drying room could be mitigated easily through modifications to the cooling units and humidifier. In the drying room, bags containing seeds were piled on top of each other resulting in the non-uniform exposure of the maximum surface areas of the samples to the drying environment. Staff members of the GRU were in agreement that a more even spreading of the seeds inside the bags and the spreading of the bags evenly on the surfaces of the racks were necessary and practicable. Another critical shortcoming was the lack of adequate space for the temporary storage of seed samples and for threshing freshly harvested materials. Currently, a concrete slab, in the open air, behind the GRU building serves as the threshing floor. These inadequacies are clearly sub-optimal and ought to be addressed urgently.

With the observed high RH, it is probable that the plastic jars being used to store the seeds could be insufficiently airtight to prevent the seeds from absorbing ambient moisture. Aluminum foil bags are becoming the storage containers of choice and AfricaRice may want to consider seriously switching from plastic jars to hermetically sealed aluminum bags. The introduction of silica gel beads into the jars and improved sealing, in the case of aluminum foil bags under vacuum, may be other mitigating measures that may even obviate the need for the continued use of the dehumidifying system in the MTS room which, though introducing additional running costs, has not been wholly effective in keeping down the humidity.

With the planned further collecting and acquisition of germplasm accessions and the imperative of introducing more samples into LTS, it would be prudent to carry out an estimation of additional storage requirements and human resources both for the LTS (currently provided by IITA) and the MTS for the coming 5 – 10 years. Options for increasing the available storage space could be the replacement of the current stationary shelves in the MTS with movable ones and/or the construction of an additional MTS room. The current LTS storage arrangements at IITA Ibadan, Nigeria – whereby the seeds are in sealed boxes and with no defined mechanism for inspecting them periodically – are akin to a black box management of germplasm strategy. This needs to be carefully reviewed with the aim to ensure adequate storage, easy retrieval of stored accession and proper viability monitoring.

Recommendation 2

It is recommended that GRU urgently reviews its germplasm conservation infrastructure and take immediate steps to ensure that the environmental conditions for its operations meet internationally agreed standards. Also, adequate threshing and temporary storage facilities for freshly harvested or collected material should be provided.

3. Germplasm management procedures

Germplasm management procedures encompass the routine operations of the genebank, starting from regeneration, threshing, seed cleaning, drying, processing, storing, viability and health testing to seed distribution. Each of these operations is in place and for most of them clear flow diagrams have been developed and posted in the work areas. During the site visit, it was observed, in general that the precision and cohesion in the movement of seed samples from one operation to the next could be further streamlined to increase efficiency. For instance, it was observed that seed samples awaiting transition to a next step of processing were left for unduly

long periods of time, usually under sub-optimal conditions with potentially grave implications for the longevity of the seeds. Improved efficiencies will lead to the shortening of such lag phases. Specific operations with aspects that need to be strengthened and/or streamlined include seed cleaning and processing, seed drying, regeneration combined with morphological characterization as well as the linking of the routine operations with information management and documentation. A recommended peer review of the draft genebank operations manual provides an opportunity to critically review and, where necessary, to adjust the current procedures.

There is an urgent need for adequate facilities for the processing of the new materials arising from collecting, regeneration or from any other activity that produces seeds that will be stored. Such facilities should, at a minimum, include a temporary storage room that is rodent- and insect-proof and provides for adequate air circulation to allow for further drying. Also, a covered threshing space with the essential equipment, benches and shelves, is urgently needed to replace the current open air threshing concrete slab behind the genebank building.

The current regeneration practices should be critically reviewed, including the regeneration sites, agronomic practices and the supervision of the operations. Considerations of cost implications (financial and time), the availability of skilled staff, the need for highest quality performance, (??) of the risks involved should be part of a critical review, especially as regeneration is one of the most critical and difficult operations of any genebank. Maintaining the genetic integrity of germplasm samples is one of the most crucial tasks of a genebank and needs to be ensured by all means. The current practice of carrying out regeneration at the campus of IITA in Ibadan, Nigeria and subsequently transporting the harvested seeds over a distance of 250km back to Cotonou, Benin Republic for processing and storage and return to Ibadan for LTS is replete with opportunities for mishaps that could range from the outright loss of the genebank materials to the compromising of their integrity.

Morphological characterization generates important information that serves as the basis for selecting the accessions – either for direct use by growers, use as parents in breeding programs or for varied scientific investigations, including gene discovery. The non-completion of the characterization of the AfricaRice germplasm accessions impacts seriously on the utility of these genetic resources. It is extremely important, therefore, that the entire collection be adequately characterized as soon as possible.

Recommendation 3

GRU should conduct a critical expert review of its chain of seed processing and storage activities that constitute the routine genebank operations, identify and remedy shortcomings in order to achieve a more effective and efficient work flow in keeping with international standards and also ensure that the entire collection is adequately characterized as soon as possible.

4. *Within accession diversity management and conservation*

Approximately 60% of GRU's maintained accessions are landraces while about 2.3% are wild relatives and therefore many of the accessions may consist of genotype mixtures or populations. Both, from a conservation and a use perspective, such germplasm materials need special attention with regard to their genetic integrity. For the purposes of conservation, efforts are made to maintain the genetic integrity of the original accession whereas for use in breeding and research activities, pure lines are developed. Increasingly, such pure lines – with homozygous alleles – are

being developed not just for breeding but for genotyping assays, including sequencing. With the increasing capacity for gene discovery and the routine adoption of genotyping by sequencing (GBS) at AfricaRice, for instance, it is expected that these pure lines developed as single seed descent progenies constitute a significant proportion of the materials to be conserved. It is therefore important to devise a clear strategy for managing the seemingly contradicting objectives of generating and using pure lines that breed true on one hand and maintaining the inherent variability that may exist in the original accessions.
Special attention should be given to the adequate short- or medium-term conservation of 'pure lines' (maximum of 2 generations of single seed descent, for instance, as is the norm at IRRI). Materials that have been both sequenced and phenotyped are stored in the IRRI genebank's MTS but they are not subjected to viability and health testing and are only regenerated when their stocks are depleted. The long-term conservation of this diversity is secured as these genotypes are derived from the accessions that are supposedly stored in the LTS already. At IRRI also, purified lines that have been only sequenced (and not phenotyped) are included in the archive collection[8]. It is expected that not more than approximately 10% of the accessions will be subjected to purification, sequencing and phenotyping and thus the additional conservation expenditures will be limited.

Recommendation 4

An institutional strategy for the management of genetic stocks such as pure lines descended from original accessions and which are used in breeding and/or research, including gene discovery and sequencing, should be developed and implemented.

