

ICRAF Genebank Review 2015

Programme: Genebanks CRP	
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Place: Nairobi, Kenya	
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Review Panel	Paul Smith
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RESEARCH
PROGRAM FOR
Managing and
Sustaining Crop
Collections



ICRAF 2015 Genebank Review: recommendations and responses

	Recommendation	Responses by ICRAF	Responses by Crop Trust
1) <i>Equipment</i>	<p>Recommendation 1: It is recommended that ICRAF purchases identified key pieces of equipment and consults as widely as possible on optimal specifications for equipment items before purchase, those consultations extending beyond the CGIAR. Specific equipment needs include: a small seed cleaning machine (zig zag or gravimetric blower/vacuum separator); a flow hood for the seed cleaning laboratory; a low energy growth chamber to replace the Sanyo incubator (1997) or Fitotron incubator if it can't be fixed; a field Rotronic hygrometer; and heavy duty weighing machine. Finally, we recommend that a barcoding system is installed, and the potential for microchipping field genebank collections is investigated. It is recommended that this equipment be purchased with the carryover funds available from the Crop Trust.</p>	<ul style="list-style-type: none"> • Equipment will be bought through routine budget and carry-over fund: <ul style="list-style-type: none"> ○ Seed cleaning machine ○ Flow hood ○ Two Field rotronic hygrometer ○ Weighing machine ○ Bar-coding equipment <p>Supplier engineers concluded that efficiencies of the Fitotron growth chambers' are affected by the seed lab ambient temperature. They have recommended improving the room's ventilation, which we are currently undertaking. Following completion of the ventilation works, we shall monitor efficiencies of the growth chambers, before a decision is made on whether there is need to purchase the recommended GC.</p>	<p>The Crop Trust supports both the recommendation and the response. It notes specifically that the reviewers have recommended that ICRAF consult widely before making significant purchases. Unwise purchase of inappropriate specialist equipment has been a frequent experience for several genebanks. This can be overcome by asking other genebanks both in the same region and beyond what experiences they have had with their equipment. ICRAF have been consulting on purchases with ILRI and MSB in the past. Consulting these and additional organizations (e.g. CIP on barcoding, IITA on other equipment) would be a good idea.</p>
2) <i>Collections coverage and cost-effectiveness</i>	<p>Recommendation 2: The review team recommends that ICRAF develops a collections acquisition and retention policy based on ICRAF's global mandate (see Section 3), identified user needs (Section 2) and cost-effectiveness using a decision matrix or similar approach (Section 1). Some of the carry over funding available from the Crop Trust could be used for this purpose. More detailed recommendations on how to achieve this are given in the main body of the text below.</p>	<p>ICRAF acquisition and retention policy will be developed as detailed in the Carry-over Funds Proposal. As suggested in this recommendation we will:</p> <ul style="list-style-type: none"> • Develop a decision matrix on the AF species in the collection; use the matrix to make decisions in cost effective conservation methods. • Identify user needs by engaging external 	<p>This is an important exercise. The Crop Trust has asked ICRAF to conduct a prioritization of its conservation efforts a number of times over the past three years and, so far, ICRAF have not addressed this need. The reviewers not only make the same recommendation but they have provided detailed guidance on the components of the prioritization process. The strategic nature of this exercise needs to be emphasized; it is of equal importance</p>

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		<p>stakeholders to understand their need for materials that ICRAF might supply.</p> <ul style="list-style-type: none"> Identify gaps in global collection 	<p>to identify taxa or field sites that are of lower priority (or someone else's priority) as it is to identify high priorities. Gaps will not be able to be identified until it is clear what is ICRAF's strategic focus within the context of organizations working in the same field. ICRAF should remain in frequent contact with the Crop Trust to ensure this exercise achieves the hoped for objectives.</p>
3) <i>Current collections status</i>	<p>Recommendation 3a. ICRAF's existing seed and field genebank collections represent a valuable resource for current and future use. Characterizing these collections and assessing their quality should remain the first priority. Based on this analysis and on ICRAF's collections acquisition and retention policy (see above), it is recommended that seeds of priority collections that are reduced to low numbers (e.g. some OFI collections) should be regenerated and/or re-collected to augment dwindling stocks. Similarly, field genebank collections should either be retained by ICRAF, handed over to country partners or discarded, depending on ICRAF's collections acquisition and retention policy.</p> <p>Recommendation 3b. It is not recommended that ICRAF develops Long Term Storage facilities at this stage. However, safety duplication is needed for as many seed</p>	<p>3a. Accession characterisation data will be generated progressively; morphological, molecular and biochemical will be used where appropriate.</p> <p>The collection and acquisition policy being developed in Recommendation 2 above will guide in the species where re-collection/regeneration will be necessary to ensure enough seeds stock.</p> <p>3b. ICRAF will consider having long term storage at the Kunming Institute of Botany Genebank and safety duplicate at Svalbard.</p>	<p>3a. This follows the previous recommendation. The reviewers are asking ICRAF to develop clear actions to address the lack of seed stock for individual species and field collections according to the acquisition and retention plan and based on quality and priority. The reviewers are not expecting ICRAF to conserve it all. ICRAF's response is a little lacking detail but suggests that this point is understood. The Crop Trust supports strongly a more strategic direction to decision taking on seed stock and conservation. This will be important for ICRAF to reach performance targets within the next 6 years.</p> <p>3b. ICRAF's response does not correspond with what the reviewers are recommending which is (1) safety duplicate in Svalbard and (2) active conservation in LTS in one other</p>

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	collections as possible (a) in Svalbard for 'black box' long term conservation and (b) in a facility that carries out characterization and viability testing. To this end, renegotiation of the duplication agreements with Kew's Millennium Seed Bank and/or the Kunming Institute of Botany is recommended. Both institutions carry out seed characterization and quality testing as part of their routine accessioning practices.		organisation. We would like to see ICRAF revisit or justify this response.
4) <i>Documentation, data and databases</i>	Recommendation 4: The Review Panel recommends that the passport and characterization data for all remaining <i>ex situ</i> genebank and field genebank accessions is completed as a priority. For this purpose, an additional laboratory technician or database person should be hired to speed up the characterization of remaining accessions. In addition, an economic botany (use) module needs to be added to ICRAF's genebank database system, and use information be made available on ICRAF's Seed List.	A Database Officer has already hired and will soon recruit a technician to assist with the characterization work. We shall also review our Database to ensure we capture additional recommended accession information such as economic botany.	The Crop Trust supports both the recommendation and the response. ICRAF has initiated a workplan to improve the levels of characterisation data. Links to existing datasets should also be considered here.
5) <i>Standard Operating Procedures</i>	Recommendation 5: The Panel recommends that ICRAF puts measures in place to ensure that prohibited alien invasive taxa are never distributed. For species identified as 'problematic' with a potential to transform native plant communities, ICRAF should strengthen its existing measures by providing a specific warning to the recipient along with the material. In addition, the recipient should be asked to declare on the Seed Request form that they have carried out a weed risk assessment.	ICRAF's Genetic Resources policy prohibits distribution of known alien invasive species. The ICRAF GRU will follow up with ICRAF Regional offices and other Science Domains to ensure adherence of the GR policy. Presently, ICRAF alerts Seed recipients on "invasive seeds" in the Seed Dispatch Form which they sign upon receiving the requested seeds. ICRAF will proceed to include a section on <i>Weed risk</i>	The Crop Trust supports the recommendation. There appears to be an opportunity to strengthen the implementation of this policy on invasive taxa. In follow up to this recommendation, we would like to see what specific measures ICRAF have put in place to identify and prevent the distribution of risky invasive species.

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		<i>assessment</i> to our current Seed Dispatch Form. However it is important to note that ICRAF does not have the mechanism or means to verify that the weed risk assessment has been satisfactorily conducted by the seed recipient.	
6) <i>Risk management</i>	Recommendation 6: We recommend that ICRAF considers and assesses reputational, financial and other non-operational risks associated with GRU activities and performance, and elevates these to institutional level.	<p>We have requested that ICRAF Risk Management Policy include these GR issues; We have started up the discussion with ICRAF Senior leadership Team on the subject.</p> <p>As a way forward on the reputational risk, ICRAF will enforce the GR Policy through the recently introduced “Project start up” and “Project close out” meetings. Via these meetings, the GRU is able to identify, along with the project Team, any activities that may be related to Genetic Resources and guide on the adherence to the ICRAF GR Policy.</p>	Crop Trust supports the recommendation and the response, and requests ICRAF to consider if there is anything we can do to support their actions on this recommendation.
7) <i>Current use trends</i>	<p>Recommendation 7a: It is recommended that ICRAF management facilitate and ensure that GRU staff are consulted, during the design of all ICRAF projects that require germplasm to be supplied from the GRU.</p> <p>Recommendation 7b: We recommend that ICRAF publicizes its Seed List more actively, specifically targeting sectors that are currently</p>	<p>7a: We have requested the Proposal Development Unit to engage GRU in the Proposal Evaluation Committee for proposals that will require tree germplasm from the unit. This way the genebank will be aware of the proposal and get ready for the request in case the proposal gets funded.</p> <p>7b: We are exploring these suggestions. We requested the ICRAF Website manager to consider uploading the Seed List and Seed</p>	<p>7a. Crop Trust supports the recommendation and response, and looks forward to hearing about the outcome of GRU’s involvement in the Proposal Evaluation Committee.</p> <p>7b. Crop Trust supports the recommendation and the response.</p>

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	<p>under-represented as users and which can add scale or impact to ICRAF’s work (notably the research sector). One suggestion would be to elevate the Seed List to the front page of ICRAF’s website.</p> <p>Recommendation 7c: It is recommended that the GRU gathers data on where seed is distributed in ICRAF-led projects, as well as the impact of the research and development GRU material supports. The seed request form should include (a) all recipients and destinations of the seed, and (b) a <i>requirement</i> for feedback, copies of publications and acknowledgement as part of the MTA.</p> <p>Recommendation 7d: The Review Team recommends that ICRAF revises its Tree Seed Suppliers Directory, focusing on seed material available from its partner organizations (public, private and civil), and promotes the use of this Directory through the development of advanced tools such as its Vegetation and Climate Change in Eastern Africa (VECEA) application currently under development.</p>	<p>Request Form in the front page of ICRAF Website-</p> <p>7c: Already the Seed Request Form demands that this information be provided. GRU will ensure that the final seeds establishment location is provided by the ICRAF scientist requesting material. This will also be followed up in the recently introduced project start up and close out meetings.</p> <p>7d: Plans are in place to revise Tree Seed Suppliers Directory</p>	<p>7c. Crop Trust supports the recommendation and the response.</p> <p>7d. Crop Trust supports the recommendation and the response.</p>
8) <i>Performance targets</i>	<p>Recommendation 8: The review team recommends to the Crop Trust that ICRAF follow the revised performance targets related, in particular, to ICRAF’s field genebanks and accessions with long regeneration times, outlined in Table 6.</p>	<p>The suggested performance targets’ revision is agreeable. We request for further discussion with the Trust on the subject.</p>	<p>Crop Trust is glad that an agreement has been made on a suggested revision to the performance targets for long-lived species. This will need to be reviewed by the other genebanks affected and then will be incorporated into the performance targets.</p>

