Table 2. Potential risks and management options for clonal banks.

Activity	Risk Sources/Indicators	Risk/Consequence	Action Plan		
			People	Facility	Procedure
ACQUISITION					
Collecting	Narrow genetic variability and large gaps in germplasm collection	Failure to capture diversity in field	Send Center genebank personnel to take the lead in joint collecting missions with national programs. Conduct training of collectors in partner countries. Maintain and hire a pool of expert collectors.		Analyse collection for un-represented regic conduct gap-filling collecting.
	Untrained personnel in collecting and documentation	Failure to capture diversity in field and document important information	Send Center genebank personnel to take the lead in joint collecting missions with national programs. Conduct training of collectors in partner countries. Maintain and hire a pool of expert collectors.		
	Misidentification of germplasm	Misleading information	Include taxonomists during collecting.		
	Lack of simple collection protocol and documentation forms	Failure to capture diversity in field			Develop simple collecting procedures and
	Agricultural intensification, replacement of traditional varieties with modern ones, urbanization, land use change, and climatic events	Loss of germplasm in habitat			Prioritize affected areas if containing germ that can fill gaps in collection.
	Strict country and international laws on access and use of germplasm	Poor access and use of germplasm in unexplored areas			Secure a Germplasm Acquisition Agreeme between donor country and Centre to man accessions under FAO conditions.
	Breach of country and international treaties	Legal consequences. Damaged reputation and relationship	Training of all institute staff on intenationally agreed protocols, in consultation with Genebank and other Center authorities.		Follow national procedures of obtaining co permits, under relevant international agree Collect in partnership with local PGR peop
	Ambiguous position of countries regarding international treaties	Poor access and use of germplasm in unexplored areas			Foster goodwill through PGR, pre-breedin breeding and Treaty-related training-works and incentivize donation.
Donation	Received foreign materials carry pests and diseases	Introduction of pest and diseases to host country			Strictly observe quarantine regulations. Ke main storage areas until fully checked and decontaminated. Grow and regenerate ma screenhouse or away from large crop prod
	Limited germplasm testing capability	Restricts international germplasm exchange		Develop testing and handling capability for pests and diseases of international importance.	
	Reluctance to share germplasm due to IP rights	Restricts international germplasm exchange		Conduct training on benefits and limitations of IP rights.	
	Working collections not duplicated in major genebanks	Failure to capture elite germplasm			Proactively conserve breeding materials.
CONSERVATION					
Registration	Unverified passport and other data submitted	Incorrect or unreliable passport data, and poor quality of scientific reports			Verify passport information with donor.
	Received materials have low viability	Loss of germplasm			Obtain large amount of samples and hand properly.
	Limited storage space for clonal materials				Priority materials for in-vitro clonal collectic a) cultivars and elite breeding lines b) clones from center of origin (tetrapoids a diploid forms) c) clones from secondary centers of divers d) clones with unique characteristics and/c specific resistances e) highly diverse clones based on molecul markers Conduct regular review to remove non-ess materials

