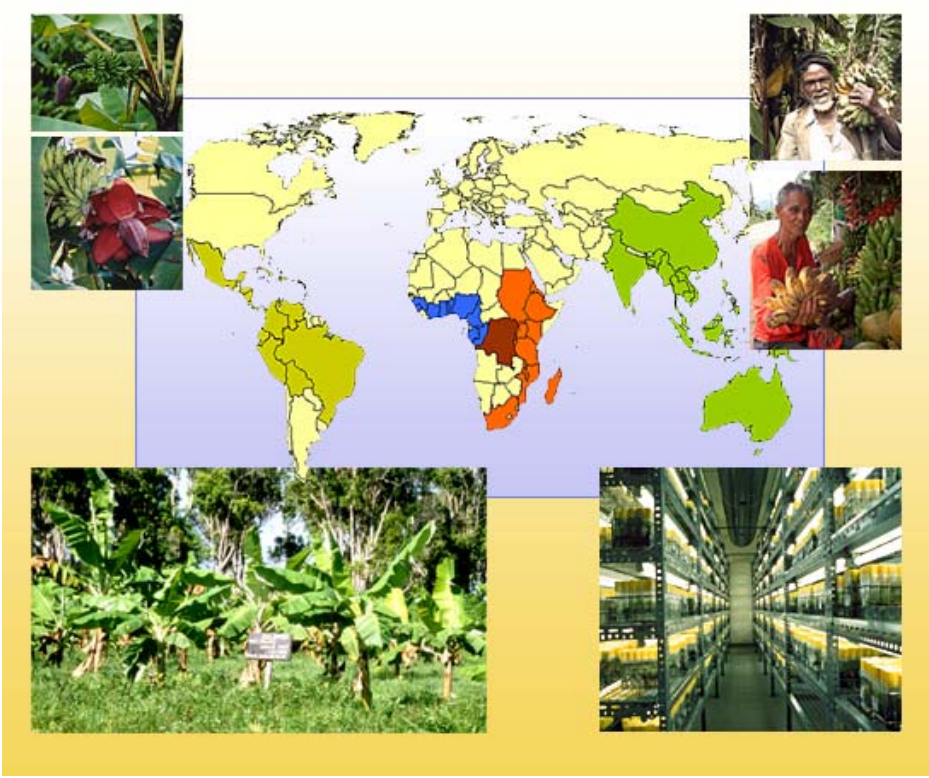
Global Conservation Strategy for *Musa* (Banana and Plantain)

A consultative document prepared by INIBAP with the collaboration of numerous partners in the *Musa* research-and-development community



INIBAP is a network of the International Plant Genetic ResourcesInstitute (IPGRI), a center of

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Acknowledgements

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Edmond de Langhe (founding Director of INIBAP and now a private citizen) provided the expertise on the taxonomy of *Musa* (banana and plantain) and origins of cultivated forms on which the strategy is founded, as well as many important perspectives on how a global strategy should take shape. Many collection curators dedicated significant time and effort to complete the detailed conservation survey. Rony Swennen (KUL*, Belgium), Jeff Daniells (QDPI&F, Australia), Michael Pillay (IITA-Uganda) and Abdou Tenkouano (IITA-Cameroon), as well as Deborah Karamura (INIBAP-Uganda) deserve special mention for their individual contribution.

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The staff of *Katholieke Universiteit Leuven* and the *Universiteitsbibliotheek Leuven*, hosted the exhibition on banana diversity ‘No end to the banana’, which provided the venue for launching the Global Conservation Strategy for *Musa*; Rony Swennen, Kodjo Tomekpe (CARBAP, Cameroon), Edmond de Langhe, Richard Markham (INIBAP and IPGRI-France) and Cary Fowler (GCDT, Italy) gave presentations or speeches in support of the Strategy at this event.

Ana Beretta and Campbell Davidson coordinated the attendance of Elizabeth Arnaud (INIBAP) in the meeting of the Regional Strategy for the Americas.

Charlotte Lusty (INIBAP) coordinated the collecting of input and feedback from stakeholders and took the lead in drafting this strategy document.

Finally, Brigitte Laliberté and Jane Toll of the Global Crop Diversity Trust have both been generous with their time in providing feedback on the strategy and helping to align it with the Trust’s thinking.

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* **acronyms and abbreviations are listed on page 25.**

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1. Strategy Development Process

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1.5 Major steps in the process

In the development of this report, the following steps were followed in 2005:

a. Jan-Mar: A survey was designed and sent out to collection curators to gather information on the accessions and eligibility of collections; 29 curators responded from a total of 40 sent and a further 16 full or partial responses were obtained from subsequent meetings (see Annex).

b. Jan: A background document on *Musa* diversity, origins and conservation needs was prepared by Prof. Edmond De Langhe.

c. Feb: Visits were made by two taxonomic experts (Jeff Daniells and Deborah Karamura) to four collections in Kenya, Papua New Guinea, Rwanda and Vietnam.

d. Feb-Mar: A brainstorming meeting was held with Edmond De Langhe and INIBAP staff (including discussions at 'Commodities for Livelihoods' annual programme planning meeting) to analyse survey results, discuss criteria for selection of collections and define major elements of the strategy.

e. Mar-Oct: The broad conservation needs at different levels (international, regional, national, local) were discussed with major stakeholders, such as banana breeders at IITA (Abdou Tenkouano and Michael Pillay) and CARBAP (Kodjo Tomekpe), and other holders of major collections, and some consensus for the priority activities obtained.

f. Aug: The draft strategy document was submitted to the GCDT Secretariat and their feedback was received and incorporated.

g. Sep-Oct: One day discussions were held at regional network meetings representing national agricultural research institutes in Sub-Saharan Africa, Asia and the Pacific to discuss further the major constraints and priorities of collections, their potential roles and criteria for selecting the priority collections for support.

h. Oct: The draft strategy was launched with the "No end to the banana" exhibition in Leuven, Belgium, in the presence of Cary Fowler, GCDT Director, and several hundred participants from Leuven and the *Musa* research community.

i. Nov: Elizabeth Arnaud attended the Regional Strategy meeting for the Americas in Montevideo, Uruguay, and presented the *Musa* strategy.

