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COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

Item x of the Provisional Agenda

INTERGOVERNMENTAL TECHNICAL WORKING GROUP ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

Ninth Session

Rome, 25-27 July 2018

FACILITATING THE IMPLEMENTATION AND MONITORING OF THE GENEBANK STANDARDS

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I. INTRODUCTION

1. The *Genebank Standards for Plant Genetic Resources for Food and Agriculture*[1] (Genebank Standards), endorsed by FAO's Commission on Genetic Resources for Food and Agriculture (the Commission), provide international standards for the *ex situ* conservation of plant genetic resources for food and agriculture (PGRFA) in seed banks, field genebanks, *in vitro* culture and under cryopreservation. They therefore constitute an important tool for implementing both the *International Treaty on Plant Genetic Resources for Food and Agriculture* (the Treaty)[2] and the *Second Global Plan of Action for Plant Genetic Resources for Food and Agriculture* (Second GPA)[3], which is a supporting component of the Treaty[4].

2. The Commission, at its Fifteenth Regular Session, requested FAO to propose a mechanism for monitoring the application of the Genebank Standards[5]. As step towards responding to this Commission's request and in a bid to receive feedback on the utility of the Genebank Standards from a wide stakeholder base, FAO undertook a global survey that targeted the relevant practitioners in national, regional and international genebanks.

3. Parallel to this, FAO received feedback from the Global Crop Diversity Trust (Crop Trust) on its experiences in working with international genebanks to implement the Genebank Standards through their respective Quality Management Systems (QMS). In general, it was indicated that the step-wise activities (action steps) for the workflows of routine genebank operations were not easily evident in the Genebank Standards. To address this shortcoming, FAO initiated first steps to prepare action steps that would guide, in a sequential manner, technical support staff of genebanks in their work. Based on the actions steps, practical guides could be developed as companion material to the Genebank Standards.

4. Subsequently, FAO, in collaboration with the Crop Trust, organized an expert consultation to deliberate on the findings of the survey and to review the draft actions steps for the practical guides. This document presents the results of the survey and the outcomes of the consultation.

II. GLOBAL SURVEY ON MONITORING THE APPLICATION OF THE GENEBANK STANDARDS FOR PLANT GENETIC RESOURCES

5. FAO invited the staff of national, regional and international genebanks to participate in an online survey between January and September 2018 to monitor both the extent of their use of, and the level of satisfaction with, the Genebank Standards.

6. Respondents were requested to indicate how 'useful' the Genebank Standards were for the workflows for the conservation of orthodox seeds; field genebanks; and *in vitro* and cryopreservation, respectively. They were also requested to rate how 'useful' they found the supporting elements of the Genebank Standards, i.e. the sections on Context; Technical Aspects; and Contingencies, respectively. The options were: 'extremely useful', 'very useful', 'useful', 'slightly useful', 'not useful', 'not applicable to our work', and 'never consulted'. Respondents were then asked to indicate if the Genebank Standards had served as a template for the development of standard operating procedures for their genebanks and whether their genebank procedures were aligned to the Genebank Standards. Additionally, respondents were asked to provide open-ended comments to all the sections of the survey, including a final one on specific suggestions for improving the Genebank Standards.

7. A total of 104 respondents from 56 countries, representing all FAO regions and five international organizations, participated in the survey (Table 1). Of these, 44 were genebank managers, 31 curators of collections, 9 documentation officers, 4 technical officers and 16 categorized as 'others'.

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[1] FAO. 2014. *Genebank Standards for Plant Genetic Resources for Food and Agriculture*. Rev. ed. Rome. http://www.fao.org/agriculture/crops/thematic-sitemap/theme/seeds-pgr/gbs/en/

[2] FAO. 2009. *International Treaty on Plant Genetic Resources for Food and Agriculture*. Rome. http://www.fao.org/3/a-i0510e.pdf

[3] FAO. 2011. *The Second Global Plan of Action for Plant Genetic Resources for Food and Agriculture*. Rome.

[4] Treaty, Article 14.

[5] http://www.fao.org/3/a-mm660e.pdf

8. The majority of the respondents (86.3 percent) considered the Genebank Standards for all three conservation types (orthodox seeds, field genebanks and *in vitro* and cryopreservation) as either 'useful' or 'very useful' (Table 2). Eight percent found them 'slightly useful' or 'not useful' and 5.7 percent reported that they had never consulted the Genebank Standards.

9. Similarly, 90.8 percent of the respondents rated the supporting sections as 'useful' or 'very useful', 8.5 percent as 'slightly useful' or 'not useful', and 0.7 reported that they had never consulted these sections (Table 3). Interestingly, 66.3 percent reported that they had used the Genebank Standards to develop standard operating procedures for their genebank operations (Figure 1), yet 82 percent responded that their genebank procedures were not fully aligned with the Genebank Standards (Figure 2).

10. In conclusion, the Genebank Standards were generally considered valuable. However, more specific technical and operational guidance was considered necessary in order to apply them effectively. It was also indicated that some areas of the Genebank Standards required updating in order to reflect the advances in the relevant scientific and technological disciplines (e.g. molecular genetics), while other areas required expansion (e.g., more specific guidance on workflow activities and more guidance for crop wild relatives). Respondents also identified poor staffing and inadequate budget and infrastructure as constraints to genebank operations.

III. EXPERT CONSULTATION TO FACILITATE THE IMPLEMENTATION OF THE FAO GENEBANK STANDARDS

11. In April 2018, FAO and the Crop Trust convened a global expert consultation in Bonn, Germany to seek advice as to how (i) to enhance the utility and user-friendliness of the Genebank Standards and (ii) to monitor the implementation of the Genebank Standards.

12. The experts reviewed draft actions steps for the conservation of orthodox seeds, conservation in field genebanks, and *in vitro* conservation, respectively. Mirroring the outcomes of the survey and the experiences of the Crop Trust with the development of QMS for the international genebanks, the experts agreed that presenting the information contained in the Genebank Standards in a concise and more user-friendly format detailing the different action steps of the genebank workflow in a sequential manner could help practitioners and facilitate more widespread compliance with the Genebank Standards.

13. Experts also expressed a strong preference for presenting the practical guides in three stand-alone booklets, corresponding to the three conservation types (i.e. orthodox seeds, field genebanks and *in vitro* culture). The reasoning was that, being less bulky, this would enable users to focus only on the practical guide of interest.

14. The expert consultation underscored the need to develop similar practical guides for the conservation of recalcitrant seeds in seed genebanks, cryopreservation, and DNA samples, respectively, especially as these become more mainstream, the underpinning technologies mature and widely applicable protocols become available.

15. The experts also deliberated on a workable mechanism for monitoring the implementation of the Genebank Standards.

IV. PRACTICAL GUIDES TO THE USE OF GENEBANK STANDARDS

16. The action steps of the workflows for routine genebank operations for the conservation of orthodox seeds, conservation in field genebanks, and *in vitro* conservation are contained in a sequential manner in Annexes 1, 2 and 3 to this document. These steps are adapted from the Genebank Standards and have been updated reflecting the current status of knowledge.

17. It is suggested that the practical guides be further developed based on the action steps. Each practical guide would include an introduction outlining the underlying principles for each conservation process; the action steps presented sequentially; and the required staffing profiles and infrastructure.

18. Similarly, as the technologies mature and validated protocols become available, FAO would develop additional standalone booklets, especially for the conservation of recalcitrant seeds in seed genebanks, cryopreservation, and DNA samples, respectively.

V. STRATEGY FOR MONITORING THE IMPLEMENTATION OF THE GENEBANK STANDARDS

19. It is envisioned that the practical guides will also facilitate the monitoring of the implementation of the Genebank Standards. Checklists or clauses based on the action steps for each conservation approach, as presented in the practical guides, could be developed. These in turn could be the tool for monitoring genebank operations based on the Genebank Standards.

20. In the future, monitoring the application of the Genebank Standards could become a part of the overall reporting on the implementation of the Second GPA. Priority Activities (PAs) 5 to 7 of the Second GPA pertain to *Ex Situ* Conservation[6,7,8]. FAO member countries are providing periodic reports on the implementation of these three PAs (along with the other 15) using the agreed Reporting Format for the Second GPA. These reports are accessible through the World Information and Early Warning System on Plant Genetic Resources for Food and Agriculture (WIEWS)[9].

21. However, the GPA indicators of PAs 5-7 do not address directly the processes (and certainly not their respective action points) as prescribed in the Genebank Standards. For this desirable level of detail, it would be useful, therefore, to develop more specific indicators for key practices and activities (for instance, the itemized action steps) in order to have a precise assessment of the extent to which germplasm management of genebanks align with the Genebank Standards. Alternatively, a simplified approach may entail only conducting qualitative assessments, based on self-evaluations by competent authorities, of overarching individual processes (e.g. acquisition, distribution, documentation). In this case, the rating provided for each process would reflect an overall qualitative assessment of the constituent action steps, which would not be reported on individually.

VI. CONCLUSION

22. Draft practical guides, as well as a proposal for monitoring the implementation of the Genebank Standards, could be prepared for consideration by the Working Group at its next session.

[6] Priority Activity 5, Supporting targeted collecting of plant genetic resources for food and agriculture; 6, Sustaining and expanding *ex situ* conservation of germplasm; 7, Regenerating and multiplying *ex situ* accessions.
[6] Article 5.1(e).
[7] Article 15.1(d).6
[8] http://www.fao.org/wiews/en/

TABLES AND FIGURES

Table 1. Respondents of the Global Survey on Monitoring the Application of the Genebank Standards for Plant Genetic Resources according to FAO regions, member countries and international organizations.

FAO Region	Country	Number of Responden
North America	Canada	2
	United States of America	1
RAF	Benin	1
	Botswana	1
	Burkina Faso	1
	Burundi	1
	Central African Republic	1
	Republic of the Congo	5
	Eritrea	1
	Kenya	1
	Mali	1
	Namibia	1
	Niger	1
	Senegal	1
	Zambia	2
RAP	Australia	2
	Bhutan	2
	Japan	1
	Malaysia	3
	Mongolia	1
	Myanmar	1
	Nepal	1
	Sri Lanka	1
REU	Albania	1
	Armenia	1
	Austria	1
	Azerbaijan	1
	Bulgaria	3
	Croatia	1
	Cyprus	1
	Czechia	1
	Estonia	1
	Finland	1
	France	1
	Georgia	1
	Germany	5
	Hungary	1
	Ireland	1
	Latvia	1
	Lithuania	1
	Netherlands	1
	Norway	1
	Nordic countries	1
	Poland	11
	Romania	1
	Slovenia	1
	Spain	1
	Sweden	1
RLC	Argentina	16
	Brazil	1
	Cuba	1
	Ecuador	1
	French Guiana	1
	Guatemala	2
RNE	Jordan	1
	Kuwait	1
	Lebanon	1
International Organizations	Bioversity[10]	1
	CIAT[11]	1
	CIMMYT[12]	1
	Crop Trust[13]	1
	ICARDA[14]	1

[10] Bioversity International
[11] International Centre for Tropical Agriculture
[12] International Maize and Wheat Improvement Center
[13] Global Crop Diversity Trust
[14] International Centre for Agriculture in the Dry Areas

Table 2. Weighted averages of responses to the Global Survey on Monitoring the Application of the Genebank Standards for Plant Genetic Resources on the usefulness of the Genebank Standards for orthodox seeds, field genebanks and *in vitro* culture and cryopreservation

	Extremely useful	**Very useful**	**Useful**	**Slightly useful**	**Not useful**	**Never consulted**
Orthodox seed	24.4	37.2	27.9	7.4	0.6	2.5
Field genebank	23.6	35	28.2	6.7	0.3	6.2
In vitro culture/ cryopreservation	23	32.5	24.5	9	0.5	10.5
Overall average	23.8	35.3	27.2	7.5	0.5	5.7

Table 3. Weighted averages of responses to the Global Survey on Monitoring the Application of the Genebank Standards for Plant Genetic Resources on the usefulness of the supporting sections of the Genebank Standards

	Extremely useful	**Very useful**	**Useful**	**Slightly useful**	**Not useful**	**Never consulted**
Context	22.4	38.8	36.7	2.0	0.0	0.0
Technical Aspects	27.0	40.0	27.0	5.0	1.0	0.0
Contingencies	22.4	26.5	31.6	16.3	1.0	2.0
Overall average	24.0	35.1	31.7	7.8	0.7	0.7

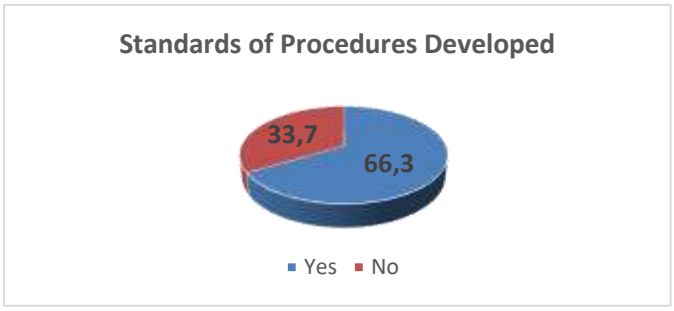

Figure 1. Percentage of respondents of the Global Survey on Monitoring the Application of the Genebank Standards for Plant Genetic Resources that reported that they have used the Genebank Standards to develop Standards of Procedures (blue) and those that reported that they have not (orange)

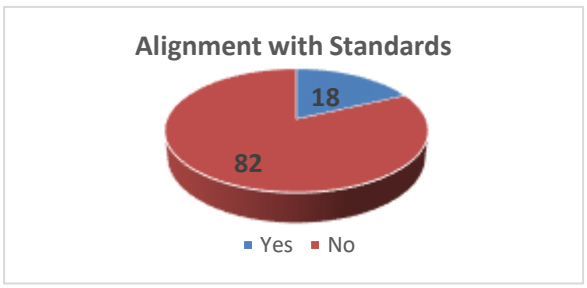

Figure 2. Percentage of respondents of the Global Survey on Monitoring the Application of the Genebank Standards for Plant Genetic Resources who reported that their genebank procedures were (blue) and were not (orange) aligned with the standards set out in the Genebank Standards

Annex 1. Action Steps for the Conservation of Orthodox Seeds

Below are the normative and operational actions required for safeguarding orthodox seeds under medium- and long-term storage conditions in seed genebanks.