External Review of the ICRAF Genetic Resources Unit Commissioned by the Global Crop Diversity Trust

Paul Smith & Lex Thomson

June 8-12th, 2015

Nairobi, Kenya



Table of Contents

Abbreviations and Acronyms	Page 3
Executive summary	Page 5
List of Recommendations	Page 9
Background	Page 11
1. Genebank operations	Page 12
1.1. Facilities and equipment	Page 12
1.2. Collections	Page 13
1.3. Documentation, data and databases	Page 15
1.4. Standard operating procedures	Page 16
1.5. Human resources	Page 16
1.6. Cost effectiveness	Page 17
1.7. Risk management	Page 17
2. The roles, services and use of the genebanks, and the linkages with users and partners both within and outside the CGIAR	Page 19
2.1. Current use trends of ICRAF material	Page 19
2.2. User's surveys	Page 22
3. The status of the genebank, or individual collections within it, in the context of a global system for the long-term conservation and use of agroforestry germplasm	Page 24
3.1. ICRAF's tree genetic resources policy and strategy 2013-2017	Page 24
3.2. Global collections gap analysis	Page 25
4. The status of the genebank with respect to the performance targets and the feasibility of proposed work plans to reach targets	Page 27
Conclusions	Page 28
Appendix 1: Review panel	Page 29
Appendix 2: Review agenda	Page 30
Appendix 3: User feedback	Page 34
Appendix 4: List of documents provided by ICRAF	Page 38

Abbreviations and Acronyms

ARI	Agricultural Research Institution
BRAHMS	Botanical Research And Herbarium Management System (database)
CBD	Convention on Biological Diversity
CBO	Community-Based Organisation
CCER	Center-commissioned external review in the CGIAR system
CGIAR	Consultative Group on International Agricultural Research
CIRAD	Centre de coopération Internationale en Recherche Agronomique pour le Développement
CRP	CGIAR Research Program
CSIRO	Commonwealth Scientific and Industrial Research Organization, Australia
DBMS	Database Management System
eRH	Equilibrium Relative Humidity
FAO	United Nations Food and Agriculture Organization
GCDT	Global Crop Diversity Trust
GBOWS	Gene Bank of Wild Species, Kunming, China
GENESYS	Gateway to Genetic Resources
GRIN	Germplasm Resources Information Network
GRU	Genetic Resources Unit
HQ	Headquarters
IARC	International agricultural research centers of the CGIAR
ICRAF	World Agroforestry Centre (WAC)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ITPGRFA	International Treaty for Plant Genetic Resources in Food and Agriculture
KEFRI	Kenya Forestry Research Institute
LTG	Long Term Grant

LTS	Long Term Storage
MSB	Millennium Seed Bank, Royal Botanic Gardens, Kew, UK
MTA	Material Transfer Agreement
MTS	Medium Term Storage
MySQL	Structured Query Language
NARS	National Agricultural Research Systems
NGO	Non Governmental Organization
ODA	Overseas Development Agency
OFI	Oxford Forestry Institute
PGRFA	Plant genetic resources for food and agriculture
PHP	Hypertext Preprocessor (HTML-embedded scripting language)
QMS	Quality Management System
SINGER	System-wide Information Network of Genetic Resources of the CGIAR
SMTA	Standard Material Transfer Agreement (under the International Treaty)
SWOT	Strengths, Weaknesses, Opportunities, Threats
UPS	Uninterruptible Power Supply
USAID	United States Agency for International Development
VECEA	Vegetation and Climate Change in Eastern Africa (project)

Executive Summary

ICRAF's Genetic Resources Unit (GRU) was established in 1993. Prior to this, germplasm-related activities were carried out within other programmes. The objective of the GRU is to collect, conserve, document, characterize and distribute a diverse collection of agroforestry trees, with a strong focus on indigenous species. The Genetic Resources Unit comprises a medium-term cold storage genebank located at ICRAF's headquarters in Nairobi, short-term seed storage facilities in Bamako (Mali) and Lilongwe (Malawi), and a series of 37 agroforestry field genebanks in 15 countries, mostly in tropical Africa, but also in South America (Peru) and Asia (Vietnam and Bangladesh).

The aim of this review is to:

- Assess the operations and activities of the ICRAF genebanks
- Assess the roles, services and use of the genebanks, and the linkages with users and partners both within and outside the CGIAR
- Consider the status of the genebanks or individual collections within it, in the context of a global system for the long-term conservation and use of the crops in question
- Review the status of the genebanks with respect to the performance targets and the feasibility of proposed workplans to reach targets
- Provide actionable recommendations related to all of the above

Genebank Operations

ICRAF's GRU is well run, with motivated and knowledgeable staff in both the *Ex situ* Genebank and field genebanks. The *Ex situ* Genebank at ICRAF Headquarters is well-equipped with regard to its facilities and equipment, and has benefitted substantially from the injection of funds since 2012 through the Genebank CGIAR Research Programme. Similarly, the field genebanks have been recently rehabilitated, significantly adding to their value. In addition, substantial and ongoing efforts to test and characterize the GRU's *Ex situ* and field genebank collections will greatly add to their value. Additional equipment needs were identified by the Review Team, and recommendations were made for a barcoding labelling system.

ICRAF's collections comprise:

- **4992 accessions** representing **190** tree species conserved, medium-term, in the *Ex situ* Genebank located at ICRAF Headquarters in Nairobi, Kenya
- Over **10,000 accessions** of **44 species** established either from seeds or clonally located in **37 sites** in **15 countries** in Africa, Latin America, South Asia and South East Asia.
- **2280 accessions** of **120 species** are held at Kunming Institute of Botany genebank, China and the Millennium Seed Bank, UK as safety duplicates.

Due to the rather *ad hoc* germplasm acquisition process hitherto – which has been based on historic project foci – ICRAF's collections coverage is patchy, comprising mainly indigenous African multipurpose/food tree species but including a number of important exotic species used in African agroforestry and other tropical zones. A key recommendation of the Review is for ICRAF to develop a collections acquisition and retention policy based on ICRAF's global mandate, identified user needs and cost-effectiveness. In addition, the Review recommended that the GRU should duplicate as many of its collections as possible (a) in Svalbard for 'black box' long term conservation and (b) in a facility that carries out characterization and viability testing. It is not recommended that ICRAF develops Long Term Storage facilities of its own at this stage.

The documentation associated with the GRU collections is appropriate and comprehensive. However, there is a significant backlog in characterizing and assessing the quality of the collections in both the *Ex situ* genebank and in the field genebanks. Passport and characterization data is still incomplete for most of the field genebank accessions. Assembling and acquiring these data has been identified as a priority for the GRU. ICRAF's genebank database system, a BRAHMS-based, locally developed web-based PHP application that runs on a MySQL relational database, appears to be comprehensive, and fit for purpose. One element that could be strengthened is information on use and, in the medium to long term, the Review recommends that ICRAF consider migrating to GRIN-Global.

ICRAF's seed laboratory procedures are derived from the FAO standards and appear to be robust and comprehensive. Seed health testing protocols are being developed with the help of a plant pathologist from the Kenya Forestry Research Institute. ICRAF's Invasive Alien Policy (2013) is clear about its commitment to minimizing the impacts of invasive alien species, and its Seed Request Form includes a general warning about the potential for invasiveness of some species. The Review recommends that ICRAF put measures in place to ensure that prohibited alien invasive taxa are never distributed. For species identified as 'problematic' with a potential to transform native plant communities, it is recommended that ICRAF should strengthen its existing measures by providing a specific warning to the recipient along with the material.

The review team were extremely impressed with the calibre of the GRU staff. All were highly engaged, proud of their work and knowledgeable.

The review team were encouraged to see that risk assessment procedures, recording of incidents and mitigation strategies were in place for the GRU. The team were also pleased to see that the operational risks associated with the GRU's activities were integrated into the institutional risk register. The Review recommends that given the high reputational – and potentially financial – risks associated with the operations of the GRU if, for example, poor quality, diseased or invasive material was supplied to third parties, that these should be considered at the institutional level as well as the current operational risks.

The roles, services and use of the genebanks, and the linkages with users and partners both within and outside the CGIAR

The GRU's current user profile demonstrates weaknesses in some sectors. For example, very little seed from ICRAF's *Ex situ* Genebank is reaching research institutions, farmer organizations, NGOs and CBOs. No seed appears to have been sent to the commercial sector in the past three years. All of these sectors have the ability to add value to or scale up the use of material. In contrast, the majority of material has gone to individual farmers where the impact will be limited. In addition, the international reach of ICRAF's GRU is quite limited currently, with 87% of the collections sent out by ICRAF in 2014 going to Kenya. In some cases, where ICRAF projects are the 'Kenyan' recipient, seed may have been distributed more widely, however it isn't currently possible to quantify this. The Review Team suggests that ICRAF's focus should be complementary to that of the national tree seed centers and forestry research institutions with which it collaborates, both in terms of the research ICRAF carries out and the material it supplies. In this context, the Review recommends that, as part of the development of its acquisitions and retention policy, ICRAF's GRU should proactively engage with external organizations to understand their need for materials that ICRAF might supply. In addition, it is recommended that ICRAF publicizes its Seed List more actively, gathers data on where seed is distributed in ICRAF-led projects, and more widely on the impact of the research and development GRU material supports.