5. *Enhanced security of accessions through adequate storage*

Definitions of different types of collections that are being maintained by GRU and the corresponding optimal storage conditions for each of them are provided in Annex 6. The overriding aim of genebanks is to implement the most effective and efficient storage of the conserved germplasm. Along with this, a number of underlying principles, including ease of access, maintenance of longevity and genetic integrity, human health and safety and maintenance costs are considered in developing the protocols for these storage conditions.

Currently, of the 19,965 unique accessions reported by GRU, 8,303 are in LTS at IITA; 8,737 are safety duplicated at Fort Collins, USA and 12,386 at Svalbard, Spitsbergen. This means that less than half of the accessions maintained by GRU are stored under LTS conditions, i.e. more than half are stored under sub-optimal conditions. Furthermore, also less than half of the accessions have been safety duplicated. This is not optimal as samples of all germplasm accessions should be under LTS and safety duplicated. The achievement of this goal at AfricaRice will require significantly increased capacities for regeneration, health and viability testing, and information management for which adequate arrangements and planning are called for.

It was observed that significant numbers of sub-samples of accessions that are closest to the original samples collected or acquired, i.e. the most original samples, are currently stored in the MTS within the same container as other samples of the same accession. These are valuable resources – as they represent most closely the genetic make-up of the original accession collected.

[8] See Annex 6 for definitions of the recognized different collection types.

These most original samples should therefore be transferred to LTS (the most ideal storage condition) as soon as sufficient newly regenerated material for the accessions in question becomes available. In practical terms also, those accessions that are maintained in the MTS facility that are used only rarely or not at all should be kept only in the LTS. This is in order to avoid the need for regeneration because of viability loss even when the stock is not depleted. In like manner, the development of a clear scheme for monitoring the viability of seed samples in LTS should also constitute part of the genebank's management procedures. Such a scheme would increase the security of the accessions and allow for a better planning of regeneration activities. GRU should also consider viability testing protocols that require less seeds.

Recommendation 5

It is recommended that GRU introduces samples of all AfricaRice germplasm holding as a matter of priority into LTS, review its operations regarding the materials under LTS at IITA, Ibadan, Nigeria with a view to greater monitoring of the status of the samples.

6. Information management

GRU maintains an internet-based searchable database for the Centre's germplasm accessions. Known as the AfricaRice Genebank Information System (ARGIS; http://eservices.africarice.org/argis/), the database can be queried for information on the germplasm accessions held by the Centre; it also has the functionality for the request of seed samples (using Standard Material Transfer Agreement – SMTA) from the Centre. While the majority of the germplasm accessions have been characterized, the data have not been uploaded onto ARGIS; this sub-optimal situation is attributed to the inadequate internet bandwidth available at Cotonou – which cannot support the uploading of the data to the server hosted at CGNET. The RP, the genebank management and personnel discussed options for uploading the data; an easily implementable solution would be to transport the information for upload on a mobile data storage device to a facility in Europe or North America with robust internet connectivity and affect the update of ARGIS with these critically important pieces of information.

A functional barcoding system was in use for most operations at the GRU but it was noted that samples were still identified and handled manually at some steps of the operations. Genebank management and staff were mindful of the fact the operations that had not been made barcode compliant constituted the weak links in the chain of operations that had real potentials for compromising the integrity of the work.

For the long-term, the Centre was actively evaluating options for increasing the robustness of its genebank management information system with the choices being considered, including the further enhancement of the functionalities of its own ARGIS or the adoption of another system, e.g. GRIMS (developed and used by the IRRI GRU) or GRIN-Global (the USDA based system that has been upgraded into a global web-based germplasm management system). The evaluation of the above mentioned options was also part of the issues discussed by the RP and IRRI genebank curator during a Skype conversation in the course of the review and it was noted that the GRIMS system might not be appropriate for AfricaRice adoption and operation, partly because of cost considerations. It is envisaged that a decision will be taken soon.

Only one staff member was dedicated to the management of GRU information system. It seemed improbable that this single support cadre staff member would implement effectively all the foreseen upgrades and the subsequent maintenance operations that would be entailed. It was understood that additional human resources may be needed.

Recommendation 6

It is recommended that GRU, as a matter of urgency, uploads the available passport and characterization data onto ARGIS and to implement fully the barcoding system for all its operations as soon as practicable. GRU should also, based on a thorough evaluation of possible germplasm management systems (e.g. ARGIS, GRIMS and GRIN-Global), adopt and implement a robust system that ensures full compatibility with especially CIAT and IRRI rice germplasm information systems and permits the use of Genesys as gateway.

7. Quality Management System

The collecting, processing, storage, characterization and evaluation of crop germplasm constitute an organically linked multi-step process for which any sub-optimally implemented step has the potential for scuttling the goal of conserving crop diversity for current and future generations. The chances for the occurrence of errors are high in multi-stage processes for which different individuals perform different tasks and/or there is a turnover of personnel. The curation of germplasm is one such process. An established means for minimizing the occurrence of errors is the instituting of a quality control and management mechanism that is usually underpinned by the development and adoption of standard operating procedures.

The RP was impressed by the availability of prominently displayed flow charts of the procedures for the different activities carried at the GRU and welcomed the information that the genebank operations manual, which is under development, will be finalized in 2014. It is suggested that the draft manual is put through a peer review process in order to ensure the highest possible level of performance of the routine operations or that it is developed further into SOPs and that further QMS measures are put into place. Currently, supervisors review the laboratory notebooks of staff on *ad hoc* basis as a quality control and quality assurance measure.

Being part of the international genebanks operated by the CGIAR, under the coordination and support of the Trust, and striving towards meeting the agreed international standards and best practices in conserving crop diversity, the GRU is encouraged to work towards the establishment of a more formal quality management system of its entire operations. The appointment of a QMS specialist by the Trust will provide an excellent opportunity to achieve this over the next few years and thus AfricaRice and its GRU will strengthen its reputation as a leader in the area of managing and conserving the precious genetic resources of rice.

Recommendation 7

GRU should as a matter of urgency, complete, peer review and publish, both as hard copy and on the GRU website, the draft genebank operations manual. Furthermore, GRU is encouraged to work towards the establishment of a quality management system for all its routine operations.