1.1 Acquisition of Germplasm

The genebank should have documented procedures for acquiring germplasm in accordance with legal and phytosanitary requirements.

- ✓ Develop a clear strategy for germplasm acquisition according to your institute's mandate:
  - Acquire germplasm to fill a gap in the collection
  - Acquire new material that is unique
  - Develop a collecting proposal that clearly states the purpose of the collection, the location and methodology.
  - For collections in other countries, collaborate with a host institute in that country and be guided by that country's regulations.
  - Plan well in advance when collecting germplasm in another country or acquiring germplasm from another genebank or research institute.
- ✓ Ensure that germplasm added to the collection is legally acquired, and accompanied by all relevant documentation.

  A. Germplasm collections
     - For collections in your own country, find out national and local regulations by contacting the appropriate National Competent Authority.
     - Obtain necessary collecting permits from national authorities required for collecting crop wild relatives (CWR) or semi-domesticated germplasm in natural populations *in situ*.
     - When collecting from farmers' fields or community areas, prior informed consent (PIC) may be required and mutually agreed terms (MAT) determined, according to relevant national, regional or international laws and regulations.

  B. Acquisition through transfer/donation from another genebank or research institute
     - A MTA (or SMTA if Annex 1 species under the ITPGRFA) should be signed by the authorities of the providing country.

- ✓ Ensure that your genebank abides by national and international phytosanitary regulations and any other import requirements from the relevant authorities in your country.
  - Obtain a phytosanitary certificate from the provider country.
  - If necessary, obtain an import permit from the relevant authorities in your country.
  - Ensure that samples collected from other countries or regions within the country pass through the relevant quarantine process and meet the associated requirements before being transferred to the genebank.
  - For collected accessions with insufficient seed quantity, conduct regeneration in containment or in an isolated area under the supervision of the national phytosanitary authority.
- ✓ Conduct seed collection missions as close as possible to the time of maturation and prior to natural seed dispersal, avoiding potential genetic contamination, to ensure maximum seed quality
  - Schedule germplasm collection missions such that you can make collections at the optimum stage of maturity.

- Look for indicators of maturity such as dry pods, some fruits/seeds already dispersing, or fruit and/or seed colour changes.
- In the event that you may have to collect immature fruits or seeds, collect in a way that retains the connection between the parent plant and the dispersal unit (for example, collect whole stems or fruiting branches). Ensure that samples that may have immature seeds are given the required time after harvest to achieve maturation.
- Label collected samples carefully and ensure they are not mixed during handling.

✓ Collect only plant propagules from visibly healthy plants, devoid of disease and insect pest infestations or other damage.

- Do not collect dispersed seeds from the ground, soiled seeds or seeds with saprophytic or pathogenic fungi/bacteria or insects to avoid potential genetic and phytosanitary contamination.

✓ Collect from an appropriate number of individual plants such that the germplasm is genetically representative of the population, depending on the breeding system of the target species, while avoiding the depletion the natural population targeted for collecting.

- Decide on the number of plants within a population to sample depending on the breeding system, the plant type, and the purpose of the collection.
  - For self-pollinated species, ideally collect from a minimum number of 60 plants.
  - For cross-pollinated species, ideally collect from a minimum number of 30 plants.
- If possible, collect enough seeds to avoid the need for an initial regeneration stage.

✓ Ensure that the period between collecting, shipping and processing and then transferring to the field genebank is as short as possible to prevent loss and deterioration of the material.

A. Packaging

- Protect seeds from crushing by mechanical mail sorters by packing them in rigid cushioned envelopes.
- Pay attention to the diseases and insect pests reportedly associated with the target species in the exporting/donating country and take appropriate measures.

B. Transport

- Give due consideration to the time needed for document processing, duration of shipment and transit time and transit conditions (high temperatures in tropical countries) to ensure that the material reaches the destination genebank in good condition.
- Send shipments the fastest means possible, either by airfreight or courier, to avoid deterioration of seed quality and exposure to adverse environmental conditions.
- Continuously track the package so that it arrives at the genebank as quickly as possible for appropriate processing.
- For transport of long duration by road, periodically aerate the collected material as a necessary precaution.

✓ Germplasm added to the collection should be accompanied by associated data outlined in the FAO/Bioversity multi-crop passport descriptors.

A. Germplasm acquired through collections

- Use a standardized collecting form to collect the associated data for each sample obtained.
- Collect the associated data for each sample obtained as detailed in the FAO/Bioversity multi-crop passport descriptors (MCPD v.2.1).
- Assign a collecting number for each sample so the samples can be linked to the passport data and any other collected information.
- During collecting, obtain as much additional information as possible, such as plant population type, habitat and ecology, GPS coordinates, photo images and the substratum in order to provide curators and users of the germplasm with an understanding of its original context.

- If collecting from farmers' fields, if possible collect information on origin of the germplasm, traditional knowledge, agronomic practices, cultural practices, etc.
- When collecting CWR, take a herbarium voucher specimen as a reference collection from the same population. Use the same collection number as the seed sample, so that voucher and seed sample are always linked by this unique identification number.
- When possible, carry out data collection via smartphones or tablets to save time and avoid transcription errors.
- Use clear, indelible ink when labelling samples and write clearly. Electronically-produced labels reduce risks of transcription errors.
- Record, validate and upload all acquisition data including associated metadata to the genebank information system.

B. Germplasm acquired through donations or transfer

- Request that samples be accompanied by the associated data as detailed in the FAO/Bioversity multi-crop passport descriptors (MCPD v.2.1).
- Assign a unique identification number to each sample that links the samples to the passport data and any other information.

1.2 Drying and Storage

The genebank should have documented procedures for introducing acquired germplasm into long-term and medium-term storage.

- ✓ Clean all seed samples to remove empty or damaged seed and unwanted residue.
- ✓ Dry all seed samples to equilibrium in a controlled environment of 5–20°C and 10–25 percent of relative humidity.
  - Genebank staff should be familiar with the relationship between seed moisture content and the relative humidity of the surrounding air, and how this is affected by temperature.
  - Determine the appropriate method to dry seeds, depending on the number and size of samples you need to dry at any one time, local climatic conditions and the financial resources available:
    - Drying room if large number of samples are regularly processed
    - Drying cabinets for smaller number of seeds
    - A desiccator drying system using a polypropylene drum or other sealed container
    - Ambient conditions (for very dry environments)
  - Monitor drying using a digital moisture sensor, indicator silica gel or low-cost dial hygrometers.
    - Refresh desiccant drying systems with newly dried desiccant if necessary.
- ✓ After drying, package samples meant for long-term storage in clearly labelled airtight containers.
  - Preferably, use trilaminate aluminium foil packet seamed on all four sides with no gusset.
  - Place both and outer and inner label (preferably barcoded) for each sample to ensure that the material is properly identified.
  - Samples in long-term storage should contain enough seeds for three regenerations.
- ✓ Store long-term base collections at a temperature of –18±3°C.
- ✓ After drying, package samples that will accessed often (and are likely to be depleted before viability falls to the regeneration level) in clearly labelled easily-opened containers
  - Use indicator silica gel sachets to monitor ingress of moisture.
  - Place both outer and inner label (preferably barcoded) for each container to ensure that the material is properly identified.
  - Samples in medium-term storage should contain enough seeds for distribution and regeneration
    - Ideally, maintain a range from 4 000 (self-pollinated) to 12 000 (cross-pollinated) seeds per accession held in medium-term storage.
- ✓ Store medium-term active collections at 5–10°C.

- ✓ Take and keep a small reference sample of seeds.
- ✓ Record, validate and upload to the genebank documentation system all cleaning, drying and storage data, including associated metadata.

1.3 Seed Viability Monitoring

The genebank should have a documented policy and procedure describing the viability monitoring system used to detect falls in viability.

- ✓ Conduct seed viability testing following optimized and well-documented procedures.
- ✓ Conduct the initial seed viability test after cleaning and drying the accession or at the latest within 12 months after receipt of the sample at the genebank.
    - If samples are acquired in very small quantities, there is no need to carry out an initial seed viability testing. Mark these accessions for regeneration.
- ✓ The minimum initial viability for most accessions should be 85 percent unless documented scientific evidence supports accepting a lower percentage for certain accessions.
    - For some specific accessions and wild and forest species that do not normally reach high levels of germination, a lower percentage is acceptable. If possible, carry out a cut-test to provide more information about the true viability of such accessions.
- ✓ Ensure that a monitoring system is in place to test the viability status of samples at regular intervals during storage.
    - Determine optimal testing intervals to maintain samples above viability thresholds for each species, as far as possible.
    - Set viability monitoring test intervals at one-third of the time predicted for viability to fall to the regeneration threshold but do not exceed 40 years.
        - If this deterioration period cannot be estimated, and accessions are being held in long-term storage at –18±3 °C. in hermetically closed containers, set the interval to ten years for species expected to be long-lived and five years or less for species expected to be short-lived.
- ✓ Ensure that the genebank documentation system includes tools to report when the next viability monitoring test is due.
- ✓ Record, validate and upload to the genebank documentation system all viability monitoring data, including associated metadata.
- ✓ The viability threshold for regeneration or other management decision should be 85 percent unless documented scientific evidence supports accepting a lower threshold for certain accessions.

1.4 Regeneration

The genebank should have a policy and procedure for regeneration of germplasm, including step-by-step instructions to monitor seed inventory and seed viability, field preparation, selection of accessions, sample size, sowing, crop management, pollination control, identity verification, harvest and post-harvest management and documentation.

- ✓ Ensure that the genebank documentation system includes tools to continuously check seed inventory and seed viability and report when regeneration is required.
- ✓ Regenerate accessions when seed viability or seed quantity fall below the respective regeneration thresholds.
    - Regenerate when the viability drops below 85 percent unless documented scientific evidence supports accepting a lower threshold for certain accessions.
    - Regenerate when the remaining seed quantity is less than what is required for three sowings of a representative population of the accession.
    - Regenerate when there is an insufficient number of seeds for long-term storage (e.g., 1 500 seeds for self-pollinated species and 3 000 for outcrossing species).
- ✓ Ensure that species-specific regeneration procedures minimize risk to the genetic integrity of the accession.

- If possible, select a regeneration environment that is ecologically similar to the original collecting site; if an ecologically different site is used, state what actions will be taken to minimize selection pressure.
- Use the most-original-sample to regenerate accessions from long-term storage. Use seeds from the active collection to regenerate accessions for medium term storage for a maximum of three consecutive regeneration cycles.
- Clearly label regeneration plots (preferably with bar-codes).
- Ensure that an effective population that represents the genetic composition of the accession is established.
- Follow appropriate crop management practices including land preparation, any pre-sowing treatments, planting time, plant spacing, irrigation, fertilizer application and pest, disease and weed control.
- Control pollination as necessary, taking the crop breeding system into account.
- Remove plants that are growing outside the planted rows.
- Remove phenotypically different plants if you are absolutely sure that they are rogue plants derived from contamination of the original accession.
- Harvest an equal number of fully ripe seeds from as many maternal plants as possible.
- Thresh and clean seeds and transfer to controlled drying conditions as soon as possible.
- Take herbarium specimens and images during the growing season and a small seed sample at harvest to verify accession identify.

✓ Record, validate and upload to the genebank documentation system all regeneration data, including associated metadata.