For seed collections that are sent out, users are generally very happy with the quality of the germplasm. In a recent survey, 97% of respondents were satisfied, indicating that in general there are no problems with the viability of the distributed germplasm. The viability of seed distributed was also rated highly with 48% and 50% of respondents rating germination as excellent and moderate respectively. Most of the respondents (80%) perceived the information accompanying seed samples as very useful for their use of germplasm. The review team commends the GRU on its efforts to gather feedback from existing customers, and encourages ICRAF to carry out follow up surveys to a wider range of users.

The status of the genebank, or individual collections within it, in the context of a global system for the long-term conservation and use of agroforestry germplasm

ICRAF's GRU has developed globally important and regionally vital tree germplasm collections for more than 30 species. ICRAF's genebanks are probably the most important global repository of agroforestry tree species conserved *ex situ*, and have taken on added importance due to the decline, loss and underfunding of the tree seed sector over the past two decades, including national facilities, previously well-supported by donors. However, ICRAF's collections represent only a fraction of the several thousand tree species that deliver a whole host of products and services in agroforestry systems to smallholder farmers in developing countries. The recent State of the World's Forest Genetic Resources Review (2014) concludes that around 8,000 tree species are used in forestry around the world. Only a proportion of these will be used in developing countries, and still fewer in agroforestry. However, the Review recommends that ICRAF considers adopting a more pro-active approach to acquire, as a minimum, genetically representative collections of the most important species globally in agroforestry systems. This would also include tree species which can ensure resilience in agroforestry systems in the face of predicted climate change and extremes. ICRAF might be able to most usefully expand its tree germplasm collections through more actively seeking donations from national institutes to fill gaps.

The status of the genebank with respect to the performance targets and the feasibility of proposed workplans to reach targets

ICRAF's Genetic Resources Unit is struggling to achieve some of the performance targets set in the Crop Trust's Work Plans compared to genebanks in the other CG centers. ICRAF is behind on some of these targets due to the size of the collections characterization backlog. This backlog is being addressed by setting targets through Annual Workplans. The review team is confident that ICRAF's GRU will be able to achieve many of these performance targets given time, and has made some specific recommendations regarding performance targets relevant to ICRAF's collections.

Conclusions

ICRAF's GRU is well run, with motivated and knowledgeable staff in both the *Ex situ* Genebank and field genebanks. The *Ex situ* Genebank at ICRAF Headquarters is well-equipped with regard to its facilities and equipment, and has benefitted substantially from the injection of funds since 2012 through the Genebank CGIAR Research Programme. The GRU's existing collections are globally significant, and their value will be increased once they are fully characterized, and their passport data is complete. However, in order for ICRAF's GRU to fulfil its true potential, it needs to develop a collections acquisition and retention policy based on ICRAF's global mandate, identified user needs and cost-effectiveness.

List of Recommendations

Area/Activity	Recommendations
<i>Equipment</i>	Recommendation 1: It is recommended that ICRAF purchases identified key pieces of equipment and consults as widely as possible on optimal specifications for equipment items before purchase, those consultations extending beyond the CGIAR. Specific equipment needs include: a small seed cleaning machine (zig zag or gravimetric blower/vacuum separator); a flow hood for the seed cleaning laboratory; a low energy growth chamber to replace the Sanyo incubator (1997) or Fitotron incubator if it can't be fixed; a field Rotronic hygrometer; and heavy duty weighing machine. Finally, we recommend that a barcoding system is installed, and the potential for microchipping field genebank collections is investigated. It is recommended that this equipment be purchased with the carryover funds available from the Crop Trust.
<i>Collections coverage and cost-effectiveness</i>	Recommendation 2: The review team recommends that ICRAF develops a collections acquisition and retention policy based on ICRAF's global mandate (see Section 3), identified user needs (Section 2) and cost-effectiveness using a decision matrix or similar approach (Section 1). Some of the carry over funding available from the Crop Trust could be used for this purpose. More detailed recommendations on how to achieve this are given in the main body of the text below.
<i>Current collections status</i>	Recommendation 3a. ICRAF's existing seed and field genebank collections represent a valuable resource for current and future use. Characterizing these collections and assessing their quality should remain the first priority. Based on this analysis and on ICRAF's collections acquisition and retention policy (see above), it is recommended that seeds of priority collections that are reduced to low numbers (e.g. some OFI collections) should be regenerated and/or re-collected to augment dwindling stocks. Similarly, field genebank collections should either be retained by ICRAF, handed over to country partners or discarded, depending on ICRAF's collections acquisition and retention policy. Recommendation 3b. It is not recommended that ICRAF develops Long Term Storage facilities at this stage. However, safety duplication is needed for as many seed collections as possible (a) in Svalbard for 'black box' long term conservation and (b) in a facility that carries out characterization and viability testing. To this end, renegotiation of the duplication agreements with Kew's Millennium Seed Bank and/or the Kunming Institute of Botany is recommended. Both institutions carry out seed characterization and quality testing as part of their routine accessioning practices.
<i>Documentation, data and databases</i>	Recommendation 4: The Review Panel recommends that the passport and characterization data for all remaining <i>ex situ</i> genebank and field genebank accessions is completed as a priority. For this purpose, an additional laboratory technician or database person should be hired to speed up the characterization of remaining accessions. In addition, an economic botany (use) module needs to be added to ICRAF's genebank database system, and use information be made available on ICRAF's Seed List.
<i>Standard Operating Procedures</i>	Recommendation 5: The Panel recommends that ICRAF puts measures in place to ensure that prohibited alien invasive taxa are never distributed. For species identified as 'problematic' with a potential to transform native plant communities, ICRAF should strengthen its existing measures by providing a specific warning to the recipient along with the material. In addition, the recipient should be asked to declare on the Seed Request form that they have carried out a weed risk assessment.
<i>Risk management</i>	Recommendation 6: We recommend that ICRAF considers and assesses

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	reputational, financial and other non-operational risks associated with GRU activities and performance, and elevates these to institutional level.
<i>Current use trends</i>	<p>Recommendation 7a: It is recommended that ICRAF management facilitate and ensure that GRU staff are consulted, during the design of all ICRAF projects that require germplasm to be supplied from the GRU.</p> <p>Recommendation 7b: We recommend that ICRAF publicizes its Seed List more actively, specifically targeting sectors that are currently under-represented as users and which can add scale or impact to ICRAF’s work (notably the research sector). One suggestion would be to elevate the Seed List to the front page of ICRAF’s website.</p> <p>Recommendation 7c: It is recommended that the GRU gathers data on where seed is distributed in ICRAF-led projects, as well as the impact of the research and development GRU material supports. The seed request form should include (a) all recipients and destinations of the seed, and (b) a <i>requirement</i> for feedback, copies of publications and acknowledgement as part of the MTA.</p> <p>Recommendation 7d: The Review Team recommends that ICRAF revises its Tree Seed Suppliers Directory, focusing on seed material available from its partner organizations (public, private and civil), and promotes the use of this Directory through the development of advanced tools such as its Vegetation and Climate Change in Eastern Africa (VECEA) application currently under development.</p>
<i>Performance targets</i>	<p>Recommendation 8: The review team recommends to the Crop Trust that ICRAF follow the revised performance targets related, in particular, to ICRAF’s field genebanks and accessions with long regeneration times, outlined in Table 6.</p>

Background

ICRAF's Genetic Resources Unit (GRU) was established in 1993. Prior to this, germplasm-related activities were carried out within other programmes. The objective of the GRU is to collect, conserve, document, characterize and distribute a diverse collection of agroforestry trees, with a strong focus on indigenous species. The Genetic Resources Unit comprises a medium-term cold storage genebank located at ICRAF's headquarters in Nairobi (*Ex situ* Genebank), short-term seed storage facilities in Bamako (Mali) and Lilongwe (Malawi), and a series of 37 agroforestry field genebanks in 15 countries, mostly in tropical Africa, but also in South America (Peru) and Asia (Vietnam and Bangladesh). Since 1994, the material in ICRAF's genebanks has been held in trust under the auspices of FAO. As part of this agreement, ICRAF 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 freely available for the purpose of scientific research, plant breeding or genetic resource conservation, under a standard Material Transfer Agreement that is used by the CGIAR for all in-trust materials. In 2006, ICRAF signed the International Treaty on Plant Genetic Resources for Food and Agriculture. Since 2012, ICRAF has received funding from the Genebank CGIAR Research Programme (CRP) managed by the Global Crop Diversity Trust to support the long-term conservation and sustainable utilization of the agroforestry germplasm held by ICRAF. This review of the ICRAF genebank is, therefore, undertaken within the framework and context of the Genebank CRP.

Aim of this review

The aim of this review is to:

- Assess the operations and activities of the ICRAF genebanks
- Assess the roles, services and use of the genebanks, and the linkages with users and partners both within and outside the CGIAR
- Consider the status of the genebanks or individual collections within it, in the context of a global system for the long-term conservation and use of the crops in question
- Review the status of the genebanks with respect to the performance targets and the feasibility of proposed workplans to reach targets
- Provide actionable recommendations related to all of the above

1. Genebank Operations

1.1. Facilities and equipment

ICRAF's *Ex situ* Genebank is well equipped with regard to its facilities and equipment. Its dry room and cold room are functioning well, the seed laboratory is of adequate size, and fulfils its function. Although not part of the Genebank *per se*, ICRAF's molecular laboratories are excellent, and bring a new and very useful genotyping capacity to characterization of the genebank collections.



Figure 1: *Ex situ* Genebank cold room collections



Figure 2: Field genebank, Kitui, Kenya

The Seed Laboratory is well equipped, combining seed processing with seed testing, including viability testing. Of the three incubators, only the Sanyo growth cabinet (1997) appears to be reliable. One of the new Fitotron incubators (2013) has not worked properly since it was purchased despite the attention of company engineers. These were locally sourced, their ready availability being the main reason why they were selected. In addition, their high energy usage means that they are not integrated into the Uninterruptible Power Supply (UPS) system.

Seed collections are currently cleaned by hand, and as there are no flow hoods in the seed cleaning laboratory, dusty seeds or seeds with irritant hairs can cause contamination and /or a health hazard.

Labelling of seed collections is a potential weakness in both the *Ex situ* Genebank and in the field genebanks. In the *Ex situ* Genebank, for example, seeds being despatched include hand-written labels, creating the possibility of transcription errors. In the field genebanks, labels are often removed or moved by children or animals. A bar-code labelling system would solve the labelling problem, particularly if it was combined with microchip labelling of all individual trees in the field collections.