8. GRU website

The GRU maintains a dedicated section on the AfricaRice website (http://www.africarice.org/warda/genebank.asp). Accessed directly from the Centre's website via a prominently located link, the information available includes an overview of the genebank, including the historical background. Quite importantly, the narrative traces the origins of the outputs of crop improvement, especially the highly successful NERICA series of Africa-adapted rice varieties developed by the Centre from *O. glaberrima,* to the genebank accessions. Links are provided from this dedicated section to GRU germplasm information management system, WAGIS; the SMTA; and INGER-Africa (i.e. the International Network for Genetic Evaluation of Rice for Africa). It is expected that ARGIS would be used to replace the defunct WAGIS in due course.

This website could be better used in advancing the work of AfricaRice regarding rice germplasm collecting, characterization and evaluation as well as to disseminate rice germplasm conservation protocols, scientific findings and experiences. In addition to its further populating with relevant information resources and tools, the regular updating of the contents would be extremely valuable. For instance, this website could easily be used to facilitate access by the rice genetic resources community of practice in Africa to relevant online resources available through the websites of, e.g. to the International Treaty on PGRFA; FAO's Commission on Genetic Resources for Food and Agriculture; the Global Crop Diversity Trust; the genebanks of other Centres of the CGIAR; and Bioversity International. Strategically, the NARS in the region look up to AfricaRice for leadership and with the increasing ease of access to the internet, this website could become an important tool for networking, advocacy, outreach, dissemination of information and the strengthening of technical capacity for the catchment NARS.

Recommendation 8

GRU is urged to enhance the utility of its website by providing an information exchange platform for use by its rice genetic resources community of practice; performing regular update of the contents; and by making copies of all validated protocols, manuals, SOPs and other relevant documents available.

9. Plant quarantine, seed health and germplasm distribution

The Centre's Plant Pathology Unit is responsible, *inter alia,* for ensuring that rice genetic resources distributed or received by AfricaRice do not harbour disease causing pathogens. It leverages its diagnostic facilities, including laboratories and confined facilities, to carry out this very important function. The leader of this Unit indicated that a survey of the germplasm accessions in the genebank demonstrated that they were overwhelmingly infected by the bacteria and fungi that cause rice diseases. The Unit was proposing the treatment of all seeds stored in the genebank with a broad spectrum antibiotic preparation marketed under the brand name 'Team' and which efficacy had been demonstrated at IITA. The undesirability of this measure was impressed upon this Unit as a number of countries explicitly prohibit the importation of seeds that have been treated with any type of seed treatment. A pragmatic means for addressing this issue would involve, at the minimum, a review by the Plant Pathology Unit of the current practice and the state-of-the-art of seed treatment before and after storage and to align its own operations with what obtains at other international genebanks, in particular those of the CGIAR.

The Plant Pathology Unit of AfricaRice also doubles as the analytical arm of the plant quarantine services of the host country, Republic of Benin, which does not have the capacity to test in-coming and out-going seed samples at internationally mandated standards. To avert the serious constraints that this weak national capacity imposes on the work of AfricaRice, this Unit has therefore assumed this role. The national authorities issue the necessary certificates on the strength of the results of the unit's testing of the health status of the rice seed samples being exported and imported by AfricaRice. It was impressed upon the Unit, GRU and the Centre's management that this arrangement was hardly sustainable as there existed grounds for a conflict of interest; the Centre cannot police itself. Weak national capacities for implementing plant quarantine regulations seem pervasive in the region; IITA is in a similar situation in Nigeria. It would seem therefore that CGIAR Centres have important roles to play in increasing awareness of the importance of plant quarantine in the region and in supporting related capacity building.

Other discussions related to the weak national capacities included considerations for bringing these sub-optimal situations to the attention of the secretariats of relevant global bodies and instruments. For instance, the countries are members of the International Plant Protection Convention which sets the standards for quarantine procedures. Also, the International Treaty on PGRFA would be interested in knowing that the distribution of crop germplasm, held *in-trust* for the global community, by CGIAR Centres, could be seriously hampered by the inability of host countries to implement plant quarantine obligations. The Centre could also proactively strengthen the analytical capacity of the national quarantine service by training and hosting its personnel on campus where they would have access to the laboratory and other analytical services which they do not have currently in the government establishment where it is hosted. A possible reduction or even avoidance of the conflict of interest, which arises in hosting such national normative responsibilities, could be through strict procedures that are fully integrated within the QMS of the Centre.

Recommendation 9

It is recommended that the Plant Pathology Unit of AfricaRice conducts a comprehensive review of the best genebank practices for controlling seed-borne pathogens and to align its own practices with those of international genebanks of the CGIAR. Regarding the weak national capacities for plant quarantine, AfricaRice is urged to take steps to improve the situation, including the hosting of the staff of the national institution within the Centre's premises and to integrate this sensitive responsibility in its institutional QMS.

10. Facilitating Use

The RP noted with satisfaction the very impressive volume of rice germplasm distributed by AfricaRice and the excellent reviews of the genebank provided by respondents to an evaluation survey.

AfricaRice has an effective rice genetic improvement program that is noted especially for the development and release of the highly successful New Rice for Africa (NERICA) set of improved varieties in several African countries. The Centre has developed a successor series to NERICA, the Advanced Rice for Africa (ARICA), seven varieties of which were nominated for official release in seven African countries in 2014. Intra- and interspecific hybridizations using parental lines from the cultivated species *Oryza sativa* and *O. glaberrima* are used to generate the

breeding lines that are subsequently subjected to multi-locational trials in the 29 countries that constitute the Africa-wide Rice Breeding Task Force. At the same time, the Centre has also developed an impressive molecular genetics infrastructure and capability and makes use of a repertoire of tools ranging from simple sequence markers through single nucleotide polymorphisms to genotyping by sequencing for characterizing rice genetic resources. The RP was particularly impressed with the use of marker-aided selection to facilitate the generation of inter-specific hybrids from *O. sativa* and *O. glaberrima* crosses.

Many of the countries in sub-Saharan Africa whose rice improvement programs rely on the provision of promising early generation lines by AfricaRice are amongst the most resource-poor nations that are expected to be the worst affected by climate change. AfricaRice is mindful of its unique role in generating well-adapted varieties for the sub-region, hence the development of the ARICA series and the significant emphasis on inter-specific crosses. With the availability of the wild relatives of rice in the Centre's genebank and with the aforementioned capacity for breeding and the use of efficiency-enhancing molecular biology techniques to trace the inheritance of traits of interest, there exists a winning opportunity for the further broadening of the genetic base of breeding materials by the Centre through the strengthening of on-going pre-breeding work. This will be achieved through the increasing of the clearly successful and essential partnership between the genebank and plant breeding operations.