1.5 Characterization

The genebank should have a procedure for characterization of germplasm, including step-by-step instructions describing field designs, growth cycle stages during which characterization data is obtained, descriptors used, and the manner in which the data is collected and validated.

✓ Characterize as many accessions as possible, and within five to seven years of acquisition.
- To conserve resources, characterization is often carried out during regeneration.
- Use an augmented design with carefully chosen check varieties.
- Use electronic barcoding if possible
- If possible, use mobile devices to capture electronic data in the field, laboratories and greenhouses.

✓ Ensure that species-specific characterization procedures are based upon standardized and calibrated measuring formats and follow internationally agreed descriptor lists as far as possible.
- If there are no existing descriptor lists for a species, use Bioversity International's Guidelines for Developing Crop Descriptor Lists.
- Characteristics and traits for crops should be defined by crop experts and/or curators in consultation with genebank managers. Traits can include morphological, biochemical, nutritional, physiological and molecular.

✓ Characterize germplasm for a set of highly heritable morphological traits to describe the phenotype of plants. The descriptive traits used will vary with the species.
- Utilize herbarium specimens and high quality voucher images to guide true-to-type identification.
- In crops with high levels of variability, take measurements at the plant level rather than at the plot level to capture the information about the variability between plants of the same accession.

✓ If resources are available, utilize molecular marker technologies and genomic tools for characterization, complementing phenotypic characterization.

✓ Record, validate and upload to the genebank documentation system all characterization data, including associated metadata.

- Ensure that trained staff are responsible for data recording and data entry, using calibrated and standardized measuring formats as indicated in the descriptor lists.
- Genebank curators and documentation officers should validate data before being uploaded into the documentation system.

✓ Make relevant characterization data publicly available.

1.6 Evaluation

The genebank should have procedures for the evaluation of germplasm, including step-by-step instructions describing seed sampling techniques, replicated multi-location, multi-year designs, growth cycle stages during which evaluation data is obtained, data collected (agronomic performance, biotic resistance, abiotic tolerance and nutritional), and the manner in which the data is analysed and validated. The methods/protocols, formats and measurements for evaluation should be properly documented with citations.

✓ Obtain evaluation data for as many accessions as practically possible, through laboratory, greenhouse and/or field analysis as may be applicable.
- Use electronic barcoding if possible
- If possible, use mobile devices to capture electronic data in the field, laboratories and greenhouses.

✓ Whenever possible, collaborate with national or international research organisations, with field stations in different agro-ecological environments, or with members of national or regional genetic resources networks.

✓ Carry out germplasm evaluation in collaboration with plant breeders and other specialists (virologists, entomologists, mycologists, statisticians).
- Work with these specialists to agree on the traits to be evaluated, the accessions that will be tested, and the experimental designs to be implemented.

✓ Use an experimental design with replicates and conduct the evaluations in different environments and/or over multiple years.
- It is advisable to confer with the statistician at your institution for selection of the most relevant experimental design.
- Ideally, carry out evaluation trials in at least three environmentally diverse location, using sound experimental designs, and collect data over at least three years.

✓ Define and identify check accessions to be included in the statistical design and use over time.
- Check accessions facilitate comparisons of data collected across locations and years.

✓ If possible, work with molecular breeders to identify appropriate trait-associated markers to streamline evaluation efforts.

✓ Use newly developed screening protocols, especially for abiotic stresses to make sure that internationally validated protocols are considered.

✓ Present evaluation data either as discrete values (e.g. scores for severity of disease symptoms or symptoms of abiotic stresses) or as continuous values based on measuring.

✓ Record, validate and upload to the genebank documentation system all evaluation data, including associated metadata.
- Ensure that trained staff are responsible for data recording and data entry.
- Genebank curators and documentation officers should validate data before being uploaded into the documentation system.

✓ Make relevant evaluation data publicly available.
- The publishing of evaluation data will enhance the use of the collection, especially for plant breeders.

1.7 Documentation

The genebank should have a policy managing genebank data and information, including data sharing guidelines.

- ✓ Ensure that your genebank adopts international data standards to provide consistency in data shared among different information systems and programs. Data should be publically available in a search-query database.
- ✓ Establish a genebank information system specifically for your genebank (which includes the fields for FAO/Bioversity multi-crop passport descriptors; MCPD v.2.1) or use/adapt one of the several models available.
    - GRIN-Global has been developed by USDA-ARS, the Crop Trust and Bioversity International to enable genebanks to store and manage information associated with plant genetic resources. Other information systems for genebanks are also available.
- ✓ Document passport data of accessions using FAO/Bioversity multi-crop passport descriptors
    - The use of Digital Object Identifiers (DOIs; MCPD v.2.1) is recommended for information sharing across different information systems and different communities.
    - Record most of the passport data during germplasm collection, or, in the case of material acquired from other genebanks, request to receive passport data alongside the donated/transferred material
    - Include additional accession information:
        - Georeferenced data which can help to identify accessions with specific adaptive traits, depending on the agro-climatic conditions of the collecting sites
        - Environmental information, such as overlaid climate and soil maps
        - Historical information – origin of the germplasm, traditional knowledge, cultural practices etc.
- ✓ Validate and upload all data and information generated relating to all aspects of conservation and use of germplasm, including metadata.
    - Document all management data including drying and storage dates and procedures, viability testing, regeneration dates and protocols.
    - Document inventory, germplasm orders, distribution data and data obtained from user feedback as accession information. This information will facilitate reporting needs of the genebank.
        - Distribution/exchange records include date of request; number of samples requested and sent; requester's name and address; copies of/reference to phytosanitary certificate; cover letter; SMTA or MTA; and shipping log.
    - Keep well-documented records on characterization and evaluation of each accession to enable the germplasm user to make an informed decision on which accession to select for the intended purpose.
    - As much as possible, record and make available molecular data generated during characterization and evaluation activities through genomics, proteomics, metabolomics and bioinformatics.
- ✓ Document other information such as crop/collection catalogues, voucher images (photos, drawings), planting and harvest dates, and notes on the identity verification of each accession.
- ✓ Process the digitizing of paper data and ensure quality information management by having measures to detect manual, hand written and electronic data entries for transcription errors.
- ✓ If possible, have one staff member with specific responsibility for managing the genebank information management system, including keeping data up-to-date at all times.
- ✓ Duplicate data at regular intervals and stored at a remote site to guard against loss from fire, computer failure, data breach, etc.

1.8 Distribution and Exchange

The genebank should have a policy and procedure for the distribution of germplasm, including the review process to check for fulfilment of legal and phytosanitary requirements, and step-by step-instructions of consignment preparation, post-consignment follow-up and reporting to the Secretariat of the ITPGRFA.

- ✓ If your country is a signatory to the Plant Treaty and you are distributing Annex 1 germplasm, you must use a Standard Material Transfer Agreement (SMTA) that covers both access to genetic materials and the benefits derived from them.
    - The voluntary Easy-SMTA information system enables genebanks to compile and generate SMTAs in the six official languages of the ITPGRFA and provides for automated reporting on the SMTAs to the Governing Body of the Treaty
    - If the recipient is not familiar with the SMTA, suggest that they refer to Treaty Learning Module.
- ✓ If your country is not yet a Contracting Party to the Treaty or if the germplasm is not an Annex 1 crop, you should come to an agreement with the recipient on the terms and conditions of germplasm distribution.
    - If your genebank does not already have a generic Material Transfer Agreement (MTA) template, refer to the CBD's Access and Benefit Sharing Clearing House.
    - For simplicity and uniformity reasons, some genebanks have chosen to use the SMTA for non-Annex 1 crops and for germplasm exchanges with non-Treaty Party countries, provided it is compatible with their national legislation.
    - Ensure that the recipient of the germplasm is aware of the conditions of the SMTA/MTA.
- ✓ Ensure that users requesting material provide full details about the documentation they require in order for you to successfully provide them with the materials.
- ✓ Arrange with the National Plant Protection Organization (NPPO), or authorized agent, in your country to inspect or test the material in order to certify that it meets the import requirements (including any mandatory fumigation or other treatment), and to issue the relevant phytosanitary certificate.
- ✓ Have a policy in place for the number of seeds to distribute for any given species.
    - For accessions with too little seed at the time of request and in the absence of a suitable alternative accession, supply samples after regeneration/ multiplication, based on a renewed request. For some species and for some research uses, a smaller number of seeds may be acceptable.
- ✓ Ensure that the time span between receipt of a request for seeds and the dispatch of the seeds are kept to a minimum.
- ✓ Use packing and shipping guidelines/recommendations similar to those utilized for acquisition.
- ✓ Include all required documentation inside the shipment (for the recipient) and attached to the outside of the container for the Customs officials to guarantee smooth processing during transit and at the border of the destination country.
    - Documentation should include data on accessions (including an itemized list with accession identification, number and/or weights of samples, and key passport data), import permit, phytosanitary certificate, commercial invoice of certificate of no commercial value, or certificate of donation, and non-GMO certificate
    - To make best use of the material, ensure that the requestor receives the characterization and evaluation data of the accessions included in the shipment.
    - The pathogen-testing history is a useful element to be added to the documents accompanying the shipment.
    - For information that is publicly available on the website of the genebank, it is sufficient to provide the respective link to each accession to the recipient.
- ✓ Once the shipment has been successfully dispatched, document the information in the genebank information system, including data such as:
    - Shipment reference number and date of shipment
    - Consignee responsible for handling the shipment and designation
    - Names and addresses of sending and receiving organizations
    - Recipient source and type of organization
    - Purpose of germplasm request and use
    - Phytosanitary certificate and reference/code numbers
    - Export permit reference/code number

- Number of transfer agreement.
- Associated metadata

✓ The supplying genebank should monitor the delivery and condition of the germplasm on arrival at its destination to ensure that high quality germplasm reaches the recipient in a minimum time:
- Track shipment and check Customs procedures - the recipient may need to hire an agent to facilitate Customs clearance and delivery to the final destination.
- Follow up with the recipient as to the status and performance of the distributed germplasm.

1.9 Safety Duplication

The genebank should have a policy and procedure for the safety duplication of germplasm, including the review process to check for fulfilment of legal and phytosanitary requirements and step-by step-instructions of consignment preparation, post-consignment follow-up, shipment schedules and monitoring of the viability of safety duplicated material.

✓ Store a safety duplicate sample for every original accession in a geographically distant area, under the same or better conditions than those in the original genebank.
- Choose the facility in a socio-politically stable country and situated in a place with low radiation (radioactivity), geological stability (low probability of earthquakes) and proper drainage from seasonal rains.
- Choose a host genebank/institute that has good management capabilities to provide appropriate conditions to the duplicated accessions and is not constrained by financial and human resources.

✓ Draw up a legal agreement setting out the responsibilities of the depositing and the recipient genebank, and the terms and conditions under which material is maintained and managed.
- If your genebank does not already have an agreement with another genebank to duplicate your original accessions, consider where best you might do so, which will depend on your chosen method of safety duplication.

✓ Ensure that legal and phytosanitary requirements are complied with and that each safety duplicate sample is accompanied by relevant associated information.
- Discuss with the host genebank early in the planning process what documentation (genebank and host country) is required, including an assessment of the customs and quarantine procedures.

✓ Ensure that the safety duplicate is of high quality and of sufficient quantity.
- Duplicate clean and healthy material.
- Ensure that the size of safety-duplicated samples is sufficient to conduct at least three regenerations.
- It is recommended to prepare and identify a subset of materials to use for viability testing in the future.

✓ Package all seed samples for safety duplication in well labelled, vacuum-sealed trilaminate aluminium foil packet seamed on all four sides with no gusset.
- Place an outer and inner label for each packet to ensure that the material is properly identified.
- Ensure that the packet is durable and impervious to moisture in order to maintain germination levels for at least 10 years.

✓ Include minimum information along with the shipment, including an itemized list with accession identification, key passport data, total amount of seeds (by weight or number), type of container, etc.
- Use shipping guidelines/recommendations similar to those utilized for distribution.
- Include relevant information about the location of the safety-duplicated accessions in the genebank's information system.

✓ Record, validate and upload to the genebank documentation system all safety duplication data, including associated metadata

- ✓ Regularly check/compare genebank information system to ensure that any new material not duplicated in the recipient genebank is identified and prepared for safety duplication, as appropriate.

1.10 Security and Personnel

A genebank should have a risk management strategy in place that includes *inter alia* measures against power cut, fire, flooding and earthquakes.