Recommendation 1: It is recommended that ICRAF purchases identified key pieces of equipment and consults as widely as possible on optimal specifications for equipment items before purchase, those consultations extending beyond the CGIAR. Specific equipment needs include: a small seed cleaning machine (zig zag or gravimetric blower/vacuum separator); a flow hood for the seed cleaning laboratory; a low energy growth chamber to replace the Sanyo incubator (1997) or Fitotron incubator if it can't be fixed; a field Rotronic hygrometer; and heavy duty weighing machine. Finally, we recommend that a barcoding system is installed, and the potential for microchipping field genebank collections is investigated. It is recommended that this equipment be purchased with the carryover funds available from the Crop Trust.



Figure 3: ICRAF’s seed processing and testing lab

1.2. Collections

ICRAF’s collections comprise:

- **4992 accessions** representing **190 tree species** conserved, medium-term, in the *Ex situ* Genebank located at ICRAF Headquarters in Nairobi, Kenya
- Over **10,000 accessions** of **44 species** established either from seeds or clonally located in **37 sites** in **15 countries** in Africa, Latin America, South Asia and South East Asia.
- **2280 accessions** of **120 species** are held at Kunming Institute of Botany genebank, China and the Millennium Seed Bank, UK as safety duplicates.

Due to the rather *ad hoc* acquisition process hitherto – which has been based on historic project foci – ICRAF’s collections *coverage* is patchy, comprising a range of mainly African indigenous timber, multipurpose, food, fertilizer and fuelwood tree species but including a number of important exotic species used in African agroforestry and other tropical zones. The comprehensiveness of ICRAF’s collections is covered more thoroughly in **Sections 2 and 3**, below. However, new projects, such as the African Orphan Crop Consortium are using a proven approach to targeted acquisition, based on consultation with national partners (public, private and civil) and identification of national needs. This particular project includes 47 agroforestry tree species targeted for collections and research.

ICRAF has a well-established international reputation and comparative advantage in conserving collections of African agroforestry tree germplasm. This unique germplasm resource must continue to be built on through additional collections of priority tree species which have yet to be scientifically sampled and conserved *ex situ*, including for example, *Dovyalis caffra*, *Diospyros* spp. including *D. mespiliformis* (indigenous persimmons), *Grewia* spp., *Parinari curatellifolia*, *Schinziophyton rautanenii* and other tree species represented in the African Orphan Crop Consortium species list.

The *quality* of the seed collections held in ICRAF’s *Ex situ* genebank has been compromised in the past due to sub-optimal processing and storage of collections, as identified in previous reviews. However, the drying room is now functioning properly, and the seed conservation procedures, have been dramatically improved over the past year, with the assistance of CRP resources, including the adoption of air-tight foil bags for packaging the seeds. To date, 1322 (i.e. ca. 26%) of the 4992 seed bank collections have been tested for viability, and only a handful of collections have been found to be non-viable. Testing of the backlog will continue as a priority.

ICRAF's field genebanks were established for different purposes in the 1990s and 2000s, and these are currently being rehabilitated. However, some individual trees and collections have died, leaving gaps that should be replaced with missing or new accessions. While all 37 field genebanks will have some value, not all will be relevant to ICRAF's global mandate. Those field genebanks that ICRAF decides to invest in should continue to have a multifunctional role, *viz* conservation, characterization and as seed orchards to augment dwindling seed stocks and to supply high quality material across regions and internationally. Field genebanks should also continue to be used for demonstration purposes for farmers through to policymakers. Improved or plus accessions in field genebanks, whether true to type or not, should be banked for conservation, if orthodox, and available for distribution.

Both the *Ex situ* genebank seed collections and the field genebanks are being assessed for plant health by an external plant pathologist, Dr Jane Wangu Njuguna.

The **characterization** of the collections, both seed and field, appears to be thorough and appropriate, albeit with a considerable backlog, particularly for the field genebank collections. The capacity for molecular characterization afforded by ICRAF's new molecular laboratory, is a particularly exciting development.

Duplication of ICRAF's seed collections – mainly in Svalbard and the Kunming Institute of Botany's Genebank of Wild Species (GBOWS) long term storage (LTS) facility – has been achieved under blackbox conditions for 2280 (45%) of the 4992 accessions and 120 (63%) of the 190 taxa. Kew's Millennium Seed Bank (MSB) also provides long term storage for a few taxa. While the LTS facilities provided by GBOWS and the MSB are a cost-effective option for ICRAF currently, this may change if these organizations started to make a charge for the service they provide. Furthermore, given that Svalbard provides perfectly adequate blackbox safety duplication, the optimal arrangement would be for the third facility (i.e. GBOWS or the MSB) to carry out duplicate characterization and viability testing, particularly as both GBOWS and the MSB carry out this testing routinely, and employ iterative testing to optimize germination protocols – useful additional research data for ICRAF.

No collections are **regenerated** currently, due to the long regeneration time of most tree species. However, ICRAF's 37 field genebanks offer an excellent opportunity for multi-purpose use as both living conservation collections and seed orchards. These stands also offer excellent potential as extension and demonstration plots or 'show and tell' resources for policymakers and funders.

Recommendation 2: The review team recommends that ICRAF develops a collections acquisition and retention policy based on ICRAF's global mandate (see **Section 3**), identified user needs (**Section 2**) and cost-effectiveness (**Section 1**). Some of the carry over funding available from the Crop Trust could be used for this purpose. More detailed recommendations on how to achieve this are given in the main body of the text below.

Recommendation 3a. ICRAF's existing seed and field genebank collections represent a valuable resource for current and future use. Characterizing these collections and assessing their quality should remain the first priority. Based on this analysis and on ICRAF's collections acquisition and retention policy (see above), it is recommended that seeds of priority collections that are reduced to low numbers (e.g. some OFI collections) should be regenerated and/or re-collected to augment dwindling stocks. Similarly, field genebank collections should either be retained by ICRAF, handed over to country partners or discarded, depending on ICRAF's collections acquisition and retention policy.

Recommendation 3b. It is not recommended that ICRAF develops LTS facilities at this stage. However, safety duplication is needed for as many collections as possible (a) in Svalbard for ‘black box’ long term conservation and (b) in a facility that carries out characterization and viability testing. To this end, renegotiation of the duplication agreements with Kew’s Millennium Seed Bank and/or the Kunming Institute of Botany is recommended. Both institutions carry out seed characterization and quality testing as part of their routine accessioning practices.

1.3. Documentation, data and databases

Documentation. The review team were shown the following documentation related to the GRU collections:

- Tree Seed Collection Report Form
- Passport Data Collection Sheet
- Field Genebank Inventory Data Collection Sheet
- Agroforestry Tree Seed Testing Laboratory Forms (sampling record; seed drying record; moisture record (eRH); moisture record (oven drying); purity record; weight determination record; germination test record)
- ICRAF’s Seed List
- Seed Request Form
- Seed Dispatch Form

All of the above documentation appears to be appropriate and comprehensive.

As mentioned above, there is a significant backlog in characterizing and assessing the quality of the collections in the *Ex situ* genebank and in the field genebanks. Passport and characterization **data** is still incomplete for most of the field genebank accessions. Assembling and acquiring these data has been identified as a priority for the GRU.

ICRAF’s genebank **database** system, a BRAHMS-based, locally developed web-based PHP application that runs on a MySQL relational database, appears to be comprehensive, and fit for purpose. It has been developed over many years, and resides on a server on the local network with backup managed by ICRAF’s IT Department. It is compatible with GENESYS, and some fields are publicly accessible through the ICRAF Website-GRU webpage. One element that could be strengthened in ICRAF’s genebank database system is information on use. In the medium to long term, ICRAF needs to consider migrating to GRIN-Global.

Other publicly available ICRAF GRU databases include:

- Agroforestree
- Tree Seed Suppliers Directory
- The Switchboard

The team were impressed with the Switchboard, a meta-database of information on tree species used in agroforestry. The Tree Seed Suppliers Directory is discussed in more detail in **Section 2**, below.

Recommendation 4: The Review Panel recommends that the passport and characterization data for all remaining *ex situ* genebank and field genebank accessions is completed as a priority. To this purpose, an additional laboratory technician or database person should be hired to speed up the characterization of remaining accessions. In addition, an economic botany (use) module needs to be

added to ICRAF's genebank database system, and use information be made available on ICRAF's Seed List.

1.4. Standard operating procedures

The review team was shown the following documentation related to Standard Operating Procedures:

- ICRAF Seed Laboratory Safety Manual
- ICRAF Seed Laboratory Procedures Manual
- ICRAF Invasive Alien Species Policy

ICRAF's seed laboratory procedures are derived from the FAO standards and appear to be robust and comprehensive. Seed health testing protocols are being developed with the help of a plant pathologist from KEFRI.

ICRAF's Invasive Alien Policy (2013) is clear about its commitment to minimizing the impacts of invasive alien species, and its Seed Request Form includes a general warning about the potential for invasiveness of some species. A further step would be to inform users of the potential invasiveness of species that ICRAF supplies that are in the high risk category of 'Problematic' taxa. Prohibited taxa should not be distributed at all. In addition, the user should be asked to declare on the Seed Request form that a weed risk assessment has been carried out by the recipient.

Recommendation 5: The Panel recommends that ICRAF puts measures in place to ensure that prohibited alien invasive taxa are never distributed. For species identified as 'problematic' with a potential to transform native plant communities, ICRAF should strengthen its existing measures by providing a specific warning to the recipient along with the material. In addition, the recipient should be asked to declare on the Seed Request form that they have carried out a weed risk assessment.

1.5. Human resources

The GRU staff complement currently comprises:

- 1 x Head of the GRU
- 4 x laboratory staff (including 1 person on short-term contract)
- 1 x database person

The review team were extremely impressed with the calibre of the GRU staff. All were highly engaged, proud of their work and knowledgeable. Although staff levels are adequate for the current scale of operations in the *Ex situ* Genebank, a further person will probably be required to help to address the characterization backlog in the short term.

The review team was similarly impressed with the knowledge of the remotely based ICRAF staff in Vietnam, Cameroon, Malawi and Peru who we interviewed during the review process.