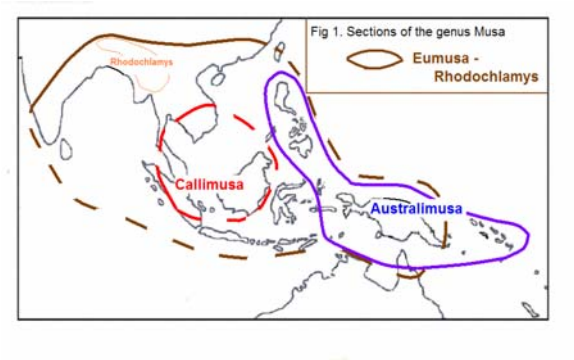
j. Nov-Jan 2006: Through email communications, BAPNET (Asia and Pacific network) members evaluated their collections according to agreed criteria and an evaluation committee analysed the results and suggested which collections should be prioritized.

2. Background

2.1 The *Musa* genepool

Wild and cultivated diversity of *Musa* (banana and plantain) is at its richest in the Asia and Pacific region. The genus *Musa* represents a group of approximately 25 forest-dwelling species, divided into four sections, distributed between India and the Pacific, as far north as Nepal and extending to the northern tip of Australia (figure 1). The genus belongs to the family Musaceae, which also comprises some seven species of *Ensete* and possibly a third, monospecific, genus *Musella*, which is closely related to *Musa.*

Figure 1. Distribution of the four sections of the genus *Musa*



Taxonomists estimate that there are at least 1000 recognizable *Musa* cultivars distributed pantropically – though molecular studies are needed to investigate possible synonymies among, and variation within, these cultivars. Edible forms have been selected by farmers from the progeny of either one or two wild parent species: *Musa acuminata* ssp. *banksii* is believed to be the ancestral parent of the majority of edible banana cultivars, contributing what is called the 'A' genome while *Musa balbisiana* contributed the 'B' genome to several banana cultivar groups and all plantain. The domesticated banana spread widely within the Asia and Pacific region and a large proportion (70-85%) of the gene pool rests there in the form of 12 cultivar types or genome groups (table 1).

At least three thousand years ago the crop was introduced to the African continent, where it diversified (through farmer selection of somatic mutants) into more than 60 cooking banana types in the East African Highlands and more than 120 plantain types in West and Central Africa. Both types have become substantial sources of staple food. The banana is believed to have been introduced into Latin America and the Caribbean after the arrival of Colombus, allowing little time for the development of indigenous cultivars. There is an additional group of edible bananas, known as Fe'i bananas, confined to the Pacific. Its genetic origin is obscure, but taxonomic studies suggest ancestral links either with the wild species *Musa maclayi* or *Musa lododensis*.

Collecting missions to the Asia and Pacific region in recent decades give reason for confidence that no or few new major cultivar groups remain to be discovered. However, new wild species and varieties continue to be described are inadequately represented in collections**.** Threats posed by habitat destruction and the replacement or loss of traditional cultivars intensify the urgency for collection and conservation efforts.

2.2 Why do we need *Musa* diversity?

2.2.1 Genetic improvement

Genetic improvement presents a potentially cost-effective mechanism to address current constraints in smallholder production by providing high-performing varieties

adaptable to diverse environments. The products of existing improvement programmes, drawing on sources of resistance from wild and edible genotypes, are not meeting several important criteria, such as widely-acceptable fruit-pulp quality, and only a fraction of the genetic diversity in diploid *Musa* is being used. Yet variation among wild and edible *Musa* species offers a wide spectrum of fruit and bunch qualities. For instance, the ecology of various wild species suggest that sources of resistance to abiotic stresses exist in Eumusa along the northern periphery of its distribution (see figure 1), including mechanisms for tolerance to cold (*M. sikkimensis, M.basjoo, M.thomsonii*), water-logging (*M. itinerans*), and drought (*M.balbisiana, M. nagensium*). Recent collecting expeditions in northern India and Malaysia suggest that other poorly known or unexplored areas of diversity are likely to harbour other agronomically-interesting characteristics. In addition, the development of powerful molecular tools by initiatives such as the Global *Musa* Genomics Consortium provides an unprecedented opportunity to use more effectively the diversity available in wild and cultivated *Musa*.

Table 1. Main groups of *Musa* species and cultivars, their centres of diversity and most suitable locations of *ex situ* collections

Cultivar types and wild species	Genome group	Centres of diversity
Edible diploids, triploids and others	AA, AAA, AS, AAS, AAT, ABBT	Indonesia-Philippines-Melanesia. Exceptionally high diversity of AA in New Guinea
East African Highland banana	AAA	Great Lakes region in East Africa (Burundi, Kenya, Rwanda, Tanzania, Uganda)
Plantains	AAB	West & Central African rainforest + India
Maia Maoli-Popoulu & Iholena	AAB	Polynesia, Melanesia and Micronesia
Edible diploids	AB	South India
Eastern ABB (BBB) subgroup	ABB	Philippines and North Vietnam
Western ABB subgroup	ABB	Northeast India and South India
Fe'i	semi-wild	Pacific Islands
Eumusa	wild	Southeast Asia
Rhodochlamys	wild	monsoonal areas in mainland Southeast Asia
Australimusa	wild	Southeast Indonesia and Southern Philippines to Melanesia
Callimusa	wild	mainly in the lowlands in the central zone of wild *Musa* distribution (South-Vietnam, Peninsular Malaysia, Borneo, Sumatra)

2.2.2 Developing diversity-based production systems

Productivity and sustainability may be enhanced by integrating inter- and/or intra-crop diversity within production systems. Experiences with rice and other cereals, currently being extended to banana, suggest that losses from epidemic diseases can

be mitigated by planting mixed genotypes in place of extensive monocrops of a single variety.

Recent INIBAP projects and other initiatives also demonstrate that a demand for increased diversity of cultivars, as well as improved varieties, exists among smallholder farmers and formal market systems, as well as within the research and breeding community. Supplying producers with a wider range of diversity can potentially enable more livelihood options to be adopted and family nutrition to be similarly diversified.

2.3 How is *Musa* diversity conserved?

2.3.1 Ex situ *conservation methodologies*

Musa cultivars are usually seedless and options for their long-term conservation are constrained by the vegetative nature of the plant's reproductive system. The vast majority of the 60 or so *Musa*-dedicated national collections manage the majority of their accessions *in vivo* (as full sized plants) in the field. In the survey of *Musa* collections, 25 field collections were reported to hold slightly more than 6000 accessions in total. Out of the same surveyed institutes, 15 hosted *in vitro* collections (i.e. as tissue culture on agar) containing slightly more than 2000 accessions (in addition to the INIBAP Transit Centre [ITC], which holds a further 1176 accessions *in vitro*).