- ✓ Risk management systems can be based on the Standard Operating Procedures (SOPs) so that each activity and task is analysed for risk.
- ✓ Develop a risk management strategy utilizing the following steps:
    - *Communication and consultation*: Ensure that all those who will be involved in implementing a risk management system are oriented in the concepts, methodology, terminology, documentation requirements and decision-making processes of the system.
    - *Establishing the context*: Consider the objectives/activities/tasks of the genebank, the environment in which the activities operate, and the stakeholders.
    - *Risk identification*: Carry out an inventory of relevant risks to the genebank operations.
    - *Risk analysis*: Carry out an analysis of potential impact (or consequence) of the identified risks and their likelihood (probability).
    - *Risk evaluation*: Determine the level of risk that is acceptable.
    - *Risk treatment*: Identify the course of action to deal with those risks where the current total risk rating is considered unacceptable, giving top priority to the highest assessed residual risks.
    - *Monitoring and review*: Analyse the risk management system and assesses whether changes to the system are needed. Responsibilities for monitoring and review should be clearly defined and documented.
- ✓ For the management of individual risks, the following considerations are relevant:
    - Extreme weather conditions such as drought, freezing, hail, cyclones, typhoons, and hurricanes are partially predictable and precautions can be undertaken to give plants additional protection during these extreme events.
- ✓ Appoint a staff member with responsibility for OSH in your genebank and arrange for that person to go for training in OSH.
    - Most countries will have an Occupational Safety and Health (OSH) policy. The International Labour Organization (ILO) provides country profiles on OSH.
- ✓ Ensure that all staff are aware of OSH requirements and are kept up-to-date regarding any changes.
    - Ensure that OSH rules are visible in the more risk-prone areas of the genebank.
    - Provide properly functioning protective equipment and clothing, as required by OSH, and ensure it is regularly checked and used in the field. The OSH officer will be responsible for safety equipment upkeep.
    - Instruct staff in the correct and safe use of equipment with regular training provided in health and safety in field, greenhouse and lab environments.
    - Choose appropriate and nationally approved agrochemicals to reduce risk.
- ✓ Ensure that the genebank has a critical human resource plan with appropriate annual budget allocation (core and project funds) and that staff have the critical skills, experience and qualifications required to implement all genebank tasks effectively and efficiently.
    - Ensure that the genebank manager and those staff carrying out specific tasks regularly review and update SOPs
    - Hold regular on-the-job training sessions and ensure that staff can attend training opportunities overseas/in other genebanks at regular intervals to keep up-to-date with the latest developments.
    - Rotate tasks to make work as varied as possible and involve all staff (where possible) in meetings and discussions.

- Retain competent staff by providing recognition and rewards for excellent performance.
- Access to disciplinary and technical specialists in a range of subject areas, such as virology, phytopathology, is desirable.

✓ Include risks associated with staffing in the risk identification, analysis and management.

Annex 2. Action Steps for Conservation in Field Genebanks

Below are the normative and operational actions required for safeguarding germplasm under medium- and long-term storage conditions in field genebanks.

1.1 Choice of Location of the Field Genebank

The genebank should have a policy and procedure in place for selecting and acquiring land for the field genebank, including a checklist of requirements and regulations.

- ✓ Select a site in which the agro-ecological conditions of the field genebank is as similar as possible to the environment where the collected plant materials originated.
    - Choose a field site with optimum climate, elevation, and soil conditions for the establishment of the field genebank to provide appropriate to optimum conditions for good adaptation and growth of plants.
        - Consider the land-use history as it can provide clues about the aptness of the land for specific crops.
- ✓ Select a site location that minimizes risks from natural and manmade disasters.
    - Maintain a safe distance of at least 10 km radius from active volcanoes to avoid damage from lava flow and rocks.
    - Avoid areas that are frequently in the path of hurricanes, typhoons or snow avalanches.
    - Establish firebreaks if bushfires are a known risk.
    - Install fencing and hire security guards to avoid vandalism, theft and damage by large animals.
    - Select a site with adequate rainfall and/or accessibility to a water source.
    - Choose a location where the target crop has not been grown previously to avoid heavy infestation of major diseases or insect pests that might cause plant losses or make disease and pest management very costly.
    - Install insect netting and use caging to prevent insect, bird and small mammal damage.
    - Ensure that a good security system is in place to avoid theft or damage of germplasm and/or equipment and facilities.
- ✓ Only choose a site that is secure over the long-term (minimum of 50 years) based on written, guaranteed or gazetted land tenure.
    - Take the development plan for the area into serious consideration – sites close to a town or city may be needed for other activities in the future.
- ✓ Select a site that provides sufficient space for future expansion as new accessions might need to be added after a couple of years of establishment of the field genebank.
- ✓ Analyse and correct the physical and nutritional status of the soil at the prospective site of the field genebank, before preparing the layout of the field genebank.
- ✓ For those species used to produce seeds for distribution, choose the site in order to minimize risks of gene flow and contamination from crops or wild populations of the same species to maintain genetic integrity.
    - Selecting a site away from crop stands or wild populations of the same species to avoid gene flow or weed contamination is important for ensuring genetic integrity in these species.
- ✓ Select a site within easy reach for curational staff and field labourers through public transport and/or other means of transportation.
- ✓ Select land area for the field genebank that is suitable for using machinery for mulching, fertilizer and pesticide applications.
- ✓ Select a site with easy access to a water source for pesticide applications and supplemental irrigation as required.
- ✓ Select a site with access to facilities for propagation and raising plants in nurseries.

1.2 Acquisition of Germplasm

The genebank should have documented procedures for acquiring germplasm in accordance with legal and phytosanitary requirements.

- ✓ Develop a clear strategy for germplasm acquisition according to your institute's mandate:
  - Acquire germplasm to fill a gap in the collection
  - Acquire new material that is unique
  - Develop a collecting proposal that clearly states the purpose of the collection, the location and methodology.
  - For collections in other countries, collaborate with a host institute in that country and be guided by that country's regulations.
  - Plan well in advance when collecting germplasm in another country or acquiring germplasm from another genebank or research institute.
- ✓ Ensure that germplasm added to the collection is legally acquired, and accompanied by all relevant documentation.

A. Germplasm collections
   - For collections in your own country, find out national and local regulations by contacting the appropriate National Competent Authority.
   - Obtain necessary collecting permits from national authorities required for collecting crop wild relatives (CWR) or semi-domesticated germplasm in natural populations *in situ*.
   - When collecting from farmers' fields or community areas, prior informed consent (PIC) may be required and mutually agreed terms (MAT) determined, according to relevant national, regional or international laws and regulations.

B. Acquisition through transfer/donation from another genebank or research institute
   - A MTA (or SMTA if Annex 1 species under the ITPGRFA) should be signed by the authorities of the providing country.

- ✓ Ensure that your genebank abides by national and international phytosanitary regulations and any other import requirements from the relevant authorities in your country.
  - Obtain a phytosanitary certificate from the provider country.
  - If necessary, obtain an import permit from the relevant authorities in your country.
  - Ensure that samples collected from other countries or regions within the country pass through the relevant quarantine process and meet the associated requirements before being transferred to the genebank.
  - For collected accessions with insufficient seed quantity, conduct regeneration in containment or in an isolated area under the supervision of the national phytosanitary authority.
- ✓ Determine type of propagating material to collect (recalcitrant seeds or vegetative materials)
- ✓ If collecting recalcitrant seeds, conduct seed collection missions as close as possible to the time of maturation and prior to natural seed dispersal, avoiding potential genetic contamination, to ensure maximum seed quality
  - Schedule germplasm collection missions such that you can make collections at the optimum stage of maturity.
  - In the event that you may have to collect immature fruits or seeds, collect in a way that retains the connection between the parent plant and the dispersal unit (for example, collect whole stems or fruiting branches).
    - Ensure that samples that may have immature seeds are given the required time after harvest to achieve maturation.
  - Label collected samples carefully and ensure they are not mixed during handling.

- ✓ Collect only plant propagules from visibly healthy plants, devoid of disease and insect pest infestations or other damage.
- ✓ Collect from an appropriate number of individual plants such that the germplasm is genetically representative of the population, depending on the breeding system of the target species, while avoiding the depletion the natural population targeted for collecting.
    - Be guided by the breeding system, the plant type, and the propagule type being collected, when taking a decision on how many plants to sample within a population.
    - As vegetative propagules are usually bulky, sample size for collecting is much more limited compared to seeds.
- ✓ Consider repeated sampling from a particular site to capture additional diversity that may be present at various points in time.
    - Stimulate the formation of adequate shoots by scoring the trunk or the branches, when collecting cuttings for rooting or grafting; these shoots could then be collected during a second visit.
- ✓ Ensure that the period between collecting, shipping and processing and then transferring to the field genebank is as short as possible to prevent loss and deterioration of the material.

A. Packaging
    - Package collected samples to ensure survival during transport.
    - Package vegetative material in polythene bags if time in transit is short; semi-absorbent material can also be used
    - Pack recalcitrant seeds in sterile cotton or other suitable material in a perforated plastic bag to ensure sufficient air exchange.
    - For recalcitrant seeds it is important that water content be maintained upon collection and during transport, by maintaining high relative humidity (RH) in the storage containers.
    - If fruits/recalcitrant seeds are to be transported between locations where there are extreme mid-summer and -winter temperature differences, insulating packaging is essential.
    - Protect from crushing by mechanical mail sorters by packing them in rigid cushioned envelopes.
    - Pack scions in sterile cotton or other suitable material in a perforated plastic bag to ensure sufficient air exchange.
    - Samples should be packed firmly, but not too tightly in a box or carton, with addition of crumpled paper or polystyrene material to protect against shocks
    - Pay attention to the diseases and insect pests reportedly associated with the target species in the exporting/donating country and take appropriate measures.

B. Transport
    - Give due consideration to the time needed for document processing, duration of shipment and transit time and transit conditions (high temperatures in tropical countries) to ensure that the material reaches the destination genebank in good condition.
    - Transport recalcitrant seeds within the fruits, both for protection and to avoid dehydration.
    - If required, obtain a plant import permit from the national plant protection services and send it to the germplasm donor prior to the shipment.
    - Send shipments the fastest means possible, either by airfreight or courier, to avoid deterioration of sample quality and exposure to adverse environmental conditions.
    - Continuously track the package so that it arrives at the genebank as quickly as possible for appropriate processing.
    - For transport of long duration by road, periodically aerate the collected material as a necessary precaution.

- ✓ Germplasm added to the collection should be accompanied by associated data outlined in the FAO/Bioversity multi-crop passport descriptors.

A. Germplasm acquired through collections
   - Use a standardized collecting form to collect the associated data for each sample obtained.
   - Collect the associated data for each sample obtained as detailed in the FAO/Bioversity multi-crop passport descriptors (MCPD v.2.1).
   - Assign a collecting number for each sample so the samples can be linked to the passport data and any other collected information.
   - During collecting, obtain as much additional information as possible, such as plant population type, habitat and ecology, GPS coordinates, photo images and the substratum in order to provide curators and users of the germplasm with an understanding of its original context.
   - If collecting from farmers' fields, if possible collect information on origin of the germplasm, traditional knowledge, agronomic practices, cultural practices, etc.
   - When collecting CWR, take a herbarium voucher specimen as a reference collection from the same population. Use the same collection number as the seed sample, so that voucher and seed sample are always linked by this unique identification number.
   - When possible, carry out data collection via smartphones or tablets to save time and avoid transcription errors.
   - Use clear, indelible ink when labelling samples and write clearly. Electronically-produced labels reduce risks of transcription errors.
   - Record, validate and upload all acquisition data including associated metadata to the genebank information system.

B. Germplasm acquired through donations or transfer
   - Request that samples be accompanied by the associated data as detailed in the FAO/Bioversity multi-crop passport descriptors (MCPD v.2.1).
   - Assign a unique identification number to each sample that links the samples to the passport data and any other information.

1.3 Establishment of Field Collections

The genebank should have policies regarding germplasm in its collections including field preparation, introduction into field and live plant collections, inventory and field maps.

- ✓ Incorporate field and plot design, individual plot layout, electronic and print maps, as well as barcodes and field labels during the establishment phase of the field genebank.
- ✓ Maintain a sufficient number of plants in order to capture genetic diversity and ensure safety of accessions.
   - For vegetatively propagated woody or herbaceous perennial crops, maintain approximately 3-6 plants per accession for medium to large trees or palms. For
   - For root and tuber crops, including annuals, biennials, and perennials that require frequent or periodic harvesting and replanting, the number of plants may be in the range from eight (taro) to 50 plants (shallot, garlic) per accession.
- ✓ Choose the optimum location of individual accessions for effective management of the field collection and ease of monitoring, characterization and evaluation purposes.
- ✓ Utilize appropriate spacing of plants at the plot design phase to allow for proper growth of individual plants.
   - Consider the growth habit and the adult size of the plants, the need for irrigation structures, and the ease of maintenance when calculating the size of the plots.
   - Address specific micro-climate requirements such as high or low shade intensity when planning the layout of the field plots.