Conservation in *in vitro* Banks					
Sample Processing	Untrained or inefficient personnel in sample processing	Reduction of good quality propagules and accidental mixtures	Conduct regular training and enforce close supervision of personnel on detection and removal of infected, infested and mechanically damaged samples.		Subculture samples of an accession in two (separated in time /different operator). Mai spare cultures of the previous subculture c new subcultures are established.
	Source of material is infected	Loss of viability of propagules		Provide an isolated growth room for in vitro explants taken directly from the field to allow time to detect insect infestations and disease infection and prevent their spread to other cultures.	Use material from virus-tested, virus-free p Indicate whether material is untested in the database records, so that virus elimination procedures can be initiated immediately. (surface disinfestation with chlorine bleach 0.5 to 1% or commercial bleach 10-15%). explants in a fungicide if fungal contamina likely. Additional treatments include short p of sonication in NaOCl, double disinfection sprays or dips, and insecticide treatment o plant before explants are taken. Wrap exp plastic wrap during transport to help decre
	Poor quality and/or suboptimal size of propagule	Loss of meristems			Have additional materials available and ch growth conditions to improve quality. Cond experimentation to establish optimal meris for moderate growth and multiplication for
	Weak mother plants	Short lifespan of propagules in storage			Collect plant material for tissue culture fror vigorous and healthy mother plants. Impro vitro introduction process.
	Ineffective pest and disease screening procedures during sample processing	Reduction of good quality propagules			If an isolation area is not available, new ex from the field should be wrapped and obse mites and thrips for several subcultures.
	No efficient tissue sterilisation procedures	Poor quality of propagules			Conduct research on tissue sterilisation fo introduction.
	Lack of proper disposal procedures of contaminated plant materials	Increase in invitro contamination with pests and diseases and dissemination to new areas			Autoclave all contaminated materials befo discarding or cleaning vessels. Dispose in areas
	Ineffective thermotherapy procedure	Failure of explants to multiply			Conduct experimentation to establish thermotherapy procedure for propagules f moderate growth and multiplication for eac Treat materials sequentially in two groups. first group is damaged, change the protoc
	Inappropriate media and conditions for culture initiation	Failure of explants to multiply			Conduct experimentation to establish med composition and culture conditions for mo growth and multiplication for each genus. U triage system and store only the best grow
Germplasm Testing	Untrained personnel in health testing of propagules	Pest and disease damage and spread in collection	Train staff to be observant of unusual growth or symptoms in the cultures.		
	Improper screening methods and monitoring regime	Pest and disease damage and spread in collection		Conduct regular monitoring of the cultures, storage rooms and growth room. Use a pyrethrum-based spray in culture rooms. Regularly check all sterilisation equipment and laminar air flow quality	Have a monitoring system for all contamin sources. Conduct bacteriogical testing of on a regular basis at initiation, during subc and before storage and apply decontamina treatments. Remove and autoclave conta cultures, unless they are the only represen of the germplasm. Handle infected culture potentially contaminated cultures at the en day to minimize spread of contamination.
	Microbes and pests are not apparent at initial testing but appear later.	Pest and disease damage and spread in collection			Test at explant initiation and at one or two intervals.
	Untrained personnel in transgene detection	Loss of genetic integrity of other accessions			
	Inadvertent presence of transgene	Loss of genetic integrity of other accessions			

	Lack or improper determination of transgene presence	Inaccurate or wrong information regarding transgene presence			
	Limited quantity of high quality propagules	Loss of accession			Monitor plants in slow-growth storage ever months to assess their viability, for occurre necrosis, chlorosis, hyperhidricity, blacken callus formation and defoliation. When the of viable cultures of an accession drops to a certain percentage, or if the quality has drastically decreased, subculture the acce into a new set of fresh tissue cultures. Opt slow growth process, monitor accession gr rate and plan successive subcultures
	Ineffective sterilization techniques	Loss of accession			To decrease contamination spread, flame with 70% ethanol with additional 95% etha or prior soapy water dip if desired. Use hot sterilizers instead of alcohol lamps.
	Misapplication of antibiotics	Loss of accession			Apply short (10 days) treatments in effecti antibiotics in the growth medium to control contamination. Apply fungicide or use high media to control fungal contamination.
	Somaclonal variation	Loss of genetic integrity			Use appropriate medium to assure genetic of in vitro collections. Monitor the plants fo somaclonal variation, and grow abnormal p maturity in field or greenhouse to observe morphological changes. Genotypes prone somaclonal variation should be monitored closely. Develop molecular tools for soma variation detection. Maintain DNA/dry leaf as reference samples for molecular integri
Conservation Procedure	Errors in media preparation	Loss of accession			Use specific protocols for each procedure down all steps to back track eventual error necessary.
	Ineffective pre-treatment	Short lifespan of propagules in storage			Apply two weeks of growth on the storage in the normal growth room temperatures o cold acclimatization before placing in cold-
	Chemical imbalance during culture	Abnormal growth of material			Check cultures for buildup of phenols, met and browning in the medium and transfer a needed. Ensure proper hormone concentra during propagation. Avoid high concentrat cytokinins, which may affect genetic stabili
	Suboptimal culture methods for a broad range of genotypes				Conduct additional research to determine techniques suitable for a range of genotyp
	Short storage life of propagules	Loss of viability			Develop methods for extending the life of i collections. Adjust osmotic pressure of in v samples to extend life rather than use horr where there is a risk of genetic change.
	Delayed inventory	Loss of material			Schedule inventories based on the shortes between which reculture is needed within t genus.
	Late subculturing	Loss of viability			Conduct regular monitoring to assess nee culturing as when the number of replicates been reduced to 3-12.
	Backlog in regeneration	Loss of viability			Periodically check viability and general performance of stored samples within recommended intervals. Back up accessio pot plants in the greenhouse if in vitro grov experienced.
Storage Facility	Unsterile transfer facilities	Loss of accession		Design transfer facilities with minimal foot traffic and outside airflow.	Regularly check culture hoods for leaks wi equipment (smoke) or with open bacteriolc plates. Check for leaks whenever laminar f hoods are moved.
	Unsuitable tissue culture containers for in vitro samples	Loss of accession			Carefully seal individual tissue culture cont invitro samples with film against air-born contamination, pest attack and dessication replicates in separate TC containers to mir container-specific risks.