The *in vitro* collections are used for safety duplication of the field collections and for rapid multiplication and dissemination of disease-free planting material. The field collections are important for taxonomic characterization, evaluation, training and demonstration. Both means of conservation demand regular replanting or subculturing. The field collections are also highly vulnerable to pests and disease. *In vitro* collections require monitoring of genetic integrity every ten years to ensure that accessions are not undergoing somaclonal variation.

According to published studies on comparable crops, management costs for both types of collection are relatively high compared to cryopreservation (Koo, B *et al.* 2004). The in-perpetuity costs of conserving and distributing a cassava accession, for example, are estimated to be US$268.73 for *in vitro* medium-term storage and US$186.69 for field genebanks, while cryopreservation costs US$69.11 per accession. Costs for banana are higher but the one-off cost of cryopreservation is expected to pay off against the recurrent costs of in vitro or in field maintenance over an approximately five-year period. Two cryopreservation protocols are available for a range of banana cultivar groups and the ITC is implementing a programme of cryopreserving its entire collection (see 2.4.1).

2.4 Existing system for *ex situ* conservation

2.4.1 The INIBAP Transit Centre and services it performs.

The Global *Musa* Germplasm Collection, otherwise known as the ITC, was set up in 1985 under the management of INIBAP and hosted by the *Katholieke Universiteit Leuven* (KULeuven). The collection represents the single centralized holding of a large proportion of the known gene pool. Around 80% of the collection is held "in trust" under the auspices of the FAO, with the aims of:

- Providing long-term and sustainable conservation of *Musa* genetic resources
- Maintaining a source of genetic diversity and related information in the public domain
- Contributing to understanding *Musa* diversity through characterization
- Providing a service for the safe movement of germplasm and related information
- Developing and transferring *ex situ* conservation technologies.

Nearly 1200 accessions are held under slow growth conditions in tissue culture. A third of the collection is now cryopreserved to acceptable standards of security (minimum of three batches prepared for each accession, each batch with regeneration rates that exceed 95%). The complete collection is expected to be cryopreserved by 2008.

The collection is made up largely of landraces and cultivars, some obtained through recent collecting expeditions but mostly donated by national collections and international research centres, particularly the International Institute of Tropical Agriculture (IITA), *Institut de recherches agronomique et zootechnique de la Communauté économique des pays des grands lacs* (IRAZ), *Fundación Hondureña de Investigación Agrícola,* (FHIA) and *Centre de coopération internationale en recherche agronomique pour le développement* (CIRAD). Wild species account for 15% of the accessions and improved varieties for 10%.

The collection is not complete. There are estimated to be between 300 and 400 cultivars *known* to be missing from the collection (20 plantains from Africa, about 50 Callimusa from Borneo, 20-30 *balbisiana* and 20 other types from India, an undetermined number of *balbisiana* from China, 10 accessions from Myanmar, 40 wild types from Thailand, Indonesia, and possibly up to 100 from the Pacific; Rony Swennen, pers. comm.). In several cases the acquisition of germplasm by the ITC has been constrained by legal and property rights issues, but these are expected to be resolved as the International Treaty on Plant Genetic Resources for Food and Agriculture is fully implemented by the relevant countries.

The entire collection is currently undergoing a major programme of rejuvenation, involving the growing out and characterization of accessions in field collections in Cameroon, Guadeloupe, Honduras, Philippines and Uganda. Accessions have been characterized using flow cytometry and are being analysed using a variety of genetic markers (STMS, RFLP and RAPD[*]). Accession passport and characterization data are fed into the *Musa* Germplasm Information System (MGIS) and day-to-day management of accessions is achieved through a newly-developed *Musa* Gene Bank Management System. The management system is linked to MGIS and tracks orders, distribution and use of germplasm, as well as the detailed management of current holdings.

The ITC's location in a non-producing country has benefits in facilitating the receipt of germplasm from, and its distribution to, all parts of the globe without restrictive quarantine procedures. Furthermore, the collection has been completely virus-indexed and is widely recognized as the safest source of *Musa* germplasm. The survey of collections provides endorsement of this: 22 of 27 surveyed collections indicated that they regularly or occasionally exchange germplasm with the ITC and since its establishment the ITC has distributed more than 60 000 germplasm samples of 450 accessions to 88 countries. Accessions are supplied without fee, but a maximum of only five plants is made available per accession. Finally, the ITC is active in training and developing 'best practice' in various areas, including germplasm acquisition, health status certification, medium- and long-term conservation, data management, monitoring genetic integrity, distributing germplasm and cryopreservation for long-term storage.

2.4.2 Collections providing international services

There is no recognised network of regional or international collections, but a number of collections have international recognition owing to the richness of their collection or to the research, expertise, services or capacity building that they provide (table 2). Around thirteen collections each hold more than 200 accessions, nine collections

[*] **acronyms and abbreviations are listed on page 25.**

distribute germplasm internationally and several collections provide essential support roles to the long term conservation of the global collection.

Table 2 International services carried out by collections other than ITC

Activity	Collections carrying out the activity	Comments
Field verification of the global collection at the ITC	• Bureau of Plant Industry (BPI), Philippines • Centre Africain de Recherches sur Bananiers et Plantains (CARBAP), Cameroon • CIRAD, France (Guadeloupe) • FHIA, Honduras • National Agriculture Research Organization (NARO), Uganda	Carried out as part of the rejuvenation of the global collection at the ITC programme funded by the World Bank and the Gatsby Charitable Foundation
Molecular characterization of international collections	• CIRAD, France • Institute of Experimental Biology (IEB), Czech Republic • IITA, Nigeria	Involves accessions from the ITC and duplicates in the collections of IITA and CIRAD; carried out as part of the Generation Challenge Programme
Pre-indexing	• University of Gembloux, Belgium	Facilities to be established
Virus indexing (and quarantine services)	• CIRAD, France • DPI&F, Australia • IITA, Nigeria • Plant Protection Research Institute (PPRI) South Africa	All ITC accessions have now been virus-indexed and only new accessions are processed. DPI&F provides quarantine services for some Pacific Islands.
Dissemination of germplasm at a regional level	• CARBAP, Cameroon • DPI&F, Australia • IITA, Nigeria • Secretariat of the Pacific Community (SPC), Fiji	Potentially also National Research Centre on Banana (NRCB), India
Major breeding initiatives	• CARBAP, Cameroon • CIRAD, France (Guadeloupe) • *Empresa Brasiliera de Pesquisa Agropecuaria* (EMBRAPA), Brazil • FHIA, Honduras • IITA, Nigeria and Uganda • NRCB, India	