- Utilize appropriate land preparation measures (deep ploughing, corrective measures for acidic or alkaline soils) for successful establishment of field collections.
- Exercise strict control of plant introductions into the field genebank to avoid introduction of diseases and insect pests.
- Choose only healthy material and vigorous parts of the plant for propagation and planting.
- Establish a sufficient number of plants in order to capture genetic diversity and ensure safety of accessions.
- For dioecious species as holly, asparagus, date palm, etc., plant a suitable number of male/female parents.

✓ Plant reference accessions in the same field to facilitate identification, etc.

✓ For crop wild relatives that originated in natural forests, provide a higher shade intensity and good drainage at the field genebank site to simulate natural growing conditions.

- Grow poorly adapted accessions at alternative sites, in greenhouses, or under *in vitro* culture or keep them in cryopreservation.

✓ Practice weed control for rapid and vigorous plant growth.

✓ Establish and follow recommended isolation distances, use isolation cages or pollination control measures for propagation purposes.

- Obtain and follow crop-specific information about isolation distance of vegetatively propagated species and forage grasses (for example see the Crop Genebank Knowledge Base).

✓ Insert hedgerows at the outside of field plots to help prevent pesticide drift and provide security to the accessions from invading animals or unauthorized persons.

✓ Install an irrigation system to water the plants in the case of drought or when there is high demand (fruit-setting period)

- Carry out regular watering of plants during the dry season until they are well established.

✓ Install clearly written labels with two water resistant indelible tags.

- Ensure that the tags contain information on accession ID, species name, field plot ID, and date of planting.
- If possible, use computer-produced labels as they reduce transcription errors in names and numbers.

✓ Prepare a field map that shows the exact location of each accession in the plot.

- Maintain both hard and soft copies of field maps developed before planting and updated regularly.
- Annual crops do not require a field layout and field plan that is fixed in time. In the case of annuals, crop rotation is essential and this requires proper scheduling and additional free space.

1.4 Field Management

The genebank should have a procedure for conservation of field and live plant collections, including step-by-step instructions for the cleaning, field management processes, cultural practices, identity verification and monitoring of germplasm in the collections.

✓ Keep in mind that maintenance practices of field collections are crop-specific and may vary according to the intended use of the collection (conservation, evaluation, distribution).

✓ Have a system in place for the correct identification of all associated pests and diseases for the range of crops that are included in the collection.

- Conduct careful inspections and record all pest management operations.
- Collaborate with specialists, such as phytopathologists, virologists, nematologists, etc. for proper identification and advice on control measures for diseases and insect pests.

✓ After establishing the collection, be proactive and aid optimum plant growth by supplying favourable conditions.

- Water the plants in the case of drought, or when there is high demand (fruit-setting period).
- If necessary, use overhead sprinklers to prevent spring frost.
- Adjust fertilization of the field collection to the different plant types that might vary between different groups of accessions.
- Ensure that disease control measures are carried out in a timely manner.
- Practice weed control as necessary.
- Depending on the environmental conditions, utilize other measures such as frost and/or hail protection needed to ensure fruit production.
- Conduct regular pruning to keep the size of plants within acceptable parameters within the plantation and, in case of trees, to shape their canopy and allow sufficient light penetration for optimum fruit growth.
- Provide support structures (trees, wooden sticks, wires, etc.) for species that grow as vines (e.g. vanilla, many beans, cucurbits, etc.).

✓ Curational staff need to pay special attention to growth and performance of accessions of CWR.
✓ Maintain the genetic integrity of the collection.
- When seeds are going to be distributed, maintain accessions of cross-pollinated crops with specific traits of economic value in isolation using distant field plots or planting barrier crops in between to retain the specific traits.
- Rogue out involuntary seedlings.
- Monitor field collections regularly to ensure that each accession and each plant within the accession is properly identified, and mapped in the field map.
- Periodically verify labelling of accessions and individual plants within each accession on site and compared to plot plans.
- Periodically verify the identity of each accession using morphological and molecular markers when possible.

✓ Monitor all accessions regularly to determine if there are any new animal, insect or disease pests and for any possible vandalism.

1.5 Regeneration and Propagation

The genebank should have a policy and procedure for regeneration and propagation of germplasm, including step-by-step instructions for the review process, field preparation, selection of accessions, sample size, sowing, crop management, pollination control, identity verification, propagation methodologies and documentation.

✓ Regularly monitor the field collection to capture any dying or dead plants within an accession.
✓ The timing of regeneration/rejuvenation should be planned in such a way that it coincides with the normal planting season of the crop. It will be species- and possibly site-specific.
- Plan raising of rootstocks such that they reach appropriate size for grafting at the best season for propagation and when scions become available.
- Initiate propagation when propagules start to sprout or mother plants start to die continuously.
- FAO has published crop calendars for Latin America and Africa (FAO, 2004, 2012) which are helpful in this regard.

✓ Whenever possible, propagate plants vegetatively so that each offspring is an exact replica of the parent plant.
- Do not use seeds for propagation in a field collection unless the population size is represented by a sufficiently large number of plants.

✓ In the case of annual crops, make storage facilities available and easily accessible for vegetative propagules that are harvested annually and kept in storage until the next planting season.
✓ Register the following information in your database:
- The accession number and the plant sequence number within each accession

- The site where regeneration/rejuvenation is carried out
- Plot number
- Type of propagation and materials used (cuttings, tubers, corms, bulbs)
- Planting date
- Survival rate of the propagated material in the nursery and after field transplanting
- The protocol of breaking dormancy of recalcitrant seed if applicable
- Management practices employed, method of planting, field conditions
- Number of plants established for each accession
- Harvest date

1.6 Characterization

The genebank should have a procedure for characterization of germplasm, including step-by-step instructions describing sampling techniques, growth cycle stages during which characterization data is obtained, descriptors used (taxonomic, morphological, phenotypic, biochemical, nutritional, physiological and molecular), and the manner in which the data is collected and validated.

- ✓ Characterize all accessions at maturity.
  - Phenotypic characterization of the perennial field collections is much easier to perform as the plants are readily and permanently available in the field.
    - The scoring of traits in the field collection can be done at the appropriate time, and repeated over the years, if necessary.
  - Characterization of annual species can be carried out during regeneration.
    - Use an augmented design with carefully chosen check varieties.
  - Use electronic barcoding if possible
  - If possible, use mobile devices to capture electronic data in the field, laboratories and greenhouses.
- ✓ Ensure that species-specific characterization procedures are based upon standardized and calibrated measuring formats and follow internationally agreed descriptor lists as far as possible.
  - If there are no existing descriptor lists for a species, use Bioversity International's Guidelines for Developing Crop Descriptor Lists.
  - Characteristics and traits for crops should be defined by crop experts and/or curators in consultation with genebank managers. Traits can include morphological, biochemical, nutritional, physiological and molecular.
- ✓ Characterize germplasm for a set of highly heritable morphological traits to describe the phenotype of plants. The descriptive traits used will vary with the species.
  - Utilize herbarium specimens and high quality voucher images to guide true-to-type identification.
  - Use reference accessions planted in the same field to facilitate the correct scoring of some traits.
  - In crops with high levels of variability, take measurements at the plant level rather than at the plot level to capture the information about the variability between plants of the same accession.
- ✓ If resources are available, utilize molecular marker technologies and genomic tools for characterization, complementing phenotypic characterization.
- ✓ Record, validate and upload to the genebank documentation system all characterization data, including associated metadata.
  - Ensure that trained staff are responsible for data recording and data entry, using calibrated and standardized measuring formats as indicated in the descriptor lists.
  - Genebank curators and documentation officers should validate data before being uploaded into the documentation system.
- ✓ Make relevant characterization data publicly available.

1.7 Evaluation

The genebank should have procedures for the evaluation of germplasm, including step-by-step instructions describing sampling techniques, replicated multi-location, multi-year designs, growth cycle stages during which evaluation data is obtained, descriptors used (agronomic performance, biotic resistance, abiotic tolerance and nutritional traits), and the manner in which the data is analysed and validated. The methods/protocols, formats and measurements for evaluation should be properly documented with citations.

- ✓ Obtain evaluation data for as many accessions as practically possible, through laboratory, greenhouse and/or field analysis as may be applicable.
    - Use electronic barcoding if possible
    - If possible, use mobile devices to capture electronic data in the field, laboratories and greenhouses.
- ✓ Whenever possible, collaborate with national or international research organisations, with field stations in different agro-ecological environments, or with members of national or regional genetic resources networks.
- ✓ Carry out germplasm evaluation in collaboration with plant breeders and other specialists (virologists, entomologists, mycologists, statisticians).
    - Work with these specialists to agree on the traits to be evaluated, the accessions that will be tested, and the experimental designs to be implemented.
- ✓ Use an experimental design with replicates and conduct the evaluations in different environments and/or over multiple years.
    - It is advisable to confer with the statistician at your institution for selection of the most relevant experimental design.
    - Ideally, carry out evaluation trials in at least three environmentally diverse location, using sound experimental designs, and collect data over at least three years.
- ✓ Define and identify check accessions to be included in the statistical design and use over time.
    - Check accessions facilitate comparisons of data collected across locations and years.
    - ✓ If possible, work with molecular breeders to identify appropriate trait-associated markers to streamline evaluation efforts.
    - ✓ Use newly developed screening protocols, especially for abiotic stresses to make sure that internationally validated protocols are considered.
    - ✓ Present evaluation data either as discrete values (e.g. scores for severity of disease symptoms or symptoms of abiotic stresses) or as continuous values based on measuring.
- ✓ Record, validate and upload to the genebank documentation system all evaluation data, including associated metadata.
    - Ensure that trained staff are responsible for data recording and data entry.
    - Genebank curators and documentation officers should validate data before being uploaded into the documentation system.
- ✓ Make relevant evaluation data publicly available.
- ✓ The publishing of evaluation data will enhance the use of the collection, especially for plant breeders.

1.8 Documentation

The genebank should have a policy managing genebank data and information, including data sharing guidelines.

- ✓ Ensure that your genebank adopts international data standards to provide consistency in data shared among different information systems and programs. Data should be publically available in a search-query database.

- ✓ Establish a genebank information system specifically for your genebank (which includes the fields for FAO/Bioversity multi-crop passport descriptors; MCPD v.2.1) or use/adapt one of the several models available.
    - GRIN-Global has been developed by USDA-ARS, the Crop Trust and Bioversity International to enable genebanks to store and manage information associated with plant genetic resources. Other information systems for genebanks are also available.
- ✓ Document passport data of accessions using FAO/Bioversity multi-crop passport descriptors
    - The use of Digital Object Identifiers (DOIs; MCPD v.2.1) is recommended for information sharing across different information systems and different communities.
    - Record most of the passport data during germplasm collection, or, in the case of material acquired from other genebanks, request to receive passport data alongside the donated/transferred material
    - Include additional accession information:
        - Georeferenced data which can help to identify accessions with specific adaptive traits, depending on the agro-climatic conditions of the collecting sites
        - Environmental information, such as overlaid climate and soil maps
        - Historical information – origin of the germplasm, traditional knowledge, cultural practices etc.
- ✓ Validate and upload all data and information generated relating to all aspects of conservation and use of germplasm, including metadata.
    - Carefully document cultural practices to guarantee their consistent employment over time and the appropriate treatment of accessions. The following major cultural practices should be documented:
        - Root stock establishment
        - Planting/drafting date
        - Irrigation dates
        - Fertilizer application dates
        - Pesticide or herbicide application dates
        - Pruning dates
        - Harvesting period
        - Regeneration activities
    - Document inventory, germplasm orders, distribution data and data obtained from user feedback as accession information. This information will facilitate reporting needs of the genebank.
        - Distribution/exchange records include date of request; number of samples requested and sent; requester's name and address; copies of/reference to phytosanitary certificate; cover letter; SMTA or MTA; and shipping log.
        - Regularly update a physical inventory and field map (physical identification and field and plot location of each plant of each accession).
        - Retain and date older field maps for reference.
    - Keep well-documented records on characterization and evaluation of each accession to enable the germplasm user to make an informed decision on which accession to select for the intended purpose.
        - As much as possible, record and make available molecular data generated during characterization and evaluation activities through genomics, proteomics, metabolomics and bioinformatics.
- ✓ Document other information such as crop/collection catalogues, voucher images (photos, drawings), planting and harvest dates, and notes on the identity verification of each accession.
- ✓ Process the digitizing of paper data and ensure quality information management by having measures to detect manual, hand written and electronic data entries for transcription errors.
- ✓ If possible, have one staff member with specific responsibility for managing the genebank information management system, including keeping data up-to-date at all times.
- ✓ Duplicate data at regular intervals and stored at a remote site to guard against loss from fire, computer failure, data breach, etc.

1.9 Distribution

The genebank should have a policy and procedure for the distribution of germplasm, including the review process to check for fulfilment of legal and phytosanitary requirements, and step-by step-instructions of consignment preparation, post-consignment follow-up and reporting to the Secretariat of the ITPGRFA.