	Poor laboratory maintenance	Contamination and loss of materials	Field and greenhouse personnel should change their shoes and clothing before entering the lab and growth rooms.	Routinely mop floors with disinfectant. Control dust and insects, especially mites. Regularly change or clean filters in the laminar flow hoods and building's ventilation system.	Autoclave contaminated cultures before th washed or remove them from the lab to a s washing area. New explants should be hel separate room or the lids wrapped with tap plastic wrap until the possibility of insects i out. Wipe cultures introduced from other laboratories with 70% alcohol or bleach an isolated from the main culture room until cl insect infestations.
Safety Duplication	Safety duplication site is vulnerable to natural calamities	Inaccessible or loss of safety duplication			Store duplicates in at least two places for s either on-site in separate storage rooms or black-box or active collection off-site. Esta duplicate as base collection in liquid nitrog (cryo).
Regeneration	Regeneration failure	Loss of germplasm			Adhere strictly to standard in vitro regener procedure.
Conservation in Cryo bank - Long Term Storage (LTS)					
Sample Processing	Incorrectly identified material is stored	Wrong germplasm stored and distributed			Use only verified materials
	Isolation of material is not done correctly, meristems are damaged and regrowth as callus	Increased chance of variation	Training of lab personnel		
	Chemical cryoprotectants injure plant cells during pre-treatment	Reduced viability during storage			Optimize procedure to minimize damage
	Plants are sensitive to preculture method	Loss of viability			Choose another preculture technique
	Technique does not work for all plants in the collection	Gaps in collection			Plan to have several techniques available
Germplasm Testing	Thawing/rewarming is done improperly	Underestimate of post-thaw regeneration rate	Training for staff		Have standard protocols in place.
	Water bath may be contaminated	Damage to samples			Use sterile water in containers within the waterbath.
	New material in cryo-collection is not viable	Loss of samples			Conduct viability testing during initial proce and have a written protocol for all aspects regrowth (medium, temperature, light)
Conservation Procedure	Dewars may fail.	Damage to samples			Use alarm systems and duplicate material: separate dewar.
	Unreliable supply of liquid nitrogen (LN)	Damage to samples			Ensure a reliable source of LN from specia companies, local hospitals, industry or art insemination centres. Alternatively, a sma manufacturing plant may be purchased. U: hold dewars and plan refills to ensure regu supply.
	Rapid loss of LN in dewar	Damage to samples			Provide a wide-mouth dewar for holding sa during processing and a narrow-mouth, lor dewar fo long-term storage. Use a sensor Liq N, with automatic text/page to 2-3 key when limits are reached. Conduct regular and fill dewars regularly. Replicate sample
	Improper placement on cryocane and to multiple rewarming and cooling cycles during sample retrievals	Loss of biological stability			Follow instructions closely on use of cryoc dewar. Group samples based on demand Make more replicates of samples under he demand. Store long-term samples separa often used samples
	Compromised integrity of cryovials	Contamination and loss of biological stability			Use cryovials with additional level of secur as cap-threads, a silicone gasket, plastic cryosleeves, and polyethylene membrane
	Insuffiicent number of stored propagules	Loss of germplasm			Determine the number of replicates for sto based on the survival rates achieved, crop speed of propagation and material availab storage.
Conservation on field banks					
Sample Processing	Low initial quality of explants.	Short lifespan of germplasm in storage			Collect plant material for field culture from and healthy mother plants.
	Improper conditioning and propagation of vegetative material	Short lifespan of germplasm in storage			Conduct immediate propagation, washing disinfection, depending on the material.