A practical way for strengthening the collaboration would be through the systematic exhaustive evaluation of the genebank accessions. Evaluations aimed at identifying accessions with traits that can confer elevated adaptation to climate change, for instance, would be of practical value to both the germplasm curators and plant breeders. The former are aided in developing trait-specific sub-sets while the latter are able to identify putative parents for use in hybridization e.g. that enhance adaptation to climate change. The successful evaluation of germplasm would dovetail with pre-breeding. The promising, but non-adapted, materials so identified from evaluations and used in hybridizations to generate intermediate materials with novel allele combinations could enhance the adaptive capacities of rice cropping systems to climate change. This would result in tangible products that demonstrate the utility of genebanking. A more assertive role of the GRU in the procedures that facilitate use as well as annual planning meetings between genebank and plant breeders/researchers to plan activities related to the characterization, evaluation and screening of germplasm will further facilitate the use of a broader genetic diversity in Africa's rice breeding programs.

The structuring of germplasm collections, into trait-specific sub-sets, for instance, is one of the management mechanisms that allows better access to desirable accessions and thus, contributes to increased use. The systematic development of core collections, possibly for each of the cultivated species and the wild relatives as well as trait-specific collections would be a powerful means to achieve this much desired increased use of the germplasm.

Recommendation 10

It is recommended that the Centre invests more resources into leveraging its extensive genebank collection, capacity in molecular techniques and plant breeding to expand its pre-breeding activities as well as to develop core and trait-specific collections in order to increase the chances for successfully generating well-adapted varieties to assist farmers cope with climate change.

11. Research and innovation

AfricaRice is the regional leader for rice genetic improvement and is therefore the first choice for NARS in the region in the quest for technical and scientific support for enhanced capacities in the spectrum of scientific disciplines relevant to the conservation and use of the crop's genetic resources. To maintain this elevated level of relevance, the Centre must continually ensure that it has the requisite in-house skills that command mastery of the state-of-the-art tools and techniques in the disciplines relevant to its mandate. These would include novel cutting-edge scientific methodologies that enhance efficiencies – including the permitting of high throughput analyses – for collecting, characterizing, evaluating and value addition to conserved rice genetic resources through breeding.

AfricaRice has plans for the continued collecting of rice germplasm, for characterizing and evaluating them and, in particular for identifying the sources of traits for use as parents in breeding new elite lines. Geographic Information System-based tools, e.g. Focused Identification of Germplasm Strategy (or FIGS)[9] is permitting more targeted identification of genotypes that may serve as putative donors for traits. In like manner, significant advances in molecular biology are permitting the adoption of whole genome scans, through genotyping by sequencing (GBS) for instance, as method of choice for germplasm characterization. The Centre is using its significant molecular biology skills, its research and development infrastructure and strategic partnerships with advanced laboratories to incorporate GBS in its toolbox of methodologies; this is commendable.

In spite of the progressively decreasing costs of molecular biology assays, time and resources can be significantly saved through a targeted identification of putative parents and/or candidates for gene mining. FIGS, which is currently not in use in the Centre, can aid this enhancement of efficiency. The need for enhanced efficiencies through the scaling down of the numbers of genotypes for assay is underscored by the sense of urgency that attends the imperative of broadening the genetic base of breeding lines in order to improve the chances of success in introgressing novel alleles that will enhance adaptation to climate change, for instance. The Centre's breeding activities are continually focused on trawling through hitherto unused genotypes (and ecotypes) in breeding for improved varieties with new traits. In this regard, the establishment of trait-specific subsets should be considered a priority. These ongoing and foreseen efforts will benefit from improved efficiencies that can be achieved by greater precision in the choice of candidate genetic resources.

Recommendation 11

It is recommended that AfricaRice GRU adopts the routine use of GIS-based tools, including FIGS, to identify putative donor candidates for climate change-related and other traits in order to reduce number of accessions for evaluation and in like manner, strengthen capacities for the

[9] "FIGS emerged as an approach to target accessions more likely to possess specific variation sought by breeders. FIGS involve gathering available information and knowledge to facilitate the identification of candidate accessions. GIS, statistical and modelling techniques can then be used to select the candidates for evaluation based on understanding the trait by environment relationships".Mackay, M.C., et al. (2004) Focused identification of germplasm strategy—FIGS. Cereals 2004. In: Black, C.K., Panozzo, J.F. and Rebetzke, G.J. (eds.), *Proceedings of the 54th Australian Cereal Chemistry Conference and the 11th Wheat Breeders' Assembly, 21–24 September 2004, Canberra, Australian Capital Territory*. Pp. 138–141.

increased use of novel efficiency-enhancing techniques for germplasm conservation and use, e.g. GBS and other tools for gene and allele mining.

12. Capacity building and training

During the course of the evaluation, room for improvement was identified in some aspects of the routine operations of the genebank. Examples include the temperatures and humidity levels of the different facilities (please see Recommendation no. 2 on Conservation Facilities). As already indicated in the section on conservation facilities a number of routine seed treatment procedures and practices should be reviewed. Furthermore, some rice germplasm, including especially CWRs, conserved by the genebank are unique to Africa, therefore AfricaRice must lead the development of specific protocols – based on empirical data – for some of the routine germplasm management practices of these resources. At the minimum, therefore, some robust R&D capacity in seed physiology is required.

A number of GRU personnel, with leadership responsibilities for modules of the germplasm conservation chain are, with the encouragement of the Centre, pursuing various advanced degrees. This is very commendable and worthy of encouragement. This is especially because these staff members in the course of their in-service training have a compelling incentive (i.e. the obtaining of higher degrees and consequent career growth) to translate the routine genebank operations into academic investigations that will lead to findings that can improve the scientific rigour of the work of the GRU and thus lead to continued improvements of the operation.

Regarding the provision of support to the strengthening of capacities of the catchment NARS, as has been indicated earlier in this report, AfricaRice is uniquely placed to provide leadership. It would seem, though, that this aspect of the Centre's mandate and/or responsibility is prosecuted in largely an *ad hoc* and opportunistic manner. The Centre has reported on training activities but no training prospectus with clearly identified modules were made available to the RP. Also, there was no suggestion that there was a plan to transfer technology to the NARS to aid the effective collecting and safeguarding of rice genetic resources by African NARS. The RP is mindful of the pervading scarcity of funds but emphasizes that human and institutional capacity in germplasm management of the partner NARS is a role of AfricaRice that should not be implemented haphazardly. A program of training of the NARS is important as this will contribute to ensuring that the collecting, conserving and use of rice germplasm in Africa is underpinned by effective grassroots activities.

Recommendation 12

It is recommended that AfricaRice acquires R&D capacity in seed physiology in order that its germplasm operations are evidence-based and to develop and implement a systematic plan for the structured training of GRU staff and, quite essentially, the NARS partners in the various aspects of rice germplasm management.