1.6. Cost effectiveness

ICRAF does not have a written ***acquisition and retention policy*** for its genebank collections (see **Section 1.1**, above). Currently, after germination testing those seed lots with no viability (0%) are discarded. While this is appropriate for seed that is clearly dead (e.g. mouldy), seed with low viability

should not be discarded as this may be a result of suboptimal pre-treatments being applied. For such collections, improved germination protocols may be developed, particularly if GBOWS or the MSB are iteratively testing duplicate ICRAF material to optimize germination (see **Section 1.2** above). Furthermore, in some cases it may not be possible to undertake recollection due to destruction/loss of the tree population, an unsafe security situation and/ or excessive field collection costs. In such cases the option of regenerating the collection through a planted seed stand/field gene bank needs to be evaluated on a case-by-case basis. Furthermore a proportion of all (or almost all) new collections entering the genebank ought to be reserved for long term conservation storage, genetic and other research which only requires a small number of seeds. A rule of thumb might be to maintain 500-1000 seeds of bulk per accession, and up to 50-100 seeds for individual tree accessions.

Maintaining, managing and replacing collections is a costly process. The need for a GRU acquisitions and retention policy is covered in more detail in **Sections 2** and **3**. However, one component of such a policy should be a rationale for cost-effective conservation methodologies appropriate to particular taxa (seed banking versus field genebanks). For example, it may be far more cost-effective to store collections of orthodox seed-bearing species in seed banks than in field genebanks. However, this decision will also depend on criteria such as:

- The value of the collection
- Demand for the collection
- The cost of collecting the seed from the wild
- Regeneration time

A decision matrix, such as the one below in **Table 1**, can be used to assess the most cost-effective way of storing material.

Table 1: Indicative decision matrix for assessing cost-effective methodologies for storage and supply of material

Low value to global users	High or unknown value to global users	Recalcitrant seed	Outcrossing with seed not true to type	Orthodox seed	High demand	Low demand	Expensive to collect or short regeneration time	Inexpensive to collect or long regeneration time	Storage strategy
*									Discard
	*	*							Field
	*		*						Field
	*			*	*		*		Field
	*			*	*			*	Seed bank
	*			*		*			Seed bank

1.7. Risk management

The review team were encouraged to see that risk assessment procedures, recording of incidents and mitigation strategies were in place for the GRU. The team were also pleased to see that the operational risks associated with the GRU’s activities were integrated into the institutional risk register. However, we felt that given the high reputational – and potentially financial – risks associated with the operations of the GRU if, for example, poor quality, diseased or invasive material was supplied to third parties, that these need to be considered at the institutional level as well as the current operational risks

Recommendation 6: We recommend that ICRAF considers and assesses reputational, financial and other non-operational risks associated with GRU activities and performance, and elevates these to institutional level.

2. The roles, services and use of the genebanks, and the linkages with users and partners both within and outside the CGIAR

The breadth of ICRAF GRU’s mandate and potential user-base is discussed in more detail in **Section 3**. In this section the review team look at ICRAF’s current user profile (sector, purpose, geographic scope) and user feedback on the quality of the service that the GRU provides.

2.1. Current use trends of ICRAF material

The GRU’s current user profile demonstrates weaknesses in some *sectors* (see **Table 2**). For example, very little seed from ICRAF’s *Ex situ* Genebank is reaching research institutions, farmer organizations, NGOs and CBOs. No seed appears to have been sent to the commercial sector in the past three years. All of these users have the ability to add value to or scale up the use of material. In contrast, the majority of material has gone to individual farmers where the impact will be limited.

Table 2: Seed distribution from ICRAF HQ Seed Bank by user sector 2011-2014

User	Number of samples	% of total
ICRAF	39	3.5
Farmer organization/CBO/NGO	15	1
Research institution/university	8	0.5
Commercial sector	0	0
Individual farmers	1067	73
Others	338	22
Total	1467	100

When ICRAF’s field genebanks are included (figures only available for 2014), the user profile improves (see **Table 3**). However, even here the major customer is ICRAF itself for its bilateral projects and, although the proportion of external research users increases to 11%, and that of commercial users increases to 4% they are still very much in the minority. Bilateral projects such as the VECEA project and phone application currently under development show great promise for scaling up the use of material from national tree seed centres and other sources of high quality seed. However, more seed/seedling supply from ICRAF direct to external users operating at scale or carrying out public domain research will greatly increase the value and impact of the GRU.

The *geographic* distribution of ICRAF seed samples for 2014 is given in **Table 4**, below. As **Table 4** shows, 87% of the collections sent out by ICRAF in 2014 went to Kenya. In some cases, where ICRAF projects are the ‘Kenyan’ recipient, seed may have been distributed more widely, however it isn’t possible to quantify this. Overall, the data suggests that the international reach of ICRAF’s GRU is quite limited currently. This issue is discussed in more detail in **Section 3**. Field genebank distribution is more limited than that of the *ex situ* genebank, and in the majority of cases is limited to national distribution – largely because local provenances are required. Exceptions are *Uapaca* accessions which have been distributed regionally in southern Africa, and *Dacryodes* and *Acacia senegal* collections likewise in west and central Africa.

Table 3: Seed and seedling sample distribution from ICRAF genebanks in 2014.

Category	<i>Ex situ</i> genebank	Field genebank	Total	%
Number of samples to NARS, ARIs and Universities	38	362	400	11
Number of samples to commercial sector	0	165	165	4
Number of samples to farmers	194	74	268	7
Number of samples to ICRAF projects	77	2844	2921	78
Total	309	3445	3754	100
SEED				
Number of accessions (external)	75	77	152	
Number of accessions (ICRAF)	45	132	177	
Total	120	209	329	

Table 4: Seed distribution by country, 2014

Country name	Number of samples	Number of species
Kenya	284	44
Liberia	8	5
Afghanistan	5	3
Somalia	7	7
Uganda	11	10
Cameroon	6	5
Sudan	1	1
Ghana	6	6
Total	329	

ICRAF's Tree Genetic Resources Policy follows a pragmatic approach with regard to the balance between material supplied internationally under the ITPGRFA SMTA and the CBD by taking a broad definition of Article 15 for material supplied prior to 2006. It is hard to gauge the challenges associated with acquiring and supplying a broader range of taxa under international, Nagoya-friendly bilateral agreements, but the more bilateral and multilateral case studies that can be developed, the better.



Figure 4: KEFRI's *Melia volkensii* improvement program

The GRU's lack of a *collections acquisition and retention policy* is covered in more detail in **Section 3**. However, ideally, ICRAF's focus should be complementary to that of the national tree seed centers and forestry research institutions with which it operates, both in terms of the research ICRAF carries out and the material it supplies. A good example is KEFRI's current focus on the improvement of *Melia volkensii* while ICRAF concentrates on the domestication of *Allanblackia*. In this context, it is strongly recommended that, as part of the development of its acquisitions and retention policy (**Recommendation 2**), ICRAF's GRU proactively engages with external organizations, including NARS, ARIs, NGOs and CBOs to understand their need for materials that ICRAF might supply. One approach would be to carry out an audit or SWOT analysis of the capacity of national partners (public, private and NGO sectors) to supply and carry out research on agroforestry seed and seedling material in order to identify opportunities for working together and gaps in current knowledge and availability of material. Additional information on species in demand might be gleaned from the seed request forms received by ICRAF for which ICRAF does not have material.

Wherever possible, ICRAF should work with and promote the activities of its national partners. One encouraging project in this respect, led by ICRAF, is the development of the VECEA vegetation map and species lists into a mobile phone app for farmers to use, ultimately not only enabling them to find out which species are appropriate to plant on their land but also where high quality seed can be obtained.

ICRAF is encouraged to document examples of material transfer and use across international boundaries using Nagoya compliant bilateral or multilateral agreements. These are useful precedents for others to follow.

Recommendation 7a: It is recommended that ICRAF management facilitate and ensure that GRU staff are consulted, during the design of all ICRAF projects that require germplasm to be supplied from the GRU.

Recommendation 7b: We recommend that ICRAF publicizes its Seed List more actively, specifically targeting sectors that are currently under-represented as users and which can add scale or impact to ICRAF's work (notably the research sector). One suggestion would be to elevate the Seed List to the front page of ICRAF's website.

Recommendation 7c: It is recommended that the GRU gathers data on where seed is distributed in ICRAF-led projects, as well as the impact of the research and development GRU material supports. The seed request form should include (a) all recipients and destinations of the seed, and (b) a *requirement* for feedback, copies of publications and acknowledgement as part of the MTA.

Recommendation 7d: The Review Team recommends that ICRAF revises its Tree Seed Suppliers Directory, focusing on seed material available from its partner organizations (public, private and civil), and promotes the use of this Directory through the development of advanced tools such as its Vegetation and Climate Change in Eastern Africa (VECEA) application currently under development.

2.2. User's surveys

ICRAF carried out a Customer Satisfaction Survey in 2013. The specific questions addressed in this survey were:

- Who are the beneficiaries of the GRU seed distribution service?
- What categories of requests for materials are made and how effectively are these met?
- For what purposes are the materials from the genebank used?
- How do the users perceive the GRU services and how can these be improved?
- How can the GRU better respond to users' present and future needs?
- What are the constraints in terms of germplasm and information provision?

In this survey, 224 emails were sent out to GRU users, and a total of 49 responses were received corresponding to a response rate of 22%. One problem identified was that email addresses were often out of date.

The most frequent purpose of using germplasm from the genebank mentioned by the respondents was for establishment in farmers' fields (68%). This was followed by community development projects (52%). Request for germplasm for research purposes was low at 21%.

Regarding efficiency in seed request and delivery, 48% and 32% of the respondents said their expectations were met 'always' and 'usually' respectively. The availability of seed was rated as above average by most respondents with 34% rating seed availability as 'excellent' while 53% rated the availability as 'good'. When seed was not available, the majority of respondents (76%) indicated that they were informed that it was out of stock. More than 97% of respondents were satisfied with the quality of the germplasm, indicating that in general there are no problems with the viability of the distributed germplasm. The viability of seed distributed was also rated highly with 48% and 50% of

respondents rating germination as ‘excellent’ and ‘moderate’ respectively. Most of the respondents (80%) perceived the information accompanying seed samples as very useful for their use of germplasm.

A major weakness of the GRU was perceived in the area of information availability especially about the availability of germplasm from the genebank. Although most respondents indicated that the GRU website was very useful, there was indication that most people do not know there is a specific page for the Unit and could probably be referring to the general ICRAF pages. The GRU is too deep in the general website and only few people are aware of its presence (see **Recommendation 7b**, above).