	Failure in propagation and storage of propagules	Loss of germplasm			Group accessions based on general propa procedures. Carry out research for genoty do not respond well to the general method Contact other facilities to obtain additional information on propagation of specific gen
Germplasm Testing					
Health Diagnosis	Failure to detect and remove samples with pests and diseases and improper disposal of contaminated materials	Increased pathogen or pest population in the facility, thereby jeopardizing the health of other accessions in the collection as well as introducing new pest or diseases in new regions/countries.	Conduct regular training and enforce close supervision of personnel on proper disposal of contaminated materials.	If applicable, grow incoming and regeneration materials in screenhouse or in isolation away from large areas of local farms. Duplicate collection in two other sites, or keep an in vitro or a cryo set.	Subject regenerated material to usual phytosanitary testing. When new cuttings a established, incinerate the original plant ar sterilize and discard the substrate. Monitor regularly and immediately rogue diseased Accessions with special vulnerability to pa diseases or pests may require special trea such as being placed in screen or greenhc being treated for those diseases on a spec schedule.
	Ineffective screenhouse to control insects			Construct and manage screenhouses to prevent disease-carrying insects from entering. Workers and visitors should not enter the screenhouses after visiting field plots. The entryway into the screenhouses should have a set of two doors that should not be opened at the same time to reduce the entry of insects. Check screens and structures periodically to assure they remain insect proof.	
	Backlogs in pest and disease monitoring	Loss of field bank samples	Hire and train adequate personnel to regularly monitor pest and diseases.		
	False positive and false negative results during plant health testing.	Loss of materials due to false positive results. Dissemination of diseased materials due to false negative results.			Repeat tests in case of doubt and have re to confirm and have more reliable results.
Storage Monitoring	Limited numbers of viable plants	Loss of germplasm			Keep 3 to 20 vegetative propagules per ac
	Mechanical mixtures or invasive plants	Loss of genetic integrity			Monitor the plants for offtypes and remove immediately.
	Late rejuvenation or multiplication (plants lost their physiologic vigour or accumulated pests and diseases)	Loss of materials			Monitor the genebank regularly and plan regeneration in advance.
Conservation Procedure	Inadequate selection, pre-conservation or pre-treatment of propagules	Poor plant establishment	Use trained personal and follow clear methodologies		Monitor all steps of sample preparation an measures to avoid unecessary risks (plan to avoid interruptions and delays during we or hollidays). Prepare all materials in adva (chemicals, tools)
	Failure in propagation and storage of propagules	Loss of germplasm			Group accessions based on general propa procedures and vegetative period. Carry c research for genotypes that do not respon the general methods. Contact other faciliti obtain additional information on propagatic specific genotypes.
	Inadequate number of replicates per accession.	Loss of germplasm			Increase number of replicates per accessi represent the genetic variability of the acc
Field Bank Specifications					
Field Monitoring	Unsuitable conditions in conservation site	Poor or suboptimal growth		Select a conservation site that is safe, favours plant development of the target germplasm, and isolated to prevent pest attacks and diseases but with easy access for management. Ensure that the climate and ecology of the site are conducive to maintenance.	
	High pest and disease pressure in field site	Loss of germplasm		Use screenhouse (SH) culture to provide the best protection against worst diseases, insects and pests.	

Field Planting	Pollen exchange with plants within and outside collection.	Loss of genetic integrity		Isolate site from potential pollinators if intended for outcrossing species.	Arrange the plants at good spacing distan prevent plants from exchanging pollen. Ba reproductive structures and manage insec pollinators, or use individual mesh houses accession. Research needed on outcros rates of certain taxa can guide field layouti
	Misidentification	Loss of germplasm			Develop field maps and use them during p evaluation and harvest. Record and identif name and accession number all plants in t on maps. Use weather resistant, and if pos computer-generated labels.
	Mixtures of clones	Loss of genetic integrity			Provide adequate spacing between acces taking into consideration the adult size gro of the plants. Plants that readily spread by rhizomes or runners may require wider spa between plots to prevent clones from mixir Accessions with different morphologies ma planted in adjacent plots when creeping or spreading is a problem. Particularly, invas clones may require planting in cans, pots o to reduce mixing or competition with less v accessions. Prune plants if necessary.
	Contamination with volunteer plants.	Loss of genetic integrity			Use adequate crop rotation system. Let vo grow after field preparation and remove th before planting new materials.
Field Maintenance& Management	Mixtures of fruits and germplasms	Loss of genetic integrity			Conduct thinning and pruning to prevent overlapping between plants and mixtures o and germplasms.
	Poor adaptation	Loss of germplasm			Monitor collection frequently and transfer s accessions to possible alternative sites su greenhouse or in vitro culture. Research is to study and understand the specific envirc requirements of different accessions in ord better manage them in field genebank.
	Disparate location of physiologically similar accessions	Inefficient management			Plant accessions in groups according to vi height, branching habit or lodging tendenc Crops that must be harvested on a regular should be planted in groups by harvest dat time to maturity.
	Poor management of weeds and low soil fertility	Loss of germplasm			Control weeds to limit competition and red weed-borne pathogens and insects. Monit fertility and adjust as needed.
Post-harvest Handling	Persistence of disease organisms and insects after harvest	Deterioration of propagules and spread of pests and diseases during storage			Treat tubers with fungicide and insecticide storage. Closely monitor for bacterial and f infections, and immediately remove rotten prevent them from infecting other healthy t
	Mishandling	Deterioration of propagules during storage			Take extreme care during harvest and transportation to avoid physical damage to
Characterization and Evaluation	Inefficient and erroneous data gathering and encoding	Backlog and inaccurate characterization data	Assign staff with adequate training in characterization following international standards.	Provide digital hand-held encoder.	Independently verify encoded data. Autom computing, updating and reporting of characterization data in database.
	Descriptors that have no clear-cut correspondence to current international standard descriptors	No or limited usefulness of characterization data			Use updated descriptors and provide refer for all measurements and classifications.
	Limited text-based description	Incomplete and inaccurate morphological description			Include images (600-800 pixels) of key pla accompanied with standard color guide eg colors.
	Lack of diversity assessment of collection	Unknown level of breadth, duplication and gaps in collection, and conservation of unnecessary duplicates			Conduct molecular profiling and diversity a
DISTRIBUTION					
Policies	Lack of knowledge or negligence on germplasm exchange Protocol and International Treaty	Distribution without accompanying MTA. Inadvertent distribution of restricted germplasm (e.g. Non-MLS materials). Wrong information on the exchange status (MLS) of the germplasm.	Conduct regular update on international agreements concerning germplasm exchange.		Implement a clearance sheet for germplas distribution ensuring appropriate MTA and documents and approval of personnel con are obtained before release.