13. Human resources

The significant progress made by AfricaRice towards becoming a Centre of excellence for the management of rice genetic resources – since its rapid relocation nine years ago from Bouaké, Cote d'Ivoire – has been severally documented in this report. One aspect of this is the human

resources that drive the work of the GRU. But, there are areas that can be strengthened. In addition to beefing up the R&D capacities highlighted above (Recommendation no. 11 on Research and Innovation), the current situation, whereby only one staff member is responsible for GRU's information infrastructure, is not optimal. Also, the regeneration operations at IITA, Ibadan, Nigeria which should be implemented under the supervision of an experienced staff member appear to be understaffed.

Recommendation 13

The Centre should strengthen the human capacity in information and data management and based on the outcome of the recommended review of the current regeneration of germplasm accessions in Ibadan, Nigeria, dedicate adequate staff strength to this activity.

14. Security and risk management

The germplasm storage and processing facilities are in a building located towards the rear of the Cotonou, Benin headquarters of AfricaRice which is dedicated solely to the operations of the GRU. The GRU management is mindful of the critical importance of not only safeguarding the collections but also of ensuring the genetic integrity of the accessions. Unauthorized entry into the genebank facilities is therefore discouraged. However, there didn't seem to be a defined mechanism for the enforcement of restricted access to the facility. It is now becoming customary to control the entrances into office buildings and laboratories by the installation of some electronic devices. Such a device, that would permit unmonitored access only to authorized personnel, would further the cause of safeguarding the germplasm collections.

A Centre-wide risk assessment and management plan is being developed by AfricaRice. All staff members of AfricaRice have been trained in risk management and an updated risk assessment was due in 2014. The GRU and its operations are unique and therefore are deserving of special considerations as the plan is developed and implemented. Modules dedicated to the GRU and the germplasm storage and processing facilities may, as part of a business continuity plan, address detailed emergency measures to mitigate possible hazards and threat situations for the staff and the conserved germplasm.

Efficient and effective germplasm storage is predicated upon the physical conditions of the storage facilities. In the course of the site visit, the RP noted some deviations from the optimal temperatures and humidity of the germplasm storage facility which, according to the Centre's maintenance personnel, could have been easily prevented by supposedly simple modifications to the air-conditioning facility and humidifiers. This would suggest the critical importance of the establishment of an open channel of communication between the GRU and facility maintenance staff so as to ensure regular and thorough routine maintenance of equipment and facilities.

Recommendation 14

GRU is urged to implement a robust procedure, preferably electronic, to control access to the genebank facilities. A risk management plan specifically for the GRU which would include detailed emergency measures for possible hazards and threats should constitute part of a business continuity plan.

Acknowledgements

The Review Panel gratefully acknowledges the excellent preparations for the review by the genebank staff and its leadership. It was evident that significant thought and preparations went into securing the availabilities of the plant breeders, plant pathologist, agronomist, molecular biologist, etc. (some out-posted with interactions via Skype) who presented their activities enthusiastically to the RP. The arrangements made for touring the facilities at AfricaRice, the scheduling of meetings, the provisions of background reading materials, the availing to the RP of physical access to national counterparts and the general logistic support were excellent and made the work of the RP all the easier. Messrs Engels and Mba are particularly grateful to the Acting Director General of AfricaRice, the Deputy Director General, Program Leader of Genetic Diversity and Improvement, other members of the Centre's senior management team and staff for the generosity of their time and the excellent hospitality. Finally, the RP acknowledges with thanks the excellent interactions with colleagues at the Trust (especially Mss Jane Toll and Charlotte Lusty, and Mr Cristian Moreno) prior to the visit. During the site visit, the insightful perspectives provided by Mss Charlotte Lusty and Amanda Dobson were extremely helpful and the RP is indebted to them.

Annexes

Annex 1: Terms of Reference to the Review Panel

Center Genebank review – Guidelines and Terms of Reference

The Global Crop Diversity Trust commissions the five-yearly review of the CGIAR Center genebanks in its role as Project Manager of the CGIAR Research Programme (CRP) for Managing and Sustaining Crop Collections and also as donor of long-term grants. This review aims to assess the efficiency and effectiveness of the genebank operation as a whole, and the status of the genebank within the context of the global system for the conservation and use of the crops in question.

The objectives of the review are to:

- Assess the operations and activities of the genebank;
- Asses the roles, services and use of the genebank, and the linkages with users and partners both within and outside the CGIAR;
- Consider the status of the genebank or individual collections within it, in the context of a global system for long-term conservation and use of the crop(s) in question;
- Assess any outcomes or impact specific to the provision of the long-term grant;
- Review the general appropriateness of current expenditures for the routine operations of the genebank with reference to the Costing Study estimates;
- Provide actionable recommendations related to all of the above.

Additional specific areas of focus for the review will be identified in phase 1 of the review.

In 2010, a comprehensive Costing Study was carried out of the genebank operations, which resulted in the publication of cost estimates for routine operations for each Center crop collection. These now form the basis of the funding allocations of the CRP and also of the Trust's endowment target. The current level of operation and operating costs may be an important consideration of the review if there are significant differences from the Costing Study. This will be clarified during the interactions with the Trust in phase 1 of the review. The Trust Finance Director will also undertake a two-day financial audit, during the review, and will provide any relevant findings to the panel. The overall responsibility to identify and resolve financial and budgeting issues will remain with the Trust.

The review will be facilitated by a Trust member of staff, who will provide background information, coordinate the development of the agenda and the execution of the review on site. The Trust facilitator will participate in all review sessions unless requested not to, and will assist the Chair in any aspects of the review and the completion of the final report. However, the Trust will not take part directly in the formulation of the review report and recommendations.

The review will be undertaken in three phases:

Phase I: General background and literature review
Reviewers will be provided with the following documents:

- Long-term grant agreement(s)
- Annual long-term grant reports
- Genebank Costing Study
- Genebank CRP proposal

- Genebank manuals, website and related materials
- Relevant past donor or internal reviews of the genebank as given by the Center
- Any other materials given by the Center as background for the review

All review panel members and the genebank 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 one interaction will take place in advance of the site visit, between the panel members and Trust staff, either through a visit to the Trust HQ or by conference call.

Phase II: Site visit and review of Centre gene bank
The panel members will conduct a site visit of the genebank following the agreed agenda. Usually the site visit involves interactions between the panel members and Center or CRP senior management and germplasm users, as well as the full genebank staff. There will also be at least one visit to field stations and, if feasible, national partner institutes. The panel members should determine the scale of these interactions in the development of the agenda in Phase I.