2.4.3 National collections

Approximately 60 collections exist, functioning to varying levels of activity in terms of developing their collections and distributing accessions. Some are more or less inactive through lack of financial support or through infection of the collection with disease, while others actively provide germplasm to farmers (e.g. 23 out of 27 surveyed collections), breeding programmes or commercial industry. At least 15 collections, including all the best-resourced and maintained collections (except ITC), are directly associated with breeding initiatives.

Those collections located in centres of diversity are strategically placed to collect diversity in farmers' fields or in the wild. In this regard, active collections in South, East and Southeast Asia represent the zones of primary diversity, and in Eastern, Central and Western Africa secondary diversity. Some of these areas are still uncovering new, potentially valuable diversity: for instance, missions in north-east India have collected a female-fertile clone with capacity to tolerate black Sigatoka and in the Solomon Islands 80 cultivars of potentially high micronutrient content have been recently collected.

National Repository Multiplication and Dissemination Centres, housed in the same institutions as national collections, have been installed in 14 Asian countries. These serve to conserve and distribute the most popular or promising planting materials to farmers at a national level.

2.4.3 Existing systems of information exchange and collaboration

The *Musa* research community is served by a relatively well developed framework for collaboration and information exchange supported through the networking approach of INIBAP.

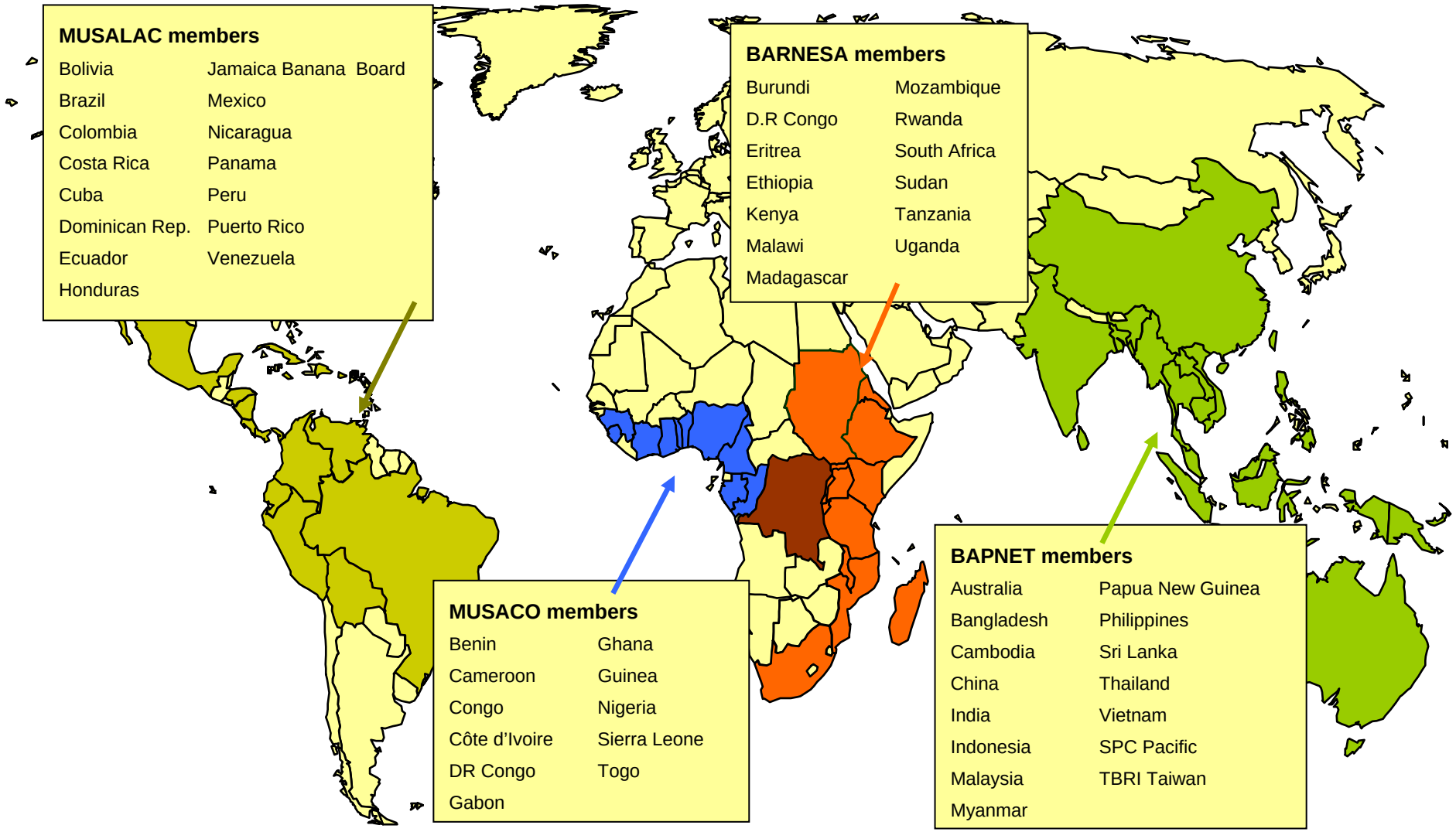
The ***Musa* Germplasm Information System** is a global exchange system and the most extensive source of data on *Musa* genetic resources. It contains information on 5188 accessions managed in 18 banana collections, including passport data, botanical classification, morpho-taxonomic descriptions and characteristics such as agronomic traits, disease resistance, stress tolerance, biochemical or molecular data, photographs and GIS information. Molecular characterization data are being incorporated and additional modules are planned for nutritional and evaluation data.