The review team carried out a similar ‘straw poll’ user survey by sending a questionnaire to a list of seed material recipients supplied by ICRAF (see **Table 5**). Emails were sent to 122 users but error messages or ‘out of office’ responses were received from 35 of these. Of the 87 remaining contacts, only eight (9%) responded. The limited feedback received suggests that material and data supply from ICRAF is generally good. The responses are included in **Appendix 3** of this document.

The review team would like to commend the GRU on its efforts to gather feedback from existing customers, and we encourage ICRAF to carry out follow up surveys to a wider range of users. Such surveys should be promoted on ICRAF’s website, newsletters and other means in order to both raise awareness of ICRAF’s seed list and to improve ICRAF’s service to its users.

Table 5: Questionnaire sent to recipients of ICRAF seed material by Reviewer team.

We have been asked by the Global Crop Diversity Trust to carry out an independent review of ICRAF’s Genebank and its activities supplying material/germplasm and data to users. ICRAF has supplied you with material, and we would be grateful if you could help us to assess the service that ICRAF provides in supplying materials to users such as yourself. Answering the questions below should take no longer than about 10 minutes. Please email us back with any answers you can provide. All responses will be treated as confidential.

- 1) How did you hear about, and access information on, ICRAF’s collections?
- 2) Did ICRAF have material available for all of the species and seed sources/varieties you were interested in?
- 3) Did you request seed or vegetative material or both?
- 4) Did ICRAF supply the material in a timely manner?
- 5) Was the material of low/medium/high quality?
- 6) Was the passport data (or information on each of the supplied materials) of low/medium/high quality?
- 7) Were there any problems with the material or data? If so please describe.
- 8) How would you rate the service that ICRAF provide (including in relation to other germplasm suppliers)? Excellent/satisfactory/poor?
- 9) Is there anything that you think ICRAF and its Genebank can do better? If so, please describe
- 10) Any further comments or suggestions (including benefits to your R & D and agroforestry activities)?

3. The status of the genebank, or individual collections within it, in the context of a global system for the long-term conservation and use of agroforestry germplasm

3.1. ICRAF's tree genetic resources policy and strategy 2013-2017

ICRAF's GRU has a global role to collect, conserve, document, characterize and distribute a diverse collection of agroforestry trees. The stated emphasis is on indigenous trees, but of course every tree species is indigenous somewhere. Accordingly this goal is interpreted as a focus on developing, domesticating and improving local tree species due to their ready acceptance by local farmers, pre-existing adaptability to site, maintenance of biodiversity conservation values and maintaining a sense of place (given the importance of trees in landscape and national identity).

ICRAF's GRU has developed globally important and regionally vital tree germplasm collections for more than 30 species: these represent only a fraction of the several thousand tree species that deliver a whole host of products and services in agroforestry systems to smallholder farmers in developing countries. The recent State of the World's Forest Genetic Resources Review (<http://www.fao.org/forestry/fgr/64582/en/>) concludes that around 8,000 tree species are used in forestry around the world. Clearly, only a proportion of these will be used in developing countries, and still fewer in agroforestry. However, some kind of prioritization exercise needs to be carried out by ICRAF to better complete its representation of globally and regionally significant agroforestry tree species, provenances/ populations and cultivars in its genebank collections (and taking into account what is being adequately conserved and available elsewhere in the Global System). Such a prioritisation process will inform the GRU's *collections acquisition and retention policy*, as discussed in **Sections 1 and 2**, above.

Collaboration with national partners, including representatives of local communities from its early days, has meant that species in ICRAF's germplasm collections (both in the form of seed and field genebanks) are those of greater regional importance. ICRAF has focused on and developed a substantial comparative advantage (including knowledge and germplasm) of indigenous African food/fruit tree species. Outstanding progress has been made in domesticating *Allanblackia* which looks set to become a new tree crop with major niche market potential in the edible oil/food ingredient sector, and with significant potential benefits to smallholder tree growers in the African humid tropical zones. Other noteworthy and internationally important collections of African food, fruit trees and food security support species (fertilizer trees) in the ICRAF genebanks include: *Adansonia digitata*, *Dacryodes edulis*, *Faidherbia albida*, *Irvingia gabonensis* and *I. wombolu*, *Prosopis africana*, *Ricinodendron heudelotii*, *Sclerocarya birrea*, *Sesbania sesban*, *Strychnos cocculoides*, *Tamarindus indica*, *Upaca kirkiana*, *Vangueria infausta* and *Ziziphus mauritiana*. Recent seed collections of the neglected fruit tree *Docynia indica* in Vietnam, extending ICRAF's fruit tree domestication work into Asia, are welcomed: in this case there is also the need to link to research and germplasm in neighbouring countries (including Bhutan, China and India), e.g. taking advantage of ICRAF's collaboration with the Kunming Institute of Botany which is also working on this species. In Latin America, ICRAF has undertaken only limited tree germplasm collection and conservation, perhaps paradoxically given the region's role as a provider of multipurpose tree species for agroforestry plantings throughout the tropics. Reasonably comprehensive collections have been undertaken of two Peruvian timber species, *Calycophyllum spruceanum* and *Guazuma cinita*, as well as a commercially important Peruvian landrace of peach palm (*Bactris gasipaes*). These have been widely distributed locally within Peru, and seed collections of the two timber species are under long term storage in the Svalbard Global Seed Vault. ICRAF has also inherited the globally vital and well-

documented germplasm collections of 3,270 accessions of principally nitrogen-fixing multipurpose tree species from Latin America, including *Calliandra calothyrsus*, *Gliricidia sepium* and *Leucaena* spp.

In summary, ICRAF's genebanks are probably the most important global repository of agroforestry tree species conserved *ex situ*. ICRAF's collections have taken on an added importance due to the decline, loss and underfunding of the tree seed sector over the past two decades, including national facilities, previously well-supported by donors such as the Danida National Tree Seed Centres, USAID/Winrock International and Nitrogen Fixing Tree Association, ODA/Oxford Forestry Research Institute collections, CSIRO Australian Tree Seed Centre and French Government/CIRAD-Forêt.

3.2. Global collections gap analysis

Loss of diversity at the population level in globally important agroforestry tree species is occurring apace due to many factors, including overharvesting, habitat loss and climate change. Loss of diversity greatly reduces future opportunities for tree selection and improvement, and associated enhanced delivery of agroforestry tree products and services and resilience in agroforestry and farming systems. Accordingly, as an integral component of the global system for conservation of forest and tree genetic resources, ICRAF's germplasm collections need to be maintained *and progressively expanded* to fill critical gaps in the conservation and sustainable use of genetic diversity in multipurpose tree species for agroforestry systems. Currently ICRAF has satisfactorily conserved collections for a number of African multipurpose tree species but the global scope and geographic coverage of agroforestry species needs to be expanded to better fulfil its stated mandate and deliver more substantially to *ex situ* conservation of agroforestry tree species.

There are many gaps in the current ICRAF genebank collections in terms of globally important agroforestry tree germplasm, and indeed there is never likely to be enough resources to address all of these. Accordingly, a gap analysis and acquisition prioritization process needs to be undertaken to address the most important gaps in terms of globally important multipurpose/ agroforestry tree species and their intraspecific diversity. Eco-geographic survey, seed zone approaches and molecular characterization need to be employed in a complementary manner to inform future collection site priorities for the most important species. Gaps in ICRAF's current collections can also be identified through examining requests and orders for tree germplasm which were not able to be met, as mentioned in **Section 2**, above. It is important not to simply look at re-collecting when a seed lot becomes exhausted, as the material may have been acquired opportunistically as part of bilateral and other donor programs and not necessarily constitute a high priority for re-collection.

ICRAF needs to consider adopting a more pro-active approach in its ***collections acquisition and retention policy*** (see **Recommendation 2**) to acquire, as a minimum, genetically representative collections of the most important species globally in agroforestry systems. This would also include tree species which can ensure resilience in agroforestry systems in the face of predicted climate change and extremes. Examples of species in this category include useful tree species with major climatic and edaphic tolerances such as *Acacia auriculiformis*, *Pinus brutia* and *Populus euphratica*; fire-resistant tree species such as *Tectona grandis*; near-coastal tree species resistant to cyclonic strength winds such as *Calophyllum inophyllum*, *Pterocarpus indicus* and *Terminalia richii*, and; multipurpose trees with high salinity tolerance such as *Acacia ampliceps*, *Melaleuca lanceolatum* and *Salvadora persicum*.

ICRAF might be able to most usefully expand its tree germplasm collections through more actively seeking donations from national institutes to fill gaps. An example is the well-documented and diverse *Pinus brutia* seed collections from Afghanistan, Iraq, Turkey and elsewhere, currently being held in quarantine for CSIRO's Australian Tree Seed Centre.

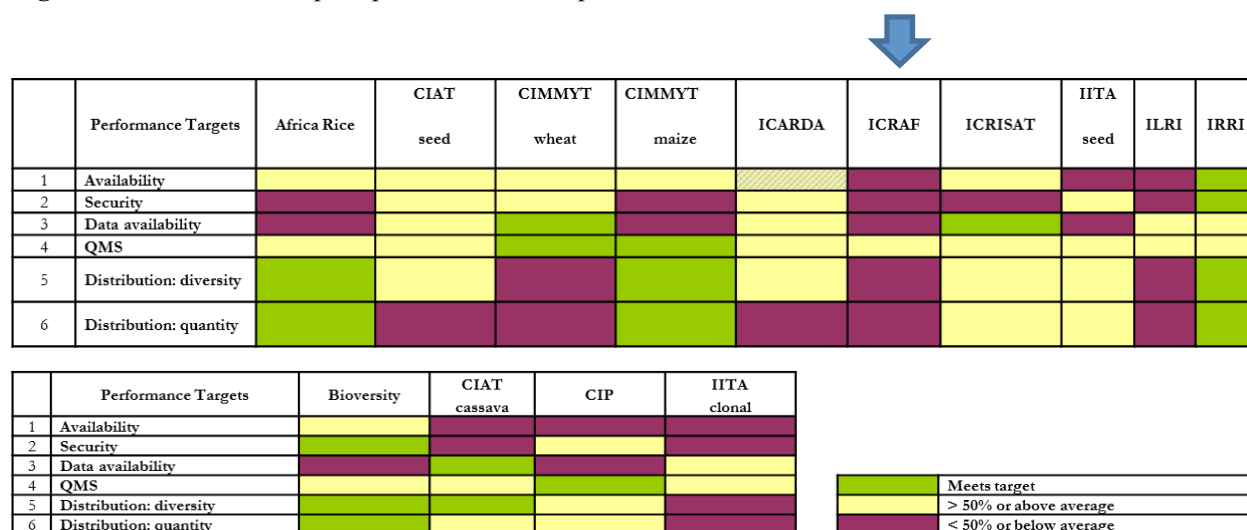
4. The status of the genebank with respect to the performance targets and the feasibility of proposed workplans to reach targets

As shown in **Figure 5**, below, ICRAF’s Genetic Resources Unit is struggling to achieve some of the performance targets set in the Crop Trust’s Work Plans, compared to genebanks in the other CG centers. The reviewer’s conclusion is that ICRAF is behind on some of these targets due to the size of the collections characterization backlog. This backlog is being addressed by setting targets through Annual Workplans. These include:

- Long Term Storage (LTS) back up
- Seed health testing
- Viability testing
- Regeneration/re-collection
- Characterization
- Prioritization/optimization
- Etc.