	Recipients of “designated” germplasm or “non-designated” germplasm attempt to claim IP rights over the germplasm	Restrictions on future access and use of germplasm			Distribute accessions under a standard FA CGIAR MTA for “designated” germplasm, Center-created "non-designated" material developed in collaboration with FAO and o CGIAR Center, with a clause on the right c Center to take legal action in case of violat the MTA, upon recipient's agreement to M conditions.
	Plant health restrictions of importing country	Low level of exchange and utilization of germplasm.			Conduct research on plant sanitation to fa germplasm exchange.
	Non compliance with phytosanitary regulations	Germplasm distributed from genebank with diseases or pest contamination.			Test materials for bacterial and fungal dise compliance and germplasm health checks according to the phytosanitary standards c importing country. Accompany outgoing m with an import permit from the requesting c and a phytosanitary certificate.
User Service	Germplasm distributed are weak	Dissatisfied recipients of germplasm			
Germplasm Preparation and Dispatch	Misclassification and wrong characterization and germplasm stocks data	Delayed identification and preparation of requested germplasm	Conduct regular training on germplasm characterization.		Check characterization data specially the e identifiable characters. Include evaluation that relate to needs of the possible differer Request all germplasm recipients within ar outside Center to share their generated da related to the provided germplasm.
	Inefficient and slow processing of requests for samples.	Dissatisfied recipients of germplasm	Dedicate personnel to serving germplasm requests.		Keep files of relevant country and internati quarantine documents .
	Errors in preparing or labeling samples	Wrong germplasm distributed by the genebank			Adopt barcoding and closely adhere to ger distribution protocol.
	Insufficient germplasm stock for distribution	Delay in serving germplasm request			Incorporate alerts in the computerized ger stock control system to call attention to ne mutlipication and regeneration. Keep plen popular genetic stocks in the active set as their DNA samples if available.
	Bulky tissue-cultured explants	Expensive shipping cost and vulnerability of material to disintegration			Use space-saving growth bags with 2 laye up.
	Unfavorable conditions during transport	Delay in delivery , reduction of viability or loss of materials			Use packing materials that can withstand unfavorable conditions. Choose express c and under dry-ice if available. Use the saf shipment services with reliable tracking sy
INFORMATION MANAGEMENT AND DISSEMINATION					
	Inefficient recording and database management	Backlog and inaccurate characterization data			Use GRU Database System and submit ne to SINGER every month. Bind hard copies in books.
	Mishandling of information and disorganized data sets (e.g. information system, field/ lab observation)	Loss or inaccessibility of information			Use GRU Database System and archive o data sheets. Integrate genebank operation distribution records,and germplasm excha policy databases.
	Improper recording of moisture content, germplasm inventory, viability, storage location, and characterization data.	Inaccurate or wrong information			Independently verify encoded data. Autom computing, updating and reporting germpla inventory, viability, storage location, and characterization data in database. Provide making tools in the database for various genebanking operations.
	Lack of adequate information about important characteristics of each accession.	Low interest and utilization of germplasm			Collect data on important traits. Include de information from various sources.