Each participating collection enters and manages their respective accession data, and provides updates to the centralized database managed by INIBAP. MGIS training courses have stimulated various efforts to harmonize nomenclature and to improve the use of the IPGRI descriptors. The database has been subject to two upgrades; links have been created to external data sources and data made available within the Consultative Group on International Agricultural Research (CGIAR) System-wide Information Network for Genetic Resources (SINGER). MGIS has been recognised by the Generation Challenge Programme as a model system for storing accession-level data. However, it represents an incomplete dataset owing to either the lack of capacity or lack of motivation in several collections to contribute to it.

There are other forms of research collaboration between institutes holding collections: The **International *Musa* Testing Programme (IMTP)** is a collaborative effort coordinated by INIBAP to evaluate elite *Musa* varieties in multiple sites worldwide (currently 23 sites in 21 countries), using agreed evaluation protocols. Trial sites, mainly geared to assessing resistance to the major diseases of Fusarium wilt and black Sigatoka, are increasingly being used for other evaluations (e.g. fruit micronutrient content) or to answer key questions about pathogen, disease and host interactions.

Four **regional banana research networks** (BARNESA for Southern and Eastern Africa, *MUSA*CO for West and Central Africa, BAPNET for Asia and the Pacific and *MUSA*LAC for Latin America and the Caribbean) are made up of national research organizations from all major banana-producing countries (see figure 2) and provide coordination and support for regional research and development initiatives, including conservation efforts. They function under the auspices of regional agricultural research fora and are coordinated by a regionally-posted INIBAP scientist. Each network has a steering committee made up of a representative from every country member. The steering committees have annual meetings hosted by invitation of participating countries. The network members collaborate through a suite of ongoing projects, workshops and training courses in the conservation, research and

Figure 2 Regional banana research and development networks and their member countries



development of banana genetic resources in each region (including an *in situ* conservation project in East Africa).

Pro*Musa* is a global programme that represents some 100 or more researchers who are collaborating to address problems of crop improvement, protection and production. The initiative is currently undergoing a process of restructuring and revision of its programme. Pro*Musa* Working Group convenors were brought together in June 2005 at INIBAP headquarters to discuss the development of a future strategy. The priorities identified included the conservation and characterization of *Musa* genetic resources. Clearly the outputs of the conservation strategy will have a direct relevance to the projects undertaken by breeders and researchers in Pro*Musa* and, likewise, applied research on pest and disease management will facilitate the functioning of germplasm field collections.

2.4.4 Constraints and risks affecting the current system

At a global level, the ITC functions effectively in assuring cost-effective medium- and long-term conservation and providing limited samples to researchers, breeders and national programmes of a large range of germplasm that are guaranteed clean of pests and diseases. However, the maintenance of the collection depends on time-bound grants, mainly from the technical cooperation agency of the host country (Belgium). Running costs (approximately $250,000 per year) are currently covered by a three-year, competitive grant that is due to expire in 2008. A more secure funding mechanism (such as a trust fund) is needed to assure the survival of this vital foundation of the international germplasm conservation and exchange system.

At a regional or national level germplasm needs are largely not being met. Numerous national collections, particularly those which are hosted by poorly-resourced organizations in Africa and in Asia and the Pacific, are functioning sub-optimally: in several cases accessions are diseased and being lost from the collections, germplasm exchange mechanisms are inadequate and the user community is not as well served as it might be. Some accessions in the ITC collection have been lost from the field collections from where they originated, and are now represented only by *in vitro* cultures.

Of the collections surveyed, 62% said that part of their collection (10-25% or more) was deteriorating because of management limitations; 69% declared that existing skilled staff capacity was insufficient for long-term conservation needs. When asked what their additional human resource requirements were, more than half of the collections specified the need for technical support in characterization; approximately a third asked for support in the general management of the collections in the field and/or *in vitro.* It is possible that for those who did not answer the survey, the situation is worse. Answers from 17 of the collections indicate that an average of US$ 172 is spent annually per accession in the field or *in vitro* (excluding capital inputs)*;* but there is wide variation in annual costs, from US$ 33/accession to US$ 625/accession.

A related challenge is exemplified by the fact that 70% of accessions in the ITC have not so far been requested and remains unused. Diversity is demanded by researchers and growers and yet many national collections and large parts of major collections are under-utilized. As long as diversity remains under-used the management of, and investment in, the collections is likely to be compromised. Taxonomic experts, breeders and researchers attribute a large part of the problem of under-utilization to inadequate information. Many *Musa* collections have not been systematically documented; only limited characterization and evaluation data are available, and information may be scattered between several institutes. The IPGRI descriptors for *Musa* are often ineffectively applied where curators are working in isolation with little training. According to the survey, an average collection is 45%

described using either the full or a partial set of IPGRI descriptors for *Musa* and the quality of data provided both in response to the survey and to MGIS illustrates that some characterization efforts do not meet appropriate standards.

Evidently there is no single way of tackling these issues and a global conservation strategy can only function effectively within a context of complementary initiatives that are further addressing the needs of *in situ* or on-farm conservation, national and local seed systems, breeding programmes and molecular research. It is also recognised that the success of the strategy depends on the genuine collaboration of a wide range of national collections; on these collections gaining clear benefits from being involved; and on a parallel investment being provided at a national level. Rather than providing support to the individual needs of each collection, a global initiative provides the opportunity to use centralized or regionalized resources to resolve shared problems and specific bottlenecks in the system.