The review team is confident that ICRAF’s GRU will be able to achieve many of these performance targets given time. However, some of the performance targets, while appropriate to crop genebanks dealing with annuals or short-lived perennials, are not appropriate for tree germplasm, especially that found in field genebanks.

Figure 5: ICRAF’s work plan performance compared to other CG centers, 2014



Recommendation 8: The review team recommends to the Crop Trust that ICRAF follow the revised performance targets related, in particular to ICRAF’s field genebanks and accessions with long regeneration times, outlined in **Table 6** compared to the original version in **Table 7**, below.

Table 6: Modified performance targets as applied to ICRAF’s GRU.

	Performance targets
1	Availability: % collection which is clean, viable, and in sufficient seed number to be made immediately available from medium term storage (90% target)
2	Security: % orthodox seed collection which is held in long term storage conditions in one location and also in the Svalbard Global Seed Vault or for recalcitrant species held in field gene banks at a minimum of two secure locations (90% target seed collections; 90% field collections)
3	Data availability: % seed collection or field genebank collection with minimum passport and characterization data available online (90% target)
4	Monitoring and evaluation: % of seed collection tested for viability every 10 years and % of field genebank collection monitored and evaluated annually (90% for seeds and 50% for field gene bank collections)
5	QMS: Stage of development (from 1 to 5) of quality and risk management system
6	Distribution diversity: diversity: % collection disseminated over 10 year period (tentative target 5% per year)
7	Distribution quantity: quantity: number of species disseminated/year as a proportion of the total collection size (tentative target 20% per year)

Table 7. Original version of performance targets

	Performance Targets
1	Availability: % collection which is clean, viable, in sufficient seed number to be made immediately available for international distribution from medium term storage (90% target)
2	Security: % collection which is held in long term storage conditions in two locations and also in the Svalbard Global Seed Vault or for clonal crops % collection in vitro in two locations (90% target seed collections; 90% clonal crop collections)
3	Data availability: % collection with minimum passport and characterization data available online (90% target)
4	QMS: Stage of development (from 1 to 5) of quality and risk management system
5	Distribution diversity: % collection disseminated over 10 year period (tentative target 10% per year)
6	Distribution quantity: number of samples disseminated/year as a proportion of the total collection size (tentative target 20% per year)

5. Conclusions

ICRAF’s GRU is well run, with motivated and knowledgeable staff in both the *Ex situ* Genebank and field genebanks. The *Ex situ* Genebank at ICRAF Headquarters is well-equipped with regard to its facilities and equipment, and has benefitted substantially from the injection of funds since 2012 through the Genebank CGIAR Research Programme. The GRU’s existing collections are globally significant, and their value will be increased once they are fully characterized, and their passport data is complete. However, in order for ICRAF’s GRU to fulfil its true potential, it needs to develop a collections acquisition and retention policy based on ICRAF’s global mandate, identified user needs and cost-effectiveness.

Appendices

Appendix 1- Review panel

Paul Smith (Chair)

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Lex Thomson (Reviewer)

Associate Adjunct Professor (Agroforestry) Faculty of Science, Health, Education and Engineering, University of the Sunshine Coast, Maroochydore, DC Qld 4558 Australia. Lex.Thomson@gmail.com

Appendix 2- Review agenda

Day 1 Monday 8th June 2015 Venue: Cocoa Room			
Time	Agenda	Presenter	Facilitator
0830-0900	Logistics and setting up base for review panel		ICRAF IT Staff
0900-0920	Welcome and brief on genebank review	Tony Simons -DG ICRAF	Ramni Jamnadass
0920-0950	Introduce the review panel/Trust staff and elaborate on the objectives of the review Q&A	Paul Smith -Chair Review Panel	
1000-1030	Group Photo & Break		Nelly & Sallyannie
1030-1110	Introduction to ICRAF Genetic resources activities and highlight on genebank linkages with other Science Domains and CRPs Q&A	Ramni Jamnadass -Leader ICRAF Science Domain 3-Diversity, Domestication and Delivery	Alice Muchugi
1110-1150	Outline GRU/Genebank activities in past 3 years. Q&A	Alice Muchugi -Genebank Manager	
1150-1230	Highlight genebank activities in the regions Q&A	Bertin Takoutsing -Regional Genebank focal person-Cameroon	
1230-1330	Lunch		Nelly & Sallyannie
1330-1500	Genebank tour- Introduction to all genebank operations and review of basic operations	Alice Muchugi & Genebank team	Alice Muchugi
1500-1530	Molecular/AOCC laboratories tour - Introduction to molecular characterisation activities and AOCC genomic sequencing lab	Prasad Hendre & Molecular/AOCC Labs team	
1530-1600	Break		Nelly & Sallyannie
1600-1630	Visit to ICRAF Nursery-Introduction to genetic resources activity at the nursery	Moses Munjuga -Nursery manager	Alice Muchugi
1630-1700	Contact agroforestry tree seed users to assess and discuss collaboration with ICRAF Genebank	Paul Smith	Alice Muchugi & ICRAF IT team
1700-1730	Regional Field genebank presentation- WCA-Sahel-Mali	Catherine Dembele	
1830-2030	Reception Dinner -Thai Restaurant – UN Avenue, Gigiri		Nelly & Sallyannie
Day 2 Tuesday 9th June 2015 Venue: Cocoa Room			
Time	Agenda	Presenter	Facilitator

0800-0830	Queries and clarifications on Day 1 and 2 activities	Alice Muchugi & Review panel	Alice Muchugi
0830-1000	<p>Review linkages between CRPs and use of the tree genetic resources-</p> <ul style="list-style-type: none"> Assess and discuss past, current and future use of the collections. Develop an understanding of the impact pathway from genebank to user and to explore current and potential entry points for the GRU into CRPs and vice versa. <p>Q&A</p>	<p>(Round Table discussion)</p> <p>Katja Kehlenbeck-CRP4- Roeland Kindt-CRP6.2 - Sammy Carsan-CRP6.1&CCAFs Catherine Muthuri-CRP6.1 Keith Shepherd-CRP5- Stepha McMullin-CBD issues Ramni Jamnadass AOCC-</p>	Alice Muchugi
1000-1030	Break		Nelly & Sallyannie
1030-1230	<p>Regional cooperation</p> <ul style="list-style-type: none"> Assess and discuss cooperation with CGIAR and national partners <p>Q&A</p>	<p>(Round Table discussion)</p> <p>Moses Siambi-ICRISAT Desterio Nyamongo-National Genebank of Kenya William Omondi-KEFRI Seed Centre Joseph Kori-Kenya Agricultural and Livestock Research Organisation</p>	Alice Muchugi
1230-1330	Lunch		Nelly & Sallyannie
1330-1430 1500-1630	Review GRU accession databases and other online services	<p>(Round Table discussion)</p> <p>John Innocent-Genebank database officer Solomon Mwangi-IT/Knowledge management specialist Roeland Kindt- Databases specialist</p>	Zakayo Kinyanjui & Alice Muchugi
Time	Agenda	Presenter	Facilitator
Parallel session 1330-1430	Discuss and highlight issues regarding the management of the Genebanks CRP Fund	Ernest Gatoru -Finance Manager Nelly Mutio -CRP Genebank Administrator,	Nelly Mutio
Parallel session 1430-1630	Review financial budgeting and reporting, review the of FCR and any issues related to annual expenditures	Ernest Gatoru -Finance Manager Alice Muchugi -Genebank Manager Nelly Mutio -CRP Genebank Administrator	Alice Muchugi & Nelly Mutio

1630-1700	Contact agroforestry tree seed users to assess and discuss collaboration with ICRAF Genebank Regional Field genebank presentation- Latin America-Peru	Paul Smith Jonathan Cornelius	Alice Muchugi & ICRAF IT team
Day 3 Wednesday 10th June 2015 Venue: Cocoa Room			
Time	Agenda	Presenter	Facilitator
0800-1200	Visit to Kitui-Tiva Field Genebank <ul style="list-style-type: none"> Example of agroforestry tree germplasm dissemination processes Q&A	Alice Muchugi & James Ndufa -Regional Director Kenya Forest Research Institute	Alice Muchugi
1400-1430	Visit to Machakos Rural Resource Centre <ul style="list-style-type: none"> Assess and discuss tree field genebank operations and the collaboration with national partners. 	Alice Muchugi & Moses Munjuga	Alice Muchugi
1700-1730	Regional Field genebank presentation <ul style="list-style-type: none"> Uganda Tanzania 	Clement Okia Mathew Mpanda	Alice Muchugi & ICRAF IT team
Day 4 Thursday 11th June 2015 Venue: Cocoa Room			
Time	Agenda	Presenter	Facilitator
0800-0830	Queries and clarifications on Day 1 and 2 activities	Review panel & Alice Muchugi	Alice Muchugi
0830-0930	Review the status of the risk and QMS management strategy for the genebank, the documentation of procedures & implementation of the QMS	Stella Muasya -QMS Officer Jimmy Kiio -H&S Committee Zakayo Kinyanjui	Alice Muchugi
09.30-10.20	Review seed health procedures	Jane Njuguna -Consultant Plant pathologist Zakayo Kinyanjui	Alice Muchugi
1020-1050	Break		Nelly & Sallyannie
1050-1230	Contact agroforestry tree seed users to assess and discuss collaboration with ICRAF Genebank Regional field genebank presentation-	Paul Smith	Alice Muchugi & ICRAF IT team