- ✓ If your country is a signatory to the Plant Treaty and you are distributing Annex 1 germplasm, you must use a Standard Material Transfer Agreement (SMTA) that covers both access to genetic materials and the benefits derived from them.
    - The voluntary Easy-SMTA information system enables genebanks to compile and generate SMTAs in the six official languages of the ITPGRFA and provides for automated reporting on the SMTAs to the Governing Body of the Treaty
    - If the recipient is not familiar with the SMTA, suggest that they refer to Treaty Learning Module.
- ✓ If your country is not yet a Contracting Party to the Treaty or if the germplasm is not an Annex 1 crop, you should come to an agreement with the recipient on the terms and conditions of germplasm distribution.
    - If your genebank does not already have a generic Material Transfer Agreement (MTA) template, refer to the CBD's Access and Benefit Sharing Clearing House.
    - For simplicity and uniformity reasons, some genebanks have chosen to use the SMTA for non-Annex 1 crops and for germplasm exchanges with non-Treaty Party countries, provided it is compatible with their national legislation.
    - Ensure that the recipient of the germplasm is aware of the conditions of the SMTA/MTA.
- ✓ Ensure that users requesting material provide full details about the documentation they require in order for you to successfully provide them with the materials.
- ✓ Subject vegetative material from field genebanks to therapy and indexing procedures before distributing it to germplasm users. Indexing for difficult to detect pathogens such as viruses is important to reduce the risk of their spread.
- ✓ Arrange with the National Plant Protection Organization (NPPO), or authorized agent, in your country to inspect or test the material in order to certify that it meets the import requirements (including any mandatory fumigation or other treatment), and to issue the relevant phytosanitary certificate.
- ✓ Have a policy in place for the number of samples to distribute for any given species.
    - For accessions with insufficient material at the time of request and in the absence of a suitable alternative accession, supply samples after regeneration/ multiplication, based on a renewed request.
- ✓ Ensure that the time span between receipt of a request for germplasm and its dispatch are kept to a minimum.
- ✓ Use packing and shipping guidelines/recommendations similar to those utilized for acquisition.
    - The type of shipping container, packing materials and the choice of shipping company depend on the plant part to be distributed and might be specified on the import permit/phytosanitary certificate.
    - Consult the Crop Genebank Knowledge Base for crop-specific information on the safe transfer of germplasm.
- ✓ For some crops, such as Musa and cacao, shipment of material through transit or quarantine centres in non-producing countries might be the best solution.
- ✓ Include all required documentation inside the shipment (for the recipient) and attached to the outside of the container for the Customs officials to guarantee smooth processing during transit and at the border of the destination country.
    - Documentation should include data on accessions (including an itemized list with accession identification, number and/or weights of samples, and key passport data),

import permit, phytosanitary certificate, commercial invoice of certificate of no commercial value, or certificate of donation, and non-GMO certificate
- To make best use of the material, ensure that the requestor receives the characterization and evaluation data of the accessions included in the shipment.
- The pathogen-testing history is a useful element to be added to the documents accompanying the shipment. For information that is publicly available on the website of the genebank, it is sufficient to provide the respective link to each accession to the recipient.

✓ Once the shipment has been successfully dispatched, document the information in the genebank information system, including data such as:
- Shipment reference number and date of shipment
- Consignee responsible for handling the shipment and designation
- Names and addresses of sending and receiving organizations
- Recipient source and type of organization
- Purpose of germplasm request and use
- Phytosanitary certificate and reference/code numbers
- Export permit reference/code number
- Number of transfer agreement.
- Associated metadata

✓ The supplying genebank should monitor the delivery and condition of the germplasm on arrival at its destination to ensure that high quality germplasm reaches the recipient in a minimum time:
- Track shipment and check Customs procedures - the recipient may need to hire an agent to facilitate Customs clearance and delivery to the final destination.
- Follow up with the recipient as to the status and performance of the distributed germplasm.

1.10 Security and Safety Duplication

A genebank should have a risk management strategy in place that includes inter alia measures against power cut, fire, flooding and earthquakes. The genebank should also have a policy and procedure for the safety duplication of germplasm, including the review process to check for fulfilment of legal and phytosanitary requirements and step-by step-instructions of consignment preparation, post-consignment follow-up, shipment schedules and monitoring of the viability of safety duplicated material.

A. Security/Personnel

✓ Risk management systems can be based on the Standard Operating Procedures (SOPs) so that each activity and task is analysed for risk.

✓ Develop a risk management strategy utilizing the following steps:
- *Communication and consultation*: Ensure that all those who will be involved in implementing a risk management system are oriented in the concepts, methodology, terminology, documentation requirements and decision-making processes of the system.
- *Establishing the context*: Consider the objectives/activities/tasks of the genebank, the environment in which the activities operate, and the stakeholders.
- *Risk identification*: Carry out an inventory of relevant risks to the genebank operations.
- *Risk analysis*: Carry out an analysis of potential impact (or consequence) of the identified risks and their likelihood (probability).
- *Risk evaluation*: Determine the level of risk that is acceptable.
- *Risk treatment*: Identify the course of action to deal with those risks where the current total risk rating is considered unacceptable, giving top priority to the highest assessed residual risks.
- *Monitoring and review*: Analyse the risk management system and assesses whether changes to the system are needed. Responsibilities for monitoring and review should be clearly defined and documented.

✓ For the management of individual risks, the following considerations are relevant:

- Extreme weather conditions such as drought, freezing, hail, cyclones, typhoons, and hurricanes are partially predictable and precautions can be undertaken to give plants additional protection during these extreme events.

✓ Appoint a staff member with responsibility for OSH in your genebank and arrange for that person to go for training in OSH.
- Most countries will have an Occupational Safety and Health (OSH) policy. The International Labour Organization (ILO) provides country profiles on OSH.

✓ Ensure that all staff are aware of OSH requirements and are kept up-to-date regarding any changes.
- Ensure that OSH rules are visible in the more risk-prone areas of the genebank.
- Provide properly functioning protective equipment and clothing, as required by OSH, and ensure it is regularly checked and used in the field. The OSH officer will be responsible for safety equipment upkeep.
- Instruct staff in the correct and safe use of equipment with regular training provided in health and safety in field, greenhouse and lab environments.
- Choose appropriate and nationally approved agrochemicals to reduce risk.

✓ Ensure that the genebank has a critical human resource plan with appropriate annual budget allocation (core and project funds) and that staff have the critical skills, experience and qualifications required to implement all genebank tasks effectively and efficiently.
- Ensure that the genebank manager and those staff carrying out specific tasks regularly review and update SOPs
- Hold regular on-the-job training sessions and ensure that staff can attend training opportunities overseas/in other genebanks at regular intervals to keep up-to-date with the latest developments.
- Rotate tasks to make work as varied as possible and involve all staff (where possible) in meetings and discussions.
- Retain competent staff by providing recognition and rewards for excellent performance.
- Access to disciplinary and technical specialists in a range of subject areas, such as virology, phytopathology, is desirable.

✓ Include risks associated with staffing in the risk identification, analysis and management.

B. Safety Duplication

✓ Store a safety duplicate sample for every original accession in a geographically distant area, under the same or better conditions than those in the original genebank.
- Choose the facility in a socio-politically stable country and situated in a place with low radiation (radioactivity), geological stability (low probability of earthquakes) and proper drainage from seasonal rains.
- Choose a host genebank/institute that has good management capabilities to provide appropriate conditions to the duplicated accessions and is not constrained by financial and human resources.

✓ If your genebank does not already have an agreement with another genebank to duplicate your original accessions, consider where best you might do so, which will depend on your chosen method of safety duplication.

✓ Discuss with the host genebank early in the planning process what documentation (genebank and host country) is required, including an assessment of the customs and quarantine procedures.

✓ Draw up a legal agreement setting out the responsibilities of the depositing and the recipient genebank, and the terms and conditions under which material is maintained and managed.
- In contrast to orthodox seed collection duplicates, duplicates managed in field genebanks need to be actively managed.

✓ Other options for safety duplication include maintenance in *in vitro* culture, cryopreservation or the storage of pollen or DNA.
- Duplication using *in vitro* culture will require active management.
- Cryopreservation can be considered as a “black box” safety duplicate.

- Pollen and DNA storage are not equivalent to ‘real’ safety duplications but are of some help.

✓ Ensure that legal and phytosanitary requirements are complied with and that each safety duplicate sample is accompanied by relevant associated information.
- Discuss with the host genebank early in the planning process what documentation (genebank and host country) is required, including an assessment of the customs and quarantine procedures.

✓ Ensure that the safety duplicate is of high quality and of sufficient quantity.
- Duplicate clean and healthy material. Ensure that the safety duplicate is of high quality and free of diseases and insect pests.
- A minimum of three to five replicates per accession should be duplicated.

✓ Use harvesting, packing and shipping guidelines/recommendations similar to those utilized for acquisition and distribution.

✓ Include minimum information along with the shipment, including an itemized list with accession identification, key passport data, total amount of propagules (by weight or number), type of container, etc.
- Use shipping guidelines/recommendations similar to those utilized for distribution.
- Include relevant information about the location of the safety-duplicated accessions in the genebank’s information system.

✓ Record, validate and upload to the genebank documentation system all safety duplication data, including associated metadata

✓ Regularly check/compare genebank information system to ensure that any new material not duplicated in the recipient genebank is identified and prepared for safety duplication, as appropriate.

Annex 3. Action Steps for Conservation *In vitro*

Below are the normative and operational actions required for safeguarding germplasm under medium- and long-term storage conditions via *in vitro* culture.

1.1 Acquisition of Germplasm

The genebank should have documented procedures for acquiring germplasm in accordance with legal and phytosanitary requirements.

- ✓ Develop a clear strategy for germplasm acquisition according to your institute's mandate:
  - Acquire germplasm to fill a gap in the collection
  - Acquire new material that is unique
  - Develop a collecting proposal that clearly states the purpose of the collection, the location and methodology.
  - For collections in other countries, collaborate with a host institute in that country and be guided by that country's regulations.
  - Plan well in advance when collecting germplasm in another country or acquiring germplasm from another genebank or research institute.
- ✓ Ensure that germplasm added to the collection is legally acquired, and accompanied by all relevant documentation.

  A. Germplasm collections
     - For collections in your own country, find out national and local regulations by contacting the appropriate National Competent Authority.
     - Obtain necessary collecting permits from national authorities required for collecting crop wild relatives (CWR) or semi-domesticated germplasm in natural populations *in situ*.
     - When collecting from farmers' fields or community areas, prior informed consent (PIC) may be required and mutually agreed terms (MAT) determined, according to relevant national, regional or international laws and regulations.

  B. Acquisition through transfer/donation from another genebank or research institute
     - A MTA (or SMTA if Annex 1 species under the ITPGRFA) should be signed by the authorities of the providing country.

- ✓ Ensure that your genebank abides by national and international phytosanitary regulations and any other import requirements from the relevant authorities in your country.
  - Obtain a phytosanitary certificate from the provider country.
  - If necessary, obtain an import permit from the relevant authorities in your country.
  - Ensure that samples collected from other countries or regions within the country pass through the relevant quarantine process and meet the associated requirements before being transferred to the genebank.
  - For collected accessions with insufficient seed quantity, conduct regeneration in containment or in an isolated area under the supervision of the national phytosanitary authority. Determine type of propagating material to collect (recalcitrant seeds, *in vitro* plantlets, vegetative materials
- ✓ If collecting recalcitrant seeds, conduct seed collection missions as close as possible to the time of maturation and prior to natural seed dispersal, avoiding potential genetic contamination, to ensure maximum seed quality
  - Schedule germplasm collection missions such that you can make collections at the optimum stage of maturity.

- In the event that you may have to collect immature fruits or seeds, collect in a way that retains the connection between the parent plant and the dispersal unit (for example, collect whole stems or fruiting branches).
  - Ensure that samples that may have immature seeds are given the required time after harvest to achieve maturation.
- Label collected samples carefully and ensure they are not mixed during handling.

✓ Collect only plant propagules from visibly healthy plants, devoid of disease and insect pest infestations or other damage.

✓ Collect from an appropriate number of individual plants such that the germplasm is genetically representative of the population, depending on the breeding system of the target species, while avoiding the depletion the natural population targeted for collecting.

- Be guided by the breeding system, the plant type (bush versus tall tree), and the propagule type being collected, when taking a decision on how many plants to sample within a population.
- As vegetative propagules are usually bulky, sample size for collecting is much more limited compared to seeds.
- If collecting *in vitro* plantlets, sample size will be determined by the efficacy of the methodology and to some extent, the time in transit.

✓ Consider repeated sampling from a particular site to capture additional diversity that may be present at various points in time.

- Stimulate the formation of adequate shoots by scoring the trunk or the branches, when collecting cuttings for rooting or grafting; these shoots could then be collected during a second visit.