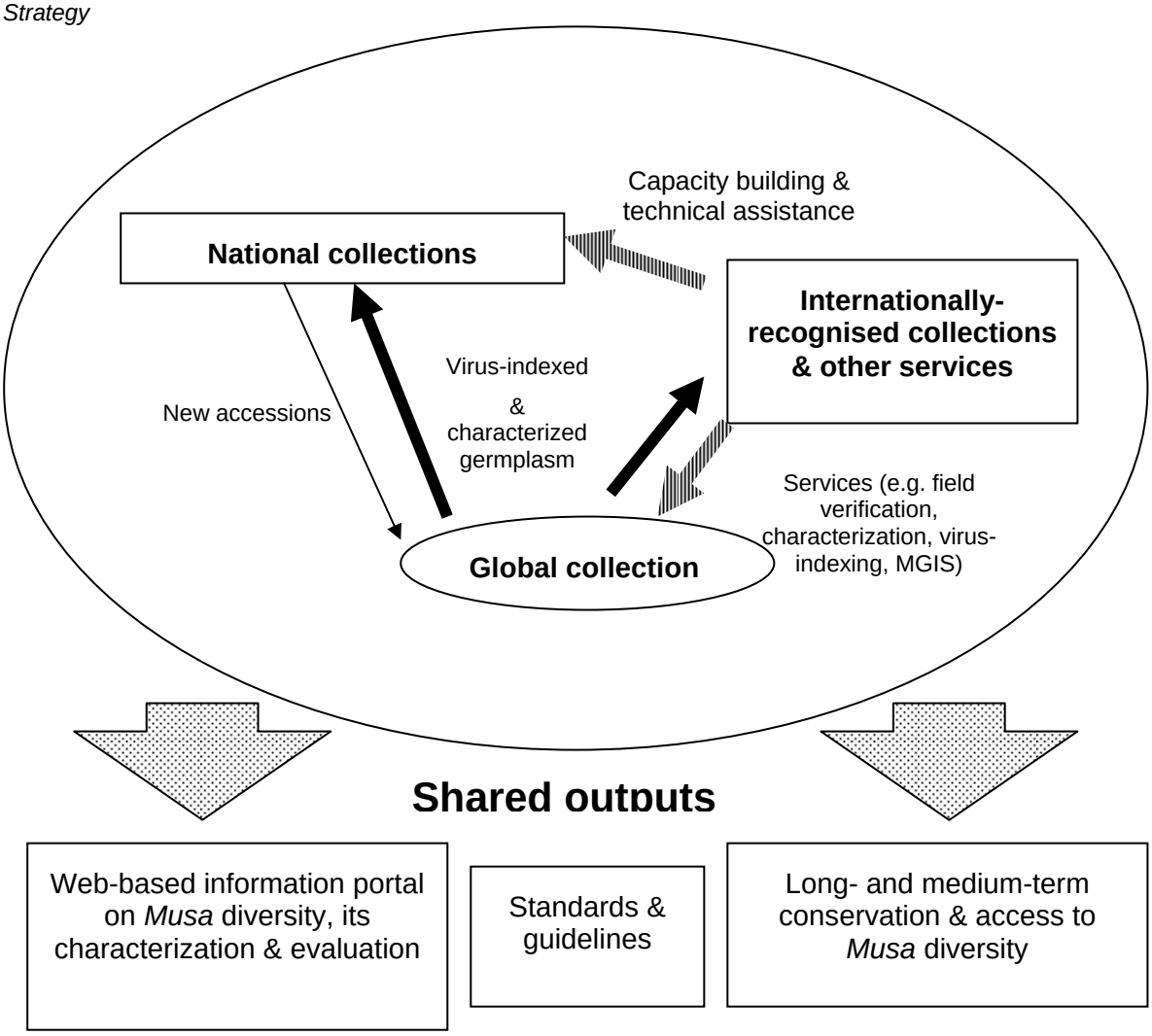
3. An ex situ *conservation strategy that fulfils global needs*

The proposed Global Conservation Strategy for *Musa* aims to build upon existing strengths in the global collection at the ITC, several 'internationally-recognised' collections and national collections and the existing culture of collaboration to rationalize the global effort to conserve the *Musa* gene pool and promote the safe use and distribution of a wide range of diversity (figure 3). The ultimate aims are to increase and expand the use of genetic diversity from high-technology research to use in farmers' fields. The following four major outputs are proposed:

- genetic diversity is comprehensively characterized and documented, taxonomy is harmonised, and collections are rationalized;
- the global system for the safe exchange of germplasm is strengthened;
- the entire gene pool is conserved in perpetuity;
- the use of genetic diversity is maximized.

Each output will be achieved through a range of complementary activities that are expected to take place in parallel and will be carried out by a network of collections. This network will not be strictly defined but will be open to collections from member countries of the regional networks that are actively contributing and benefiting from shared standards, technical capacity, germplasm and information exchange (figure 2, page 10). Through intensive characterization and analysis by taxonomists, a core collection of accessions, which represents *Musa* diversity without significant redundancy, will be identified and long-term support will be focused on maintaining duplicate sets of these: one set *ex situ* in the ITC, the other set in the field shared between collections. Within the network, therefore, only selected collections will be the focus of initiatives for upgrading and long-term support according to their defined roles and prioritization in the strategy. Some effort has already been made by regional networks to prioritize national collections according to agreed criteria (see section 3.5). However, the detailed elements or roles to be supported at national and regional levels are not yet established.

Figure 3. Interactions between national and international collections in the Global *Musa Conservation Strategy*



The coordination and implementation of the strategy will be influenced by three bodies providing oversight:

- a Taxonomic Advisory Group (TAG) of *Musa* taxonomists, breeders, collection managers and molecular experts will be formed to provide technical backstopping and advice for the implementation of the strategy;
- the regional banana and plantain research networks will provide the coordination of activities at a regional level and play an essential role in integrating the proposed activities with ongoing initiatives influencing seed systems and germplasm conservation and exchange; and
- INIBAP will provide overall coordination and linkages to Pro*Musa,* IMTP and other relevant research programmes and projects.

4. Expected outputs of the strategy

4.1 Genetic diversity is characterized and collections are rationalized

A global initiative will be launched to characterize and harmonize the taxonomy of collections. The first aim will be to derive an agreed taxonomy for use by the *Musa* community. This will in turn provide information to allow collection curators to make decisions on the rationalization of their own accessions. Then, at the regional and global level, this effort will provide the rationale and tools which will allow the *Musa*

community to select a core set of accessions, for long-term conservation, which will embody the entirety of *Musa* diversity.