	Mislabelling of new bags and other containers for the germplasm accession and samples are placed in the wrong container.	Loss or misplacement of materials			Set up a standard protocol for labeling and placement of samples from registration to regeneration to harvesting. One label shou an explant through the entire process. Use mixture of letters and numbers to decrease possibility of transposing numbers. Use a barcoding system to keep track of all acce Use preprinted labels to reduce human err scanners and pocket PCs in data gatherin labeling that does not require continual rev the label. Maintain lyophilized leaf samples accession as a reference for identification
	Lack of secure back-up	Loss of genebank data		Transfer new data on CD or tape in two central databases kept in separate buildings in the institute. They can be stored also in secure, passport-regulated cyberspace.	Produce hard photocopy and electronic co original data sheets. Use automatic back-u transaction computer after each session. I daily incremental back-ups and weakly full ups.
	Important data and information remain in unuseful form.	Low level of utilization of germplasm and information.			Disseminate relevant information about germplasm and genebank operations by p in germplasm catalogs, newsletters, journa bulletins, and operation manuals in print a media.
	Outdated or inaccessible procedures manual	Loss of improvements in procedures			Write out in detail all procedures and recip procedures manual as a reference guide f workers. Update the manual yearly or any major procedure changes are instituted.
	Inconsistent protocols	Much variation in quality of process outputs			Develop standard protocols and recipes. I media sheets as worksheets to minimize e When new protocols and recipes are deve file the old ones for reference.
	Lack or complicated tracking and inventory system	Loss or misplaced samples and failure to regenerate and serve germplasm request on time			Design a computer inventory system that researchers to follow each accession from acquisition through culture and storage. Th system should include and link acqusition information, field data, image data and in records for each accession. Include storag location in dewar, number of vials, number meristems per vial, technique used, thawir technique required, recovery medium and important procedures.
	Insufficient data on accession identity and culture conditions	Underestimate of germplasm viability or failure to propagate by recipient			Include each accession's explanting date, initiation medium, multiplication medium, r medium, growth information, experimental length of subculture, etc. Identify plants by same numbering or labelling system as the genebank to allow the plants to be traced the mother plant when necessary.
	Limited ICT capability; server, network and IT related problems	Lack or poor accessibility of germplasm and important data to potential users	Engage a competent data curator to document decades of evaluation data in a centralized database system.	Use stable software and hardware and engage full technical support from Information Technology Unit. Change computers every 5 years. Upgrade memory and operating system every year.	Regulate software installation and downloa Restrict use of computer to authorized per
	Malfunctioning equipment, hardware and software problems	Failure to update data by genebank staff. Delays in recording of accessions and declaring them to FAO & SINGER		Install redundant UPS units and hot-swappable battery packages. Enforce automatic start-up of generator within 30 seconds. Use alternating 2 power-supplies connected to the same server.	Enable immediate notification of 2 staff at home phones in case of database-related problems. Back up data weekly to 2 tapes kept in Center, the other in staff's home fo and later in the international data hub.
INFRASTRUCTURE/PHYSICAL FACILITY					