✓ Ensure that the period between collecting, shipping and processing and then transferring to the field genebank is as short as possible to prevent loss and deterioration of the material.

A. Packaging

- Package collected samples to ensure survival during transport.
- Package vegetative material in polythene bags if time in transit is short; semi-absorbent material can also be used
- Pack recalcitrant seeds in sterile cotton or other suitable material in a perforated plastic bag to ensure sufficient air exchange.
- For recalcitrant seeds it is important that water content be maintained upon collection and during transport, by maintaining high relative humidity (RH) in the storage containers.
- If fruits/recalcitrant seeds are to be transported between locations where there are extreme mid-summer and -winter temperature differences, insulating packaging is essential.
- Protect from crushing by mechanical mail sorters by packing them in rigid cushioned envelopes.
- Pack scions in sterile cotton or other suitable material in a perforated plastic bag to ensure sufficient air exchange.
- Samples should be packed firmly, but not too tightly in a box or carton, with addition of crumpled paper or polystyrene material to protect against shocks
- Pay attention to the diseases and insect pests reportedly associated with the target species in the exporting/donating country and take appropriate measures.

B. Transport

- Give due consideration to the time needed for document processing, duration of shipment and transit time and transit conditions (high temperatures in tropical countries) to ensure that the material reaches the destination genebank in good condition.
- Transport recalcitrant seeds within the fruits, both for protection and to avoid dehydration.
- If required, obtain a plant import permit from the national plant protection services and send it to the germplasm donor prior to the shipment.

- Send shipments the fastest means possible, either by airfreight or courier, to avoid deterioration of sample quality and exposure to adverse environmental conditions.
- Continuously track the package so that it arrives at the genebank as quickly as possible for appropriate processing.
- For transport of long duration by road, periodically aerate the collected material as a necessary precaution.

✓ Germplasm added to the collection should be accompanied by associated data outlined in the FAO/Bioversity multi-crop passport descriptors.

A. Germplasm acquired through collections
   - Use a standardized collecting form to collect the associated data for each sample obtained.
   - Collect the associated data for each sample obtained as detailed in the FAO/Bioversity multi-crop passport descriptors (MCPD v.2.1).
   - Assign a collecting number for each sample so the samples can be linked to the passport data and any other collected information.
   - During collecting, obtain as much additional information as possible, such as plant population type, habitat and ecology, GPS coordinates, photo images and the substratum in order to provide curators and users of the germplasm with an understanding of its original context.
   - If collecting from farmers' fields, if possible collect information on origin of the germplasm, traditional knowledge, agronomic practices, cultural practices, etc.
   - When collecting CWR, take a herbarium voucher specimen as a reference collection from the same population. Use the same collection number as the seed sample, so that voucher and seed sample are always linked by this unique identification number.
   - When possible, carry out data collection via smartphones or tablets to save time and avoid transcription errors.
   - Use clear, indelible ink when labelling samples and write clearly. Electronically-produced labels reduce risks of transcription errors.
   - Record, validate and upload all acquisition data including associated metadata to the genebank information system.

B. Germplasm acquired through donations or transfer
   - Request that samples be accompanied by the associated data as detailed in the FAO/Bioversity multi-crop passport descriptors (MCPD v.2.1).
   - Assign a unique identification number to each sample that links the samples to the passport data and any other information.

✓ Carry out all checking and decontamination activities in an area physically separated from laboratory and storage facilities
   - Check all samples for any sign of deterioration, such as contamination and/or damage.

✓ Treat samples with a surface disinfectant agent to remove all adherent microorganisms and handle so that its physiological status is not altered (treatment will depend to some extent on any decontamination treatment given prior to packaging and transporting.

✓ After decontamination, the action taken with the newly-arrived sample will depend on the species, the type of propagule and any surface decontamination carried out in the field
   - For *in vitro* cultures from another genebank or institute – action taken will depend on the phytosanitary status and whether or not they have been virus tested. Samples could get contaminated in transit and so would require decontamination or planting out in a greenhouse or screenhouse for virus testing.
   - Plant roots and tubers in pots in an isolation screen house and test for viruses.
   - Cuttings from woody plants can be planted for bud break/bud induction and tested for viruses.

- Screen any *in vitro* collected material for epiphytic and endophytic contamination and decide whether surface sterilization and/or culture on microorganism-detection medium is justified (see *in vitro* collecting handbook)

✓ All samples must be correctly labelled with the unique identification number

1.2 *In vitro* Culture and Slow-growth Storage

The genebank should have a procedure for *in vitro* culture and slow-growth storage including guidelines and methodologies for explant identification, initiation into *in vitro* and propagation/multiplication, medium composition, light and temperature regimes, regeneration, rejuvenation, characterization and evaluation.

A. *In vitro* culture

✓ Carry out a literature review to see if conditions for *in vitro* culture conditions (initiation, normal growth and multiplication) have been established for the species/variety you are working with, or any related species. If this information is not available then conditions will have to be established by experiment.

✓ Determine the appropriate explant and the optimum time (growth stage and physiological age of parent plant) for initiation into culture for a particular genus from the literature or by experiment.

✓ Explants should be free from known diseases and microbial contaminants
- Mother plants should be vigorous and healthy
- Mother plants should be tested for known viruses and shown to be free of viruses.

✓ Ensure that your surface decontamination method eliminates fungal contaminants from explants excised from field-grown or greenhouse-grown material (*ex vivo*).

✓ Screen explant on appropriate detection medium to ensure it is free from endogenous contamination.

✓ If you are culturing explants from a woody species decontamination can be difficult with the exudation of polyphenolics a particular problem.
- Antioxidants and activated charcoal can be incorporated in the medium to minimize the problem.

✓ Determine the culture media composition for initiating the explant *in vitro* and for multiplication.
- The use of growth regulators in the multiplication phase should not be excessive to avoid problems, such as callus formation, in storage later.

✓ When an accession has been successfully initiated into culture, it can be multiplied for storage, either for normal growth (active growing conditions) or slow growth storage.
- Normal *in vitro* growth conditions are usually used to provide the source material for multiplication - multiplication is required for rapid propagation of selected materials for research or distribution.
- Multiplication rate strongly depends on the genomic group to which the accession belongs and is influenced by the composition of the medium (particularly the cytokinin concentration), the explant size, age of culture and the size of the culture vial.

✓ Clearly label culture containers following genebank practice. If material is new to the genebank it will have to be given a unique identification number.

✓ As the storage capacity of *in vitro* cultures strongly depends on the initial quality of the cultures, visually assess the general performance of each culture using the following criteria prior to selection for slow growth storage: vigour, absence of fungal and bacterial contamination, chlorosis, blackening and tissue necrosis.
- Contaminated and low quality cultures should be immediately discarded. If all cultures under evaluation have been assessed below standard because at least one of the criteria is not met, the cultures should be re-propagated onto a new medium.

✓ Select germplasm for storage from young cultures – germplasm that has not been subject to too many subcultures and from several cultures not just one, in order to minimize the chance of selecting a variant plant.

B. Slow-growth Storage

- ✓ Carry out a literature review to see if conditions for slow-growth storage conditions have been established for the species/variety you are working with, or any related species. If this information is not available then conditions will have to be established by experiment.
- ✓ Decide the type of slow growth storage required. Slow growth storage conditions can include:
    - Physical growth limitation, including: (a) low temperature; (b) low light/restricted photoperiod; (c) minimal containment; (d) minimal O_2; and (e) osmotic (water) stress.
        - The simplest and most successful slow growth strategies involve temperature and light limitation.
        - Optimal storage temperatures for extending subculture conditions for cold-tolerant species may be from 0 to 5 °C or somewhat higher; for material of tropical provenance the lowest temperatures tolerated may be in the range from 15 to 20 °C, depending on the species.
        - It is possible to take advantage of natural dormant periods or seasons of slow growth for some plants, for example, cold-related dormancy in temperate plants.
    - Chemical growth limitation, including: (a) growth regulators' retardation and (b) growth inhibitors.
        - As tropical species are cold sensitive, procedures for extending the subculture periods will mainly focus on modifying the chemical composition of culture medium.
    - Nutrient limitation, including: (a) low macro nutrient levels; and (b) low micronutrients levels.
    - Avoid the formation of callus and abnormalities, such as hyperhydration.
- ✓ Select the optimum storage conditions by visually assessing the general performance of each culture using the following criteria, vigour, fungal and bacterial contamination, chlorosis, blackening, tissue necrosis, hyperhydration and etiolation.
    - Storage conditions are minimal growth conditions that prove to be acceptable for most genotypes. Not all accessions and genotypes respond equally well to the applied conditions.
- ✓ From experimentation determine the number of replicates to put into storage by monitoring the duration of the between-subculture period and how the slow-growth conditions affect the propagation potential – number of shoots/nodes available for multiplication after storage.
    - Sample size should also take into account most risks of possible losses – the greater the risks, the larger the sample size.

C. Regeneration

- ✓ At the end of a storage period cultures can be placed for a short period in optimal conditions to encourage regrowth before the start of the next storage cycle.
    - For safety reasons it is always recommended to hold 2-4 viable and healthy cultures of the previous subculture cycle as spare materials until it is known that the newly subcultured set is healthy and growing.
- ✓ Carry out regular screening to remove *in vitro* cultures that show any variation from whole plantlets or shoots etc. and develop a system for monitoring quality, viability, stability and contamination
- ✓ Quantitative and qualitative criteria should be considered to assess the viability of an accession and identify when it should be recycled or rejuvenated after the material has been maintained for a given time in storage. These criteria can be determined from the literature or by experimentation.
    - Recycling involves subculturing under normal growth conditions. Cultures that are too old are rejuvenated by transferring them to the screenhouse or field environment and re-initiating into tissue culture. Rejuvenation reduces risks of somaclonal variation.
    - Generally, a threshold value for when action should be taken with a particular genotype is established based on experimentation (or is known from the literature). This value is

the number of cultures at which experiments have shown vigour declines and/or cultures are too old.
    - If the number of cultures is below this threshold value or if the number of cultures is above this value but all cultures have significantly deteriorated according to assessment criteria, the accession should be either moved to the transfer room for subculturing or transferred to the screenhouse or field for rejuvenation and re-initiation into tissue culture.
- ✓ Identify when cultures require regeneration (transfer of accessions to the greenhouse and field) to reduce risks of somaclonal variation and check their trueness-to-type (identity and conformity) (can insert a table here that gives examples). Timing of when rejuvenation and regeneration are required will depend on the genotype and the *in vitro* conditions. For example, regeneration and rejuvenation of banana accessions is carried out for any accession being maintained continuously *in vitro* for more than ten subculture cycles (or ten years in medium-term storage):
    - Accessions must be verified for their trueness-to-type in the field. The morphological and taxonomic characteristics of the plants must be compared with those of the original accession. Ideally, they are grown in a field collection next to the original mother plant.
    - Accessions with the same characteristics as the original genotype can be declared true-to-type and can be re-established in *in vitro* culture.
    - Accessions identified as off-types with no value, or accessions which are found to be mislabelled, must be discarded and replaced with the original true-to-type material from the donor source.
    - Using field established plants to rejuvenate and regenerate the accession in storage would require re-indexation for viruses, as the plants could have been exposed to viruses.
- ✓ Unless germplasm is regularly regenerated and transferred to the field for morphological observations, combined with the use of cytological techniques, genetic stability of a certain sample cannot be ascertained. Occasionally, abnormalities can be assessed in the *in vitro* samples.
- ✓ Genetic stability of an accession can be determined using molecular techniques, but can be expensive.
    - There is some evidence that somaclonal variation can arise from organized meristematic shoot cultures, but its prevalence is likely to be genotype-specific.
- ✓ Taking accessions out of *in vitro* conditions allows characterization and evaluation data to be generated. Evaluation can also be carried out *in vitro*, for example, screening for salt and drought tolerance
- ✓ In the case of contamination of all replicates, material should be transferred to the greenhouse, if plantlets are available. Otherwise, the plantlets are subjected to regeneration and/or a decontamination treatment.
    - Screening on bacteria detection medium for endogenous contaminants is recommended at the start of the culture period.
    - In some cases, latent or covert bacteria may become a gradually increasing obstacle for prolonged slow-growth storage.
    - Knowledge of the symptoms of mites/thrips contamination is important, including how to minimize the risk

1.3 Documentation

The genebank should have a policy managing genebank data and information, including data sharing guidelines.

- ✓ Ensure that your genebank adopts international data standards to provide consistency in data shared among different information systems and programs. Data should be publically available in a search-query database.