	<ul style="list-style-type: none"> Southern Africa-Malawi South East Asia-Vietnam 	Simon Mng'omba Viet Bac	
1230-1300	Lunch		Nelly & Sallyannie
1300-1600	Prepare first written draft of the review report	Paul Smith	Alice Muchugi
1600-1630	Break		Nelly & Sallyannie
1630-1700	Open Session		
Day 5 Friday 12th June 2015 Venue: Cocoa Room			
Time	Agenda	Presenter	Facilitator
0830-0900	Queries and clarifications	Review panel & Alice Muchugi	Alice Muchugi
0900-1000	Reviewers to provide findings of the review and draft recommendations to ICRAF Senior Management (Ravi to join over Skype) Trust to provide findings of financial review to ICRAF Senior Management	Paul Smith Amanda Dobson	Luigi Guarino
1000 -1030	Break		Nelly & Sallyannie
1030-1230	Reviewers to provide findings of the review and draft recommendations Science Domain 3 staff Wrap up Session	Paul Smith	Luigi Guarino
1230-1330	Lunch		Nelly & Sallyannie
1330-1700	Open		

Appendix 3- User feedback

	Question	Respondent 1	Respondent 2	Respondent 3	Respondent 4
1	How did you hear about, and access information on, ICRAF's collections?	For the internet and visit to ICRAF	I was a staff member for over 20 years	We had a meeting with ICRAF staff and We had requested seeds	Through direct contact with Lucy Mwaura and Alice Muchugi
2	Did ICRAF have material available for all of the species and seed sources/varieties you were interested in?	yes	Practically all the species were available	Yes all species materials were available	We were interested in a very wide range of species (about 100), so no it did not. However, it was able to source many additional species on our behalf from KEFRI.
3	Did you request seed or vegetative material or both?	seeds	Yes, I was able to collect both seed and vegetative material	We requested the seeds	Only seed
4	Did ICRAF supply the material in a timely manner?	prompt	Every time I requested for material, it was availed to me - I am a satisfied customer	Yes, they supplied in timely manner	Yes. it took time, but we did not expect it to be quick and factored this in
5	Was the material of low/medium/high quality?	Mixture of medium and high quality	High quality material always	High quality	We only needed seed to germinate and produce a small root. Most samples did. For some that did not, this was probably down to our set up. Information on seed pretreatments was given by ICRAF.
6	Was the passport data (or information on each of the supplied materials) of low/medium/high quality?	Got the seed direct on visit to ICRAF and not sure I saw such information.	Informative, applicable and understandable	high quality	(KEFRI + ICRAF material) Good enough for our purposes - location of collection available for most
7	Were there any problems with the material or data? If so please describe.	Germination for few seeds were medium	Initially, I did not understand the type of trees/germplasm to acquire for my Ngong soils, but this was resolved through the mapping that had been done earlier and I obtained materials	No	If I remember rightly, we were not given ICRAF/KEFRI accession numbers for all material, when material was first sent. This required follow up

	Question	Respondent 1	Respondent 2	Respondent 3	Respondent 4
			on preferences		
8	How would you rate the service that ICRAF provide (including in relation to other germplasm suppliers)? Excellent/satisfactory/poor?	Satisfactory	Satisfactory	Excellent	In this case, I would say very good.
9	Is there anything that you think ICRAF and its Genebank can do better? If so, please describe		Provide sufficient information and guidance on how to obtain information on some species names that are available locally but only scientific names are provided. Expand the Genebank to enhance use of indigenous plants	No	First, make better use of the collections for own research. Second, collect interpolated environmental data sets of collection sites and post these with accessions. Third (difficult), operate more follow up on research outcomes. Fourth, be realistic with requesters about what is really possible.
10	Any further comments or suggestions (including benefits to your R & D and agroforestry activities)?		These are carried out on my own small plot therefore I consult whenever I require something or information on activities. The close relationship between myself and ICRAF is wonderful and beneficial to me and my friends on an individual basis. We have not yet started any project therefore, I am unable to fully respond to your enquiry here.		We think getting access to this seed made for a good research study and a good public resource (the tropiTree database).

	Question	Respondent 5	Respondent 6	Respondent 7	Respondent 8
1	How did you hear about, and access information on, ICRAF's collections?	Through the colleagues of ICRAF	I did my MSc project at ICRAF that's how I knew Genebank	From my former student working with ICRAF Yaounde	I was an intern in SD3
2	Did ICRAF have material available for all of the species and seed sources/varieties you were interested in?	No, some seeds were not available	They have most of them but not all. I however got the ones I wanted	yes	Yes
3	Did you request seed or vegetative material or both?	Seed	Seeds	Seeds	Seed
4	Did ICRAF supply the material in a timely manner?	Some, but for the rest, a promise not followed	Yes	Very timely	Yes
5	Was the material of low/medium/high quality?	High quality	High quality	The material was of high quality following the germination test I carried out.	High
6	Was the passport data (or information on each of the supplied materials) of low/medium/high quality?	High quality	High quality	Passport data of medium quality.	Yes
7	Were there any problems with the material or data? If so please describe.	No problem	No	The passport data did not carry some relevant information	None. Germination was high and trees are already seeding
8	How would you rate the service that ICRAF provide (including in relation to other germplasm suppliers)? Excellent/satisfactory/poor?	Satisfactory	Excellent	Excellent	Satisfactory
9	Is there anything that you think ICRAF and its Genebank can do better? If so, please describe	Timely response to demand for seeds and germplasm. Provide opportunities for resource centers		More information should be included on the passport data sheet like date of collection, storage conditions, accession. Information on materials held should be included on the website	Publicity and training of farmers
10	Any further comments or suggestions (including benefits to your R & D and agroforestry activities)?	Strong demand for fertilizing soil species in our intervention sites, possibility for ICRAF promotion with NARS and other donors	The seeds were of great help to me as I managed to introduce fodder in the farm. Gene bank should diversify the varieties of timber and fodder species. Create	The services rendered are very important especially for research as funding period may not necessary match fruiting periods	Domesticated MPTs are not known to many farmers and normally there is resistance to change thus sensitization is

	Question	Respondent 5	Respondent 6	Respondent 7	Respondent 8
			<p>awareness to farmers/public so that more people can know there are such materials they can benefit from. Also they should move to the farms (door to door) and encourage farmers to grow the species since farmers are not aware of genebank existence</p>	<p>of these species.</p>	<p>necessary</p>

Appendix 4- List of documents provided by ICRAF

Strategy and Policy

ICRAF Tree Genetic Resources Policy November 2013
ICRAF Agroforestry Tree Genetic Resources Strategy 2013-2017
ICRAF Strategy 2013-2022
ICRAF Policy Guideline Series: Invasive Alien Species
The ICRAF Genebank Brief
ICRAF Private Sector Engagement Policy, April 2014

External Reports

ICRAF Genebank Crop Trust Visit Recommendations 2013
Summary report of the ICRAF collections 2011 – 2014
Improving ICRAF Genebank Operations. Jean Hanson
Upgrading ICRAF Genebank Operations and Facilities. Report by Jean Hanson, May, 2012
Upgrading ICRAF Genebank Operations and Facilities. Kate Gold, January 2013
Health Status of Field Genebanks in Muguga, Meru, Kakamega, Malava and Kitui. Jane Wangu Njuguna

Annual Workplans

ICRAF Annual Workplan Fruit Trees 2013
ICRAF Annual Workplan Multipurpose Trees 2013
ICRAF Annual Workplan Institute 2013
ICRAF Annual Workplan Fruit Trees 2014
ICRAF Annual Workplan Multipurpose Trees 2014
ICRAF Annual Workplan Institute 2014
ICRAF Annual Workplan Fruit Trees 2015
ICRAF Annual Workplan Multipurpose Trees 2015

Annual Reports

ICRAF Annual Report Fruit Trees 2012
ICRAF Annual Report Multipurpose Trees 2012
ICRAF Annual Report Institute 2012
ICRAF Annual Report Fruit Trees 2013
ICRAF Annual Report Multipurpose Trees 2013
ICRAF Annual Report Institute 2013
ICRAF Annual Report Fruit Trees 2014
ICRAF Annual Report Multipurpose Trees 2014
ICRAF Annual Report Institute 2014

Accession lists

ICRAF Genebank Species List
Field Genebanks Summary
OFI ICRAF-ILRI-CIAT Duplicate Accessions
Africa Priority Species for Conservation

Staff

Staff Covered Under 2015 Genebanks Fund

Performance Indicators

ICRAF Institute Baseline Performance Indicators 2011

ICRAF Institute Target Performance Indicators 2016

Partners

Memorandum of Understanding between ICRAF and KEFRI, August 2008

Procedures

ICRAF Seed Laboratory Safety Manual

ICRAF Seed Laboratory Procedures Manual

Major Control Strategies for Hazards

Tree Seed Collection Report Form

Field Genebank Inventory Data Collection Sheet

Passport Data Collection Sheet

GRU Seed Request Form

GRU Seed Dispatch Form

Germplasm Characterisation Report

Descriptors for Baobab (*Adansonia digitata* L.)

Users

Sample ICRAF Genebank Users

Seed Distribution Per Country 2014

Presentations

Introduction to Genetic Resources Activities – Ramni Jamnadas

Outline of Genebank Activities – Alice Muchugi

Genebank Activities WCA-HT Cameroon, DRC and Nigeria – Bertin Takoutsing et al.

AOCC and GRC complementing SD3 – Prasad Handre

WCA Sahel Mali Field Genebank – Catherine Dembele

The Role of Price Satisfaction in Enhancing Long-term Relationships in the Kenyan Mango Supply Chain – Catherine Muthuri

Food Tree Diversity for Improved Nutrition – Katja Kehlenbeck

Component 2: Management and Conservation of Forest and Tree Resources. Linkage with the ICRAF Genebank – Roeland Kindt

Forests, Trees and Agroforestry (FTA 6.1) and Genebank - Sammy Carsan

Biodiversity and Nutrition Overview of Activities and Outcomes at COP12 – Stephan McMullin

Major Control Strategies for Hazards – Stella Muasya

The ICRAF Latin America Genebank – Jonathan Cornelius

Field Genebanks in Tanzania; Achievements, Current and Future Priorities – Mathew Mpanda & Moses Munjuga

Southern Africa Field Genebank – Simon Mng'omba

Genebank Review Presentation Vietnam: *Docynia Indica* (Son tra) domestication in Vietnam – Dam Viet Bac