The field verification and molecular characterisation of ITC accessions is already under way as part of a rejuvenation programme funded by the World Bank and The Gatsby Charitable Foundation (see section 2.4.1 on the ITC). The data from this effort will provide morphological and molecular references, which collections worldwide will be able to apply to their own accessions and studies. In addition, the following steps are envisaged:

a) A meeting of taxonomists and molecular biologists will be held to form the TAG and to agree mechanisms and standards for the characterization of collections, for the harmonization of taxonomy and nomenclature at regional and global levels and for the rationalization of collections (in particular the ITC).

b) Where necessary, national collections will be provided with support to characterize and document their collections. This support may include providing data, training in characterization and/or data management (MGIS), taxonomic expertise on troublesome accessions (provided by TAG) or updated software (MGIS) or hardware. In due course, molecular tools may be recommended for distinguishing between hard-to-separate phenotypes.

c) Information resulting from characterization efforts will be entered by collection data managers into MGIS and provided for incorporation into the centralized database managed by INIBAP. The centralized dataset will be rationalized; synonyms and duplicates recognised and accession data linked to characterization and evaluation data from the global collection at the ITC and other collections. Other datasets relating to evaluation, including postharvest and processing characteristics, will also be compiled and updated versions of the global dataset will be regularly provided by INIBAP to all MGIS participants.

d) TAG will agree a strategy for harmonizing nomenclature of cultivar groups, most likely necessitating regional workshops. A global taxonomy will be agreed and published.

e) MGIS will be upgraded and a comprehensive catalogue (*Musalogue*) of cultivar and species diversity and taxonomy will be published in hard copy and on the Internet.

f) TAG will provide recommendations for rationalization of internationally-recognised collections and those national collections who seek guidance.

All national collections will be encouraged to take part in the characterization and documentation initiative. Training courses will be targeted at a regional or sub-regional level so that multiple national collections may benefit; although all participating collections should provide assurance that:

1. once financed or provided with training, they have the capacity and willingness to document the results and provide them to MGIS;
2. there is evidence of support for the collection and its use at a national level.

In addition, priority collections may receive additional support to complete the comprehensive documentation and rationalization of accessions. It is also foreseen that some characterization and documentation activities will be undertaken through regional conservation strategies. In this case, regional conservation activities should be coordinated, where relevant, with those of the *Musa* strategy so that appropriate standards are maintained and mutual benefit is assured. This is particularly important for the region of Latin America and the Caribbean, where banana is a priority crop for

several countries according to the regional conservation strategy, but which is less prominent in the crop strategy primarily on account of the indigenous diversity being negligible .

4.2 Global system for the safe exchange of germplasm is strengthened

The virus-indexing system through which all existing ITC accessions have passed (and new accessions will continue to be passed) is the only comprehensive mechanism available to ensure that germplasm is, as far as possible, free of all viruses. The sustainability of the service should be assured as part of the strategy. For cost-effectiveness, a pre-indexing facility that will function in concert with the formal virus-indexing centres will also be developed at the University of Gembloux. Newly-received material may be rapidly tested for viruses at the pre-indexing facility. If the germplasm is positive then action may be taken to obtain fresh material from source and comprehensive virus-indexing, if started, may be halted. Germplasm that tests negative will continue to be virus-indexed following the normal routine. In addition, research into viruses and virus therapy are components of Pro*Musa* and INIBAP's research programme and will require support as part of the conservation strategy.

There is a need for larger quantities of virus-indexed material within regions. However, it is recognised that the level of service provided through the ITC cannot be achieved cost-effectively at national or even regional levels. Instead, the regional networks will work to identify specific bottlenecks in the exchange of clean germplasm and propose areas for action, which may involve either building up *in vitro* collections, optimizing plant conservation and multiplication strategies or equipping collections with virus-indexing kits customised to detect predominant diseases within the region (e.g. banana bunchy top virus). Such mechanisms should be developed in consultation with national authorities, regional agricultural research-and-development fora, and relevant organizations and statutory bodies, such as FAO and the Inter-African Phytosanitary Council.

4.3 Entire gene pool is conserved in perpetuity

The conservation of the gene pool will be achieved through long-term support to prioritized collections with the aim of securing, permanently, the conservation of a core set of accessions, embodying the entire range of *Musa* diversity. The core set will be conserved both at the ITC (with the most-used accessions in medium-term storage, *in vitro,* and all accessions cryopreserved, with safety duplication at a separate site) and in the field, with accessions shared among priority collections.

It should be noted that the context in which collections in banana-producing region function is very different: Latin America and the Caribbean is remarkable for its large historical collections predominantly used for breeding and the absence of significant indigenous diversity; Sub-Saharan Africa represents a secondary centre of diversity with very few adequately-resourced national collections but four important regional collections: NARO and IRAZ in East Africa and CARBAP and IITA in West Africa; whereas there are numerous national collections in Asia and the Pacific which represent unique indigenous diversity. While no single model of national and international collections can be superimposed on all of the regions, the broad roles of collections at a national, international and global level can be broadly described (table 3, figure 4).

Conservation responsibilities may, therefore, be shared among more than one collection within a region. The strategy will aim to give long-term support to specific activities of 'internationally-recognised' collections (e.g. field verification of ITC accessions) and to support or upgrade priority collections or subsets of collections that are responsible for conserving specific parts of the *Musa* gene pool. Support activities may involve training and assistance in characterization and taxonomic

studies (linking with output 1), or in germplasm management, particularly pest and disease management. As primary *Musa* diversity is found in Asia and the Pacific—and several collections in this region are in a fragile state—the strategy will provide some focus on upgrading collections here. The Pacific, in particular, represents a poorly-researched region containing unique genetic diversity of importance in various respects—perhaps most notably nutritionally given the existence of cultivars with extremely high carotene content (Englberger *et al*. 2003, Englberger 2003)—which is not well represented in *ex situ* collections. A proposal is under development to coordinate conservation efforts using complementary *in situ* and *ex situ* mechanisms.