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 Center staff and management on the last day of the site visit.

The Trust Finance Director will work with the Center financial staff in parallel to the panel review. Initial findings of the financial review will be shared with the panel members in order to inform discussions on general management, the appropriateness of genebank and institutional costs in relation to the Costing Study estimates, and any needs for investment in infrastructure or equipment. If necessary, the Finance Director may provide a recommendation for inclusion in the review report.

Phase III: Completing the report and presenting the recommendations
The review panel will produce a report of no less than 5,000 words in which actionable recommendations are clearly stated and justified. The report should be submitted to the Trust for initial review to ensure that the recommendations are clear and actionable. A response will be solicited from the Center by the Trust. Specific actions or workplans to respond to individual recommendations may be requested.

The Trust will, finally, provide its own response to the recommendations. In the event of a lack of endorsement by the Center or the Trust to a recommendation, further discussions may be necessary between the Trust, panel members and the Center staff. If necessary, the CGIAR Consortium Office or other bodies may be consulted.

The Trust Executive Board and the CGIAR Consortium Office will review the completed report. The report will also be made available on the Trust web site and circulated to the CGIAR genebank managers and presented at the Annual Genebanks Meeting.

Terms of reference of Review Panel members

The specific responsibilities of the Review Panel Members are to:

- Review background documents and data
- Participate in developing the site visit agenda
- Conduct any background research, ground-truthing or informal consultation concerning the review crops or Center in preparation for the site visit
- Participate in discussions with Trust staff to form an understanding of past interactions and experiences between the Trust and the review Center, and of future workplans for the Genebank CRP.
- If required, present the aims of the review to the Center staff
- Participate and/or conduct interviews with participants of the review
- Contribute to the formulation of the review recommendations and the written report
- If required, present the findings and recommendations of the review in subsequent relevant meetings.

In addition, a chair will be appointed by the Trust and will be required to take overall responsibility for:

- Organizing and conducting review presentations and interviews (unless otherwise delegated)
- Leading the panel members in formulating the recommendations and writing the review report
- Ensuring that the feedback from the Trust or review institute is adequately incorporated into the review report
- Ensuring that the formulation of the recommendations is based on principles of scientific and political objectivity, and that the interests or opinions of any one interviewee or panel member do not override this need for objectivity
- Ensuring that the final report is of an acceptable standard to the Trust.

Annex 2: Profiles of the Review Panel members

Johannes M.M. Engels (RP Chairman)

Johannes Martinus Marie Engels has been trained in genetics, plant breeding and pedagogic and didactics at the Agricultural University of Wageningen between 1967 and 1974.

He started his career at the tropical Central American research institute CATIE, Costa Rica in 1976 as a team member of a GTZ (now GIZ) implemented project on the establishment of a regional plant genetic resources programme for Central America. During this period he also initiated his PhD research on taxonomic and genetic aspects of cacao genetic resources and defended his thesis successfully in Wageningen in 1986.

From 1981 -1987 he was project leader of the BMZ funded and GIZ implemented genebank project in Ethiopia with technical responsibilities on genetic resources management and use aspects as well as managerial project responsibilities.

In 1988 he joined the International Board for Plant Genetic Resources (IBPGR). He coordinated for three years regional PGR activities in South and Southeast Asia, from the base in New Delhi, India.

In 1991 he moved to Rome and joined the Field Programme of IBPGR (later IPGRI and now Bioversity International). In 1993 he assumed the responsibility as Director of the Germplasm Management Unit. In 1998 he was appointed Director of the Genetic Resources Science and Technology Group. In 2006 he stepped down as Director and continued as Genetic Resources Management Advisor. The latter included more specific responsibilities such as the coordinator of the global cacao genetic resources network (CacaoNet) and coordinator of the virtual European genebank system initiative (AEGIS). He also acted as the Interim Director Commodities for Livelihoods Programme in Montpellier from November 2008 until end of June 2009 and from September 2010 until December 2011 as Acting Director of the Regional Office for Europe, based at Bioversity's headquarters in Maccarese, Italy.

In January 2012 he formally retired from Bioversity and was offered an Honorary Research Fellowship with a number of specific responsibilities. He also continued his AEGIS Coordinator responsibilities, on a consultancy basis. Both positions are ongoing.

Chikelu Mba

Chike is responsible for the Use of Plant Genetic Resources for Food and Agriculture (PGRFA) in the Seeds and Plant Genetic Resources Team of the Plant Production and Protection Division of the Food and Agriculture Organization of the United Nations (FAO). His work at FAO involves the deployments of combinations of normative and operational interventions to strengthen capacities and foster the requisite enabling environments in member countries for the translation of the potentials of PGRFA into improved productivities in farmers' fields

Prior to joining FAO and relocating to its Rome headquarters in March 2010, he had been:

- Head, Plant Breeding and Genetics Laboratory of the Joint Programme of Nuclear Techniques in Food and Agriculture of FAO and the International Atomic Energy Agency (IAEA) in Vienna and Seibersdorf, Austria from 2003 to 2010;
- Research Fellow and Coordinator, Cassava Biotechnology Network (Latin America and the Caribbean), International Centre for Tropical Agriculture (CIAT), Cali, Colombia. 1998 to 2003; and

- Plant Breeder – Geneticist and Leader, Cassava Program, National Root Crops Research Institute, Umudike, Abia State, Nigeria. 1993 to 1998.

He holds a PhD in Plant Breeding and Genetics and has published extensively on themes relating to plant breeding, molecular genetics, induced mutations and plant genetic resources.