	Storage conditions at genebank not suitable (temperature, humidity, light conditions, exposure to contaminating organisms, pests)	Reduction or loss of viability		Treat culture rooms with pesticides on a regular time basis. Regularly check and maintain cooling units. Maintain storage room conditions and monitor conditions daily via remote sensing devices. Install a High Efficiency Particle-removal Air system (HEPA) and alarm systems for open doors, temperature/ humidity changes in the culture areas. Provide a dehumidifier.	Conduct regular monitoring and cleanup to fungus problems especially in tropical clim Monitor MTS materials every 3-4 months f occurrence of necrosis, chlorosis, hyperhic blackening, contamination, callus formatio defoliation. Develop in vitro diagnostic tool
	Poor organization of storage trays, shelves and compartments	Loss or misplacement of germplasm	Restrict storage facility access to authorized genebank personnel.	Rationalize arrangement of storage trays, shelves, and compartments.	Develop a simple labeling system for the s space units. Conduct regular and indepen verification of location of accession, and u on computerized database system.
	Deterioration of facilities and equipment	Reduction or loss of viability		Pursue continual upgrading and expansion of field and laboratory equipment, etc.	
	Cold room malfunction	Reduction or loss of viability		Place hygrothermographs that are connected to back-up power supply and alarm system. Provide the rooms with multiple compressors and dehumidifiers that are programmed for alternate operation.	
	Power supply cut-off	Reduction or loss of viability		Install, regularly check, and maintain an emergency electrical generator for back-up power to the storage rooms, essential genebank lighting, monitoring devices, and access locks during electrical power failures.	
	Theft or vandalism	Loss of germplasm		Place the building under 24-hr perimeter security surveillance. Link the alarm system by optical fiber with security office and police. Install double locks in sensitive areas and closed-circuit camera monitoring by guards. Install sensors for door contacts, glass breaks and unusual motion outside work hours.	Restrict access to genebank facilitites to a personnel with assigned badge and PIN c access. Conduct background check on p who will use facility. Regularly brief securit on the safety and security protocols of the genebanks.
	Environmental risks/weather elements, earthquakes, other catastrophic events (civil war,…), and fire	Reduction or loss of viability	Assign personnel from genebank unit and security office for 24/7 watch of the facility.	Design and construct building according to safety, environmental and artillery protection, and earthquake proof standards. Install automatic fire and gas alarm systems and provide fire isolation doors and fire extinguishers. Provide doors than can open from inside cold chambers to prevent personnel getting trapped.	Conduct periodic maintenance checks and genebank during heavy rains and earthqua leaks in the cold and drying rooms. Period check fire safety checks.
Safety Duplication	Safety duplication site is vulnerable to natural calamities	Inaccessible or loss of safety duplication		Establish duplicate back-up in a geologically secure site with low radiation (radioactivity) and stable (low probability of earthquakes). The facility must be situated at an altitude that guarantees proper drainage during seasonal rains and eliminates the risk of flooding in the event of rising sea levels due to global warming.	
	Changing policies, financial and technical capabilities of governments hosting safety duplication	Inaccessible or loss of safety duplication		Establish safety backup arrangements in two different, economically stable countries, preferably in different continents, for black-box storage. Prepare a pull-out scheme in the event of instability in host country. Duplicate collection in two other sites, or keep an in vitro or a cryo set.	
PERSONNEL AND SUPPORT SERVICES					

	Inadequate complement of technical staff	Inefficient operations	Hire at least one highly qualified technician each to manage germplasm viability test, germplasm drying and moisture test, germplasm health test, characterization and regeneration, data management, and germplasm distribution. For an active collection with research and development needs, hire a scientist to take charge of planning, research and analysis, a technician to take charge of daily operation of the laboratory, laboratory assistants for germplasm cleaning, germplasm processing and germplasm packaging, and field workers for germplasming, field-layout, screenhouse and field maintenance and harvesting.		
	Incompetent staff	Inefficient operations	Hire researchers with advanced degrees in plant physiology/genetics. Hire laboratory technicians with a background in plant science. Hire laboratory assistants with training in basic botany. Provide 1-2 weeks intensive on-site training for each new staff member on standardized laboratory and field protocols, followed by close supervision for as long as needed.		
	Routine tasks and uncompetitive remuneration	Fast staff turnover	Rotate work assignments as much as possible or assigning special projects to laboratory assistants. Train each assistant to make medium, wash dishes, transfer cultures, check cultures for contaminants, do basic record keeping, and other required laboratory tasks. Educate workers on the mission of the facility to provide a morale boost and establish a research-oriented approach to work.		
	Exposure to occupational hazards	Reduced manpower capability		Provide potective clothing, gloves and safety devices such as showers, eyewash and fire extinguishers.	Protect staff members from pesticide expo example, by spraying during weekends.
	Suffocation/asphyxiation and frostbite and cold injury from LN exposure. Mechanical injury incurred on explosion of a pressurized vessel containing LN.		LN safety considerations should be included in the training of all new staff.	Well-ventilated room; handling and storage dewars must be vented; skin and eyes must be protected with cold-resistant gloves, aprons, safety glasses and closed-top shoes. Only LN-resistant vessels and instruments guaranteed by the manufacturer should be exposed to its vapor and liquid phases. Install oxygen level sensors and self-contained breathing apparatus.Install door magnetic locks that automatically unlock during emergencies.	Enforce pal system when entering cryo tar Constantly monitor cryo tank area on close tv.
	Inefficient human resources services	Delayed hiring of required manpower			Review and streamline hiring/recruitment p
	Inefficient purchasing and repair services	Delayed delivery/repair of required supplies and equipment			Review purchasing protocol to speed up re process. Keep spare parts for crucial piece equipment in stock (specially the ones not available), as a risk mitigation procedure (f batteries, lamps, fuses, sealing devices)
	High cost of genebank operations	Loss of donor and user support			Closely follow and seize funding opportuni The Global Crop Diversity Trust and other donors.