- ✓ Establish a genebank information system specifically for your genebank (which includes the fields for FAO/Bioversity multi-crop passport descriptors; MCPD v.2.1) or use/adapt one of the several models available.
    - GRIN-Global has been developed by USDA-ARS, the Crop Trust and Bioversity International to enable genebanks to store and manage information associated with plant genetic resources. Other information systems for genebanks are also available.
- ✓ Document passport data of accessions using FAO/Bioversity multi-crop passport descriptors
    - The use of Digital Object Identifiers (DOIs; MCPD v.2.1) is recommended for information sharing across different information systems and different communities.
    - Record most of the passport data during germplasm collection, or, in the case of material acquired from other genebanks, request to receive passport data alongside the donated/transferred material
    - Include additional accession information:
        - Georeferenced data which can help to identify accessions with specific adaptive traits, depending on the agro-climatic conditions of the collecting sites
        - Environmental information, such as overlaid climate and soil maps
        - Historical information – origin of the germplasm, traditional knowledge, cultural practices etc.
- ✓ Validate and upload all data and information generated relating to all aspects of conservation and use of germplasm, including metadata.
- ✓ Keep well-documented records on management data. Management data should include:
    - Germplasm health status, including treatments at collecting, any contamination at point of initiation into culture, for example, bacterial contaminants, virus testing, any anti-fungicidal/bactericidal treatments in culture.
    - For *in vitro* culture:
        - Explanting/initiation date
        - Initiation/establishment medium
        - Multiplication medium
        - Rooting medium
        - Slow growth storage medium
        - Number of replicates for slow growth storage
        - Performance indicators for slow growth storage
        - Duration of subculture period
        - Any specific growth characteristics, for example, tendency to develop hyperhydricity
- ✓ Document inventory, germplasm orders, distribution data and data obtained from user feedback as accession information. This information will facilitate reporting needs of the genebank.
    - Distribution/exchange records include date of request; number of samples requested and sent; requester's name and address; copies of/reference to phytosanitary certificate; cover letter; SMTA or MTA; and shipping log.
- ✓ Keep well-documented records on characterization and evaluation of each accession to enable the germplasm user to make an informed decision on which accession to select for the intended purpose.
    - As much as possible, record and make available molecular data generated during characterization and evaluation activities through genomics, proteomics, metabolomics and bioinformatics.
- ✓ Document other information such as crop/collection catalogues, voucher images (photos, drawings), planting and harvest dates, and notes on the identity verification of each accession.
- ✓ Process the digitizing of paper data and ensure quality information management by having measures to detect manual, hand written and electronic data entries for transcription errors.
- ✓ If possible, have one staff member with specific responsibility for managing the genebank information management system, including keeping data up-to-date at all times.
- ✓ Duplicate data at regular intervals and stored at a remote site to guard against loss from fire, computer failure, data breach, etc.

1.4 Distribution and Exchange

The genebank should have a policy and procedure for the distribution of germplasm, including the review process to check for fulfilment of legal and phytosanitary requirements, and step-by step-instructions of consignment preparation, post-consignment follow-up and reporting to the Secretariat of the ITPGRFA.

- ✓ If your country is a signatory to the Plant Treaty and you are distributing Annex 1 germplasm, you must use a Standard Material Transfer Agreement (SMTA) that covers both access to genetic materials and the benefits derived from them.
    - The voluntary Easy-SMTA information system enables genebanks to compile and generate SMTAs in the six official languages of the ITPGRFA and provides for automated reporting on the SMTAs to the Governing Body of the Treaty
    - If the recipient is not familiar with the SMTA, suggest that they refer to Treaty Learning Module.
- ✓ If your country is not yet a Contracting Party to the Treaty or if the germplasm is not an Annex 1 crop, you should come to an agreement with the recipient on the terms and conditions of germplasm distribution.
    - If your genebank does not already have a generic Material Transfer Agreement (MTA) template, refer to the CBD's Access and Benefit Sharing Clearing House.
    - For simplicity and uniformity reasons, some genebanks have chosen to use the SMTA for non-Annex 1 crops and for germplasm exchanges with non-Treaty Party countries, provided it is compatible with their national legislation.
    - Ensure that the recipient of the germplasm is aware of the conditions of the SMTA/MTA.
- ✓ Ensure that users requesting material provide full details about the documentation they require in order for you to successfully provide them with the materials.
- ✓ Arrange with the National Plant Protection Organization (NPPO), or authorized agent, in your country to inspect or test the material in order to certify that it meets the import requirements (including any mandatory fumigation or other treatment), and to issue the relevant phytosanitary certificate.
- ✓ Have a policy in place for the number of samples to distribute for any given species.
    - For accessions with insufficient material at the time of request and in the absence of a suitable alternative accession, supply samples after multiplication, based on a renewed request.
- ✓ Endeavour to assess the capacity of the recipient in adequately managing *in vitro* material
    - A simple questionnaire form should provide the information you need with which to make that assessment.
    - If the recipient does not have the capacity to carry out either activity then they should demonstrate that arrangements exist with an institute that has the capacity to carry out either task.
- ✓ Determine from the recipient how the germplasm will be used which will identify the type of *in vitro* culture.
    - For example, cultures can be provided as: (a) sterile proliferating cultures which are clusters of multiple shoots or buds for further multiplication; or (b) sterile *in vitro* rooted plantlets ready for soil planting.
- ✓ The species and type of culture required by the recipient will to some extent determine the sample size.
    - Generally, genebanks provide three to five samples per accession.
- ✓ Ensure that germplasm for distribution is in good condition when it leaves the genebank. There should be no visible signs of deterioration, such as yellowing, etiolated growth of *in vitro* plantlets.
- ✓ Ensure that the label is correct and indestructible. Computer-produced labels reduce transcription errors in names and numbers

- ✓ Ensure that the time span between receipt of a request for germplasm and its dispatch are kept to a minimum.
- ✓ Use packing and shipping guidelines/recommendations similar to those utilized for acquisition.
    - Package sample using packaging suited to the type of culture, for example, gas-permeable, heat-sealable polyethylene bags can be used for rooted plantlets.
    - Arrange transport such that adverse environmental conditions during transport and clearing customs are minimized.
    - Avoid shipments during hot times of the year.
- ✓ Include all required documentation inside the shipment (for the recipient) and attached to the outside of the container for the Customs officials to guarantee smooth processing during transit and at the border of the destination country.
    - Documentation should include data on accessions (including an itemized list with accession identification, number and/or weights of samples, and key passport data), import permit, phytosanitary certificate, commercial invoice of certificate of no commercial value, or certificate of donation, and non-GMO certificate
    - To make best use of the material, ensure that the requestor receives the characterization and evaluation data of the accessions included in the shipment.
    - The pathogen-testing history is a useful element to be added to the documents accompanying the shipment. For information that is publicly available on the website of the genebank, it is sufficient to provide the respective link to each accession to the recipient.
- ✓ Support the recipient in effectively using the germplasm by providing the necessary information to either continue with *in vitro* culture, or acclimatize the material for eventual field planting.
- ✓ Once the shipment has been successfully dispatched, document the information in the genebank information system, including data such as:
    - Shipment reference number and date of shipment
    - Consignee responsible for handling the shipment and designation
    - Names and addresses of sending and receiving organizations
    - Recipient source and type of organization
    - Purpose of germplasm request and use
    - Phytosanitary certificate and reference/code numbers
    - Export permit reference/code number
    - Number of transfer agreement.
    - Associated metadata
- ✓ The supplying genebank should monitor the delivery and condition of the germplasm on arrival at its destination to ensure that high quality germplasm reaches the recipient in a minimum time:
    - Track shipment and check Customs procedures - the recipient may need to hire an agent to facilitate Customs clearance and delivery to the final destination.
- ✓ Follow up with the recipient as to assess the recipient's capacity in handling germplasm and status and performance of the distributed germplasm by requesting feedback. A questionnaire can be provided with the shipment.

1.5 Security and Safety duplication

A. Security/Personnel

- ✓ Risk management systems can be based on the Standard Operating Procedures (SOPs) so that each activity and task is analysed for risk.
- ✓ Develop a risk management strategy utilizing the following steps:
    - *Communication and consultation*: Ensure that all those who will be involved in implementing a risk management system are oriented in the concepts, methodology, terminology, documentation requirements and decision-making processes of the system.

- *Establishing the context*: Consider the objectives/activities/tasks of the genebank, the environment in which the activities operate, and the stakeholders.
- *Risk identification*: Carry out an inventory of relevant risks to the genebank operations.
- *Risk analysis*: Carry out an analysis of potential impact (or consequence) of the identified risks and their likelihood (probability).
- *Risk evaluation*: Determine the level of risk that is acceptable.
- *Risk treatment*: Identify the course of action to deal with those risks where the current total risk rating is considered unacceptable, giving top priority to the highest assessed residual risks.
- *Monitoring and review*: Analyse the risk management system and assesses whether changes to the system are needed. Responsibilities for monitoring and review should be clearly defined and documented.

✓ For the management of individual risks, the following considerations are relevant:
- Extreme weather conditions such as drought, freezing, hail, cyclones, typhoons, and hurricanes are partially predictable and precautions can be undertaken to give plants additional protection during these extreme events.
- Containers with environmental control can be used for evacuation and temporary storage of *in vitro* cultures.

✓ Appoint a staff member with responsibility for OSH in your genebank and arrange for that person to go for training in OSH.
- Most countries will have an Occupational Safety and Health (OSH) policy. The International Labour Organization (ILO) provides country profiles on OSH.

✓ Ensure that all staff are aware of OSH requirements and are kept up-to-date regarding any changes.
- Ensure that OSH rules are visible in the more risk-prone areas of the genebank.
- Provide properly functioning protective equipment and clothing, as required by OSH, and ensure it is regularly checked and used in the field. The OSH officer will be responsible for safety equipment upkeep.
- Instruct staff in the correct and safe use of equipment with regular training provided in health and safety in field, greenhouse and lab environments.
- Choose appropriate and nationally approved agrochemicals to reduce risk.

✓ Ensure that the genebank has a critical human resource plan with appropriate annual budget allocation (core and project funds) and that staff have the critical skills, experience and qualifications required to implement all genebank tasks effectively and efficiently.
- Ensure that the genebank manager and those staff carrying out specific tasks regularly review and update SOPs
- Hold regular on-the-job training sessions and ensure that staff can attend training opportunities overseas/in other genebanks at regular intervals to keep up-to-date with the latest developments.
- Rotate tasks to make work as varied as possible and involve all staff (where possible) in meetings and discussions.
- Retain competent staff by providing recognition and rewards for excellent performance.
- Access to disciplinary and technical specialists in a range of subject areas, such as virology, phytopathology, is desirable.

✓ Include risks associated with staffing in the risk identification, analysis and management.

B. Safety duplication

✓ Store a safety duplicate sample for every original accession in a geographically distant area, under the same or better conditions than those in the original genebank.
- Choose the facility in a socio-politically stable country and situated in a place with low radiation (radioactivity), geological stability (low probability of earthquakes) and proper drainage from seasonal rains.

- Choose a host genebank/institute that has good management capabilities to provide appropriate conditions to the duplicated accessions and is not constrained by financial and human resources.

✓ If your genebank does not already have an agreement with another genebank to duplicate your original accessions, consider where best you might do so, which will depend on your chosen method of safety duplication.

✓ Discuss with the host genebank early in the planning process what documentation (genebank and host country) is required, including an assessment of the customs and quarantine procedures.

✓ Draw up a legal agreement setting out the responsibilities of the depositing and the recipient genebank, and the terms and conditions under which material is maintained and managed.

- In contrast to orthodox seed collection duplicates, duplicates managed in *in vitro* culture need to be actively managed.

✓ Other options for safety duplication include maintenance in field genebanks, cryopreservation or the storage of pollen or DNA.

- Duplicating in a field genebank is an option but risky and will require active management.
- Cryopreservation is the preferred method and can be considered as a "black box" safety duplicate.
- Pollen and DNA storage are not equivalent to 'real' safety duplications but are of some help.

✓ Ensure that legal and phytosanitary requirements are complied with and that each safety duplicate sample is accompanied by relevant associated information.

- Discuss with the host genebank early in the planning process what documentation (genebank and host country) is required, including an assessment of the customs and quarantine procedures.

✓ Ensure that the safety duplicate is of high quality and of sufficient quantity.

- Duplicate clean and healthy material. Ensure that the safety duplicate is of high quality and free of diseases and insect pests.
- A minimum of three to five replicates per accession should be duplicated.

✓ Use harvesting, packing and shipping guidelines/recommendations similar to those utilized for acquisition and distribution.

✓ Include minimum information along with the shipment, including an itemized list with accession identification, key passport data, total amount of propagules (by weight or number), type of container, etc.

- Use shipping guidelines/recommendations similar to those utilized for distribution.
- Include relevant information about the location of the safety-duplicated accessions in the genebank's information system.

✓ Record, validate and upload to the genebank documentation system all safety duplication data, including associated metadata

✓ Regularly check/compare genebank information system to ensure that any new material not duplicated in the recipient genebank is identified and prepared for safety duplication, as appropriate.