Annex 3: Schedule for Review Panel

Genebank Review by Jan Engels, Chikelu Mba, Amanda Dobson and Charlotte Lusty

Date	Time	Agenda item	Staff involved	Venue
May 4 (Sun)	13:15 and 19:15:00	**Arrival in Cotonou (ET917 and AF805)**	Safiatou Yabre	Cotonou Airport
		Transport from airport to Hotel Ibis	Safiatou Yabre	Hotel Ibis
May 5 (Mon)	09:00 - 09:30	Courtesy meeting with DG and DDG R&D	Reviewers, DG & DDG	Director General Office
		Session I: Overview presentation of AfricaRice Strategy and Genebank activities		
	09:30 - 10:00	Introductory presentation from the Reviewers (objective of their visit) and Trust Representative	Reviewers	Main Conference room
	10:00 - 10:30	Presentation of AfricaRice overall strategy and where its genebank fits in	Marco Wopereis,DDG R&D	Main Conference room
	10:30 - 11:00	Coffee Break		
	11:00 - 11:30	Presentation of the Overview of Genetic Diversity and Improvement Program	Takashi Kumashiro, Program 1 Leader	Main Conference room
	11:30 - 12:30	Presentation of the activities of Genetic Resources Unit (GRU)	Marie Noelle Ndjiondjop	Main Conference room
	12:30 - 13:00	Discussion		Main Conference room
	13:00 - 14.00	Lunch		
		Session II: Utilization of genebank materials for Rice breeding at AfricaRice		
	14:00 - 14:30	Presentation on Rice Breeding at AfricaRice Ibadan in Nigeria	Venuprasad Ramaiah, Lowland Rice Breeder	EPMR Meeting room
	14:30 - 15:00	Presentation on Rice Breeding at AfricaRice Cotonou in Benin	Moussa Sie, Senior Rice Breeder	EPMR Meeting room
	15:00 - 15:30	Skype Discussion on Rice Breeding at AfricaRice Saint Louis in Senegal	Babouccar Manneh and Kofi Bimpong, Rice Breeders	EPMR Meeting room
	15:30 - 16:00	Coffee break		

	16:00 - 16:30	General Discussion		EPMR Meeting room
	19: 30 - 21: 00	Dinner		
May 6 (Tue)		**Session III: Visit of the genebank facilities, Laboratories & Fields and presentation of Other Units activities**		
	09:00 - 10:00	Visit of the Genebank Building and interaction with staff	Genebank staffs	GRU building
	10:00 - 10:30	Coffee break		GRU building
	10:30 - 11:30	Visit of screen houses and regeneration field	Marie Noelle Ndjiondjop	Screen house and field
	11:30 - 12:00	Presentation on Pathology and Quarantine Unit activities	Drissa Silue, Plant Pathologist	EPMR Meeting room
	12:00- 12:45	Visit of the Pathology Laboratory and Quarantine facilities	Drissa Silue	Pathology Laboratory
	12:45 - 14:00	Lunch		
	14:00 - 14:30	Presentation on Molecular characterization of Rice Accessions at AfricaRice	Mounir Sow, Molecular geneticist	EPMR Meeting room
	14:30 - 15:00	Visit of the molecular laboratory	Mounir Sow	EPMR Meeting room
	15:00- 15:30	Coffee break		
		Session IV: AfricaRice Genebank Information management		
	15.30 -16.30	Presentation and discussion on AfricaRice genebank data management	Marimagne Tchamba, genebank data manager	EPMR Meeting room
May 7 (Wed)		**Session V: Interaction with External partners of the genebank**		
	08:30 - 09:30	Skype discussion with Ruaraidh Sackville Hamilton, Head of TT-Chang GRC of IRRI	Ruaraidh Sackville Hamilton, Head of TT-Chang GRC of IRRI,	EPMR Meeting room
	09:30 - 10:00	Presentation on collaborative activities with Benin National Research Institute (INRAB) and discussion	Cyriaque Akakpo & Bello Iliath, INRAB	EPMR Meeting room
	10:00 - 10:30	Coffee break		EPMR Meeting room
		Session VI: New collection, LTS monitoring and risk management		
	10:30 - 11:00	Discussion on Collection of new rice germplasm and discussion	Marie Noelle Ndjiondjop,	EPMR Meeting room

	11:.00 - 11:30	Discussion on procedures including strategy for increasing and monitoring accessions in LTS	Marie Noelle Ndjiondjop,	EPMR Meeting room
	12:00 -13:30	Lunch		
	13:30 - 15:00	Discussion on reaching performance targets for availability and security	Marie Noelle Ndjiondjop,	EPMR Meeting room
	15:00 - 15:30	Coffee break		
	15:30 - 16:30	Discussion on the facilities (capacity), QMS and risk management	Marie Noelle Ndjiondjop, Drissa Silue & Takashi Kumashiro	EPMR Meeting room
May 8 (Thur)		**Session VII: Overview of the Reviewer report**		
	08:30 - 10:00	Reviewers wrap up	Reviewers only	EPMR Meeting room
	10:00 - 10:30	Coffee break		EPMR Meeting room
	10:30 - 12:00	Presentation of recommendations to GRU staff	Reviewers	EPMR Meeting room
	12:00 - 13:30	Lunch		
	13:30 - 14.30	Presentation of recommendations to Director General & DDG R&D	Reviewers, Takashi Kumashiro, Marie Noelle Ndjiondjop	Director General Office
May 9 (Fri)	22:35	Departure (AF804)	Safiatou Yabre	Cotonou Airport

AfricaRice Headquarter in Cotonou, Benin

Annex 4: List of people the Review Panel met at AfricaRice (05-08 May 2024)

Name	
Face to face meeting	
Adama Traoré	Acting Director General, AfricaRice
Marco Wopereis	Deputy Director General, Director of Research for Development, AfricaRice
Takashi Kumashiro	Genetic Diversity & Improvement Program Leader, AfricaRice
Marie-Noelle Ndjiondjop	Head Genetic Resources Unit (GRU), AfricaRice
Venuprasad Ramaiah	Senior Lowland Breeder, AfricaRice – Ibadan, Nigeria
Moussa Sie	Senior Rice Breeder, Breeding Task Force Coordinator, AfricaRice
Drissa Silué	Head Plant Pathology Unit, AfricaRice
Dro Daniel Tia	Research Assistant (genebank operations), GRU, AfricaRice
Marimagne Tchamba	Data Manager, GRU, AfricaRice
Sèdjro Bienvenue Kpeki	Research Technician, GRU, AfricaRice
Fatimata Bachabi	Research Assistant (seed health testing), GRU, AfricaRice
Mounirou Sow	PDF Molecular Geneticist, AfricaRice
Blandine Fatondji	Research Technician Molecular Biology, AfricaRice
Fisayo Kolade	Research Assistant Molecular Biology, AfricaRice
Thèotime Adouhoun	Field Assistant, GRU, AfricaRice
Dagnogo Klana	Head Facilities and Operations, AfricaRice
Cynaque Akakpo	Agronomist, INRAB, Cotonou
Iliath Bello	Rice Breeder, INRAB, Cotonou
Skype call	
Ruaraidh Sackville Hamilton	Head Genetic Resources Unit, IRRI, Los Baños, Philippines
Baboucarr Manneh	Rice Breeder, AfricaRice, Saint Louis, Senegal
Kofi Bimpong	Rice Researcher, AfricaRice, Saint Louis, Senegal