Contingency	Responsible Unit
Send a follow-up collecting mission.	GRU
Based on level of risk and of diversity in collecting site to target germplasm, send a follow-up collecting mission.	GRU
Use molecular methods to verify identity. Invite taxonomists and other experts to verify identity of ambiguous materials.	GRU
	GRU
	GRU
Arrange for unrestricted use with new leaders of donor countries. Acquire material through friendly 3rd party countries. Offer technical incentives.	GRU
Keep acquired material under restricted use and access, and seek de-restriction with donor country.	Center top mgt; new employees orientation;GRU
Help build capacity of national bodies in germplasm collecting.	Center partnership and collaboration office, GRU
Confine affected areas, discontinue planting of crop and eliminate other hosts in adjacent areas.	GRU; Germplasm Health unit
	GRU; Germplasm Health unit
	GRU
	GRU
Classify accessions as 'tentative' until standard characterization, etiology and DNA analysis establish their identity.	GRU
Seed increase immediately.	GRU

	GRU
Obtain virus-free materials from other institutes as replacement accessions if virus testing or elimination are not available on-site.	GRU; Germplasm Health unit
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	GRU; Germplasm Health unit
	GRU; Germplasm Health unit
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	GRU; Germplasm Health unit
	GRU; Germplasm Health unit
	GRU; Germplasm Health unit
	GRU/Biotechnology unit
	GRU/Biotechnology unit

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	GRU/Biotechnology unit
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	GRU; Germplasm Health unit
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	GRU/Purchasing
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	GRU

	GRU
	GRU; Germplasm Health unit
	GRU/ Physical Plant unit
	GRU
	GRU; Germplasm Health unit
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	GRU; Germplasm Health unit; Physical Plant unit

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	GRU; Germplasm Health unit
	GRU
	GRU
Re-characterize accessions for problematic traits using current international standard descriptors.	GRU
	GRU
Determine a set of core collection and begin eliminating redundant duplicates of the core materials.	GRU
Immediately send correct documents and information to recipient of germplasm, including acknowledgment receipt and agreement forms to be completed and returned.	GRU; Plant Breeding; Training

Send a notice to patent and PVP offices about status of germplasm materials in question. File legal suit against violators and prohibit their access to IT germplasm.	GRU; Center Mgt; FAO
Immediately send disease and pest management procedures to recipients of germplasm.	GRU; germplasm Health
	GRU
Acknowledge receipt of germplasm request. If there is reasonable doubt on identity and availability of requested germplasm, notify requester of possible delay of delivery pending confirmation of identity and availability.	GRU, Library, Communications Office
	GRU; germplasm Health
Immediately send correct germplasm and instructions on disposing received wrong germplasm. Recipient should be required to send written confirmation of compliance with the disposal procedures.	GRU
Conduct germplasm mutliplication of the accessions concerned and notify requestor of expected date of germplasm availability. Make an agreement with requestor on funding and schedule of germplasm increase, if Center cannot immediately meet request.	GRU
If route and time taken by material are unreasonably extended, resend new germplasms using an alternative courier.	GRU
	GRU, IT unit
Regularly monitor data handling and encode stray data.	GRU, IT unit
Re-encode inventory and viability data from data sheets if reliable, otherwise repeat inventory and viability tests.	GRU
	GRU

	GRU
Retrieve data from back-up electronic copies and /or paper records if available. Otherwise, conduct germplasm stock inventory and retake viability tests of materials, prioritizing the weakest germplasm types based on experience and literature. Hire necessary personnel to complete work as quickly as possible.	GRU, IT unit
Provide on-demand technical assistance for special data and information search about germplasm.	GRU, Library, Communications Office
	GRU
	GRU
	GRU
	GRU
Provide information request menu on the webpage and serve requests by digging print and/or electronic records.	GRU, IT unit
	GRU

Multiply, carefully process and send accessions to better genebanks for safety back-up.	GRU, Physical Plant
	GRU
	GRU
	GRU, Physical Plant
	GRU, Physical Plant
	GRU, Physical Plant, Security
	GRU
	GRU
	Center top mgt; SGRP; GRU

	GRU; HR unit
	GRU
	GRU, Pest Control unit
	GRU
	HR
Tap equipment and supplies of partner organizations, for a fee if required, pending delivery of ordered equipment and supplies.	GRU
Charge shipping fees to recipients of germplasm especially the private sector and well-funded public organizations.	GRU; Center mgt