Annex 5: List of documents provided to the Review Panel

Year	Item
2010	Global strategy for the ex situ conservation of rice genetic resources, Ruaraidh Sackville-Hamilton, IRRI
2010	Global Rice Science Partnership (GRiSP), CGIAR Thematic Area 3; IRRI, AfricaRice and CIAT
2011	Proposal to the Fund Council. Submitted by Consortium Board of Trustees for 'Financial Support to the CGIAR Center Genebanks in 2011'
2012	Annual Report, Performance Indicators, Rice and Institute
2012	Rapport de mission: consultation sécurité, CIRAD
2011	Baseline Performance Indicators, Rice and Institute
2012	In Trust for the International Community. Plan and Partnership for Managing and Sustaining CGIAR-held Collections. CRP Research Support.
2012	The rational conservation and maintenance of rice genetic resources in the CGIAR; M1.1.1.3 (2012) Plan for rationalized conservation and maintenance of the IRRI, AfricaRice and CIAT collections established and implemented
2013	2013 Annual Report GENEBANK CRP, Global Crop Diversity Trust
2013	Annual Workplan, Performance Indicators, Institute
2013	Annual Report, Performance Indicators, Rice and Institute
2014	Operational Manual (Draft Document), GRU

Annex 6: Types of collections and their definitions

Storage conditions

The definitions below have been taken, and where necessary modified, from the '*Global strategy for the ex situ conservation of rice genetic resources*'. Typically, and in accordance with the FAO 'genebank standards for Plant Genetic Resources for Food and Agriculture'[10] , the length and conditions for storage are as follows:

- **Long-term storage (LTS).** Seed samples are stored at –18 ±3°C and RH of 15 ±3%. These conditions result in a seed moisture content (smc) on a wet weight basis (ww) of 8.4% or 9.2% on a dry weight basis (dw) and it would take 78 years for the seeds to lose viability of 1 probit[11].
- **Medium-term storage (MTS).** Seed samples should be stored under refrigeration at 5-10°C and RH of 15 ±3%. These conditions should be adequate to guarantee a life-span of 30 years for the seeds. For rice specifically, storage at 5°C and RH of 15% result in smc of 7.2% (dw) and an expected viability loss of 1 probit in 59 years. By comparison, storage at 10°C would result in the loss of viability of 1 probit in 47 years[12].
- **Short-term storage (STS).** The samples are stored at room temperature (i.e. under as cool and stable temperatures as possible but not more than 25°C). The RH is controlled either through the use of airtight containers or by using a dehumidifier. It is important that the RH is maintained at a level that ensures that the estimated time to the loss of viability of the samples is not shorter than the period within which the samples would have been used up or distributed. For instance, storage at 20°C and RH of 10% results in a smc (dw) of 5.0% and it would 68 years to lose 1 probit of viability. By comparison again, storage at RH of 25% would lead to smc (dw) of 8.3% and it would take 6 years to lose 1 probit of viability!
- **Temporary storage (TS).** Freshly harvested material or material that has been processed but not yet included in formal storage facilities, for instance, should be maintained at conditions that equate short-term storage. It is estimated, for instance, that seeds with a smc of 12% (expected for fully matured seeds harvested during a dry period) which are stored at room temperature in Cotonou (where the average daily high RH is higher than 90%) would lose viability within months.

Types of collections

Active collection: A collection that is maintained by a genebank and used as the source of seeds for on-going and continuous use, including distribution, characterization, and regeneration. It is usually conserved under MTS conditions. However, whenever possible, storage under LTS conditions is recommended in order to avoid a premature loss of viability which would trigger regeneration (rather than the depletion of the samples).

Every unique accession in active collections should be safely conserved in well maintained LTS, i.e. in a base collection.

Most-original-samples should be stored under LTS as mentioned above.

[10] FAO 2013. Genebank standards for Plant Genetic Resources for Food and Agriculture. Commission on Genetic Resources for Food and Agriculture. FAO, Rome, Italy
[11] To calculate the various parameters the following website could be used: http://data.kew.org/sid/viability/mc1.jsp
[12] To calculate the various parameters the following website could be used: http://data.kew.org/sid/viability/final_percent.jsp

Base collection: A collection of seeds prepared and held in ideal conditions for long-term conservation. The seeds are conserved and never used except for:

i. periodic germination tests;
ii. regeneration of samples when their viability decreases below a threshold value of 85%;
iii. regeneration to replace stocks in an active collection after having used material from the active collection for 3-4 successive cycles of regeneration; and
iv. as the primary point of rescue when the accession is accidentally lost from all active collections.

Working collection: A collection of germplasm maintained and used by a breeder or other scientist for their own breeding or research, without taking any specific measures to conserve. The collection may have a short life span and the composition of the collection may vary greatly during its lifetime. The storage conditions should equate those of short-term storage.

Safety back-up: Duplicate samples of the base collection (or active collection when material is not yet included in the base collection), stored in a different genebank, preferably in a different continent. The storage conditions in the safety back-up should be at least as good as those in the corresponding base collection. The holder of the safety back-up has no right to use or distribute the seeds in any way or the responsibility to monitor seed health or viability. Additional duplication of the base collection to the Svalbard Global Seed Vault provides definitive safety back-up in case of large scale loss of crop diversity.

Seed or reference file: A small sample of original seeds, set aside when a seed sample first arrives at the genebank, to serve as the definitive reference sample. The seed file should be maintained dry under conditions preventing disease or pest damage, although not necessarily alive. Other seed samples of the same accession, *e.g.* for every new harvest, should be visually cross-checked with the seed file.

Core collection: Contains a subset of accessions from the entire collection that captures most of the available genetic diversity for a given species[13]. The core is composed of about 10% of the total collection. The selection of the core entries should be based on the available data on the geographic origin, the genetic characteristics, and the possible value to breeders and other users of each accession in the collection. It should be noted that a core collection does not have to be a physically assembled collection; it can just be a list of identified and selected accessions.

Archive collection: Consists of germplasm accessions that are stored but not actively managed. A genebank has relinquished responsibility for conserving or distributing these accessions[14]. As the maintenance of such material is for any possible future use it is recommended to store archived accessions under long-term conditions.

Trait specific collection: Consist of accessions (or genotypes) that possess a defined trait. Also such a collection does not have to be physically assembled and could consist of a list of accession numbers.

[13] Definition from: A. H. D. Brown 1989. Core collections: a practical approach to genetic resources management. Genome, 1989, 31(2): 818-824.
[14] For more details see J.M.M. Engels and L. Visser (eds.) 2003. A guide to effective management of germplasm collections. IPGRI Handbook for Genebanks No. 6. IPGRI, Italy.