4.4 Use of genetic diversity is maximized

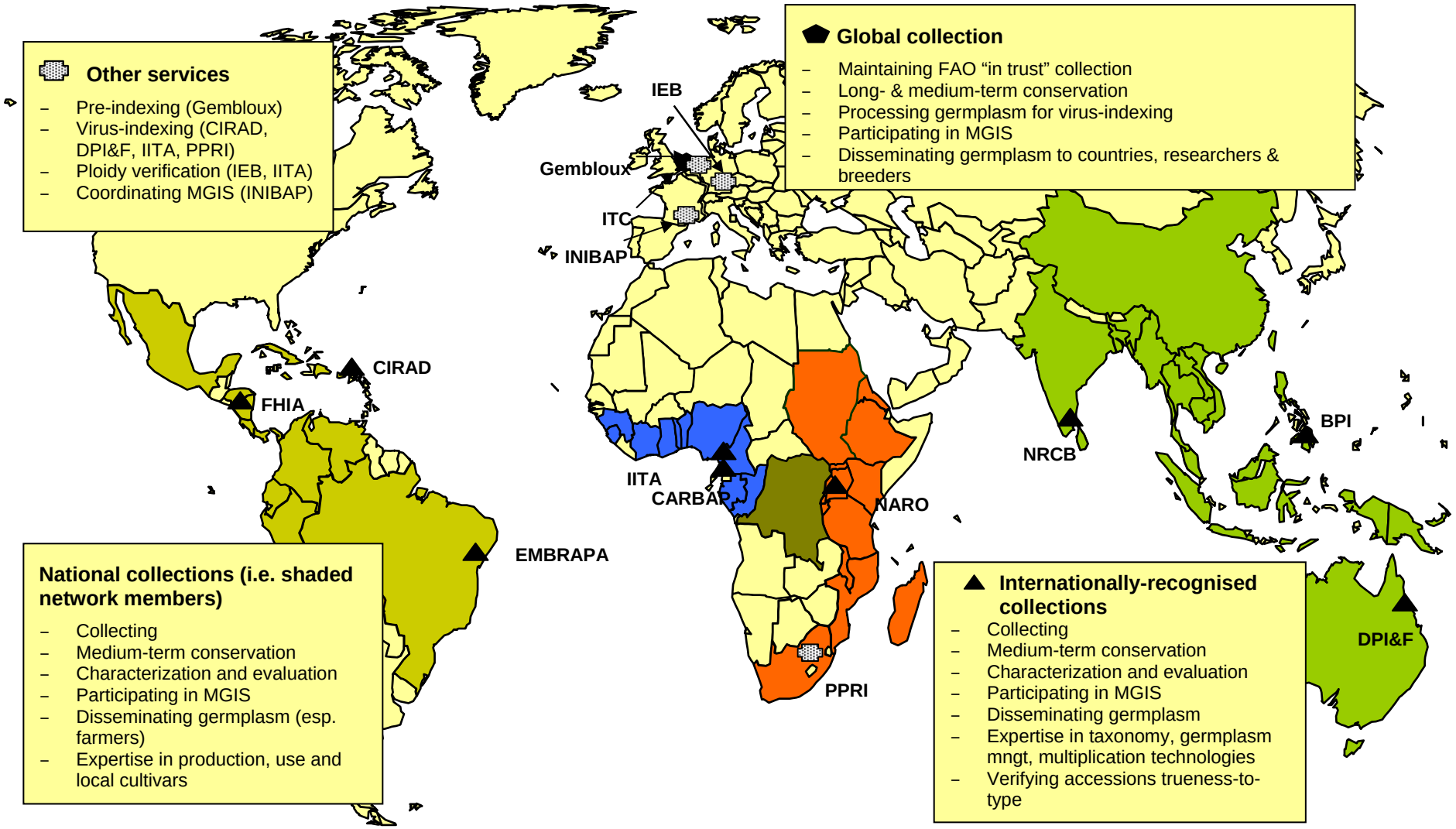
The use of diversity and the services of collections will be promoted worldwide by upgrading collections to serve users' needs and providing easy access to key information about the use of accessions. The partnership of germplasm collections with multiplication, demonstration and dissemination facilities will be a high priority. Where relevant accessions may be kept in different forms according to expressed needs (e.g. lyophilized leaves). Support for awareness-raising efforts to promote germplasm exchange and conservation may also be appropriate.

One major output, to which other initiatives (e.g. IMTP, the HarvestPlus and Generation Challenge Programmes) are adding value, will be a web-based portal that provides a comprehensive one-stop reference system on *Musa* taxonomy, accession availability, characterization, evaluation, and practical experiences in using diversity for improving livelihoods. MGIS and its continued revision will form the foundation of this portal.

Table 3. Roles of collections in the conservation strategy

National collections	Internationally-recognised collections	Global collection
CONSERVATION		
– Collecting and documenting traditional knowledge – Medium term conservation of unique germplasm and improved varieties (priority collections conserve part of the core collection)	– Collecting and documenting traditional knowledge at a national level – Medium term conservation of unique germplasm and improved varieties (priority collections conserve part of the core collection)	– Maintaining FAO "in trust" collection – Long- and medium-term conservation of entire gene pool
CHARACTERIZATION, EVALUATION AND DOCUMENTATION		
– Characterizing and evaluating varieties – Participatory evaluation of germplasm with farmers/consumers – Participating in MGIS	– Characterizing and evaluating varieties (including molecular characterization in some cases) – Verifying germplasm from the global collection in the field – Participatory evaluation of germplasm with farmers/ consumers – Participating in MGIS	– Coordinating and upgrading MGIS (INIBAP) – Participating in MGIS
DISSEMINATION		
– Disseminating germplasm at a national level	– Disseminating germplasm at a national level and potentially at a regional level in specific cases	– Processing germplasm for virus indexing – Disseminating germplasm to all collections, breeders and researchers
SPECIALISED EXPERTISE		
– Production and use, local cultivars	– Expertise in taxonomy, germplasm management and multiplication technologies	– Expertise in taxonomy, in vitro technologies, germplasm exchange & MTAs, accession information management
Other services		
Pre-indexing	University of Gembloux, Belgium	
Virus indexing	CIRAD, France; DPI&F, Australia; IITA, Nigeria; PPRI, South Africa.	
Ploidy identification	IEB, Czech Republic; IITA, Nigeria.	

Figure 4. Map of the collections and their roles



5. Priority collections for support

Criteria developed to prioritize collections in Asia and Pacific

Germplasm accessibility:

- Collection is in the public domain and accessions are available to all users through the use of a material transfer agreement or similar mechanism
- Accessions can be exchanged (i.e. they are healthy and virus indexed)

Genetic diversity

- Collection holds distinct germplasm that is unavailable elsewhere except in duplication (land races and wild relatives)
- Collection is located in a country of high indigenous *Musa* diversity
- The size of the rationalized collection (not including duplicates, synonyms) available in the public domain is at least 200 accessions
- Collection has ecogeographical representation

Status of threat

- Collection is under threat or has no safety duplication
- Collection holds accessions from isolated or threatened areas, where collecting is logistically difficult or expensive (e.g. several days' travel, need for armed guards etc)

Use

- Collection holds accessions with specific sought-after traits
- Collection is documented with at minimum passport data

Willingness to collaborate

- Collection from institution where regional/international collaboration is active (e.g. contributes to MGIS, IMTP, BAPNET activities)
- Government gives high priority to the crop.

A subset of collections in Asia and the Pacific have been evaluated to be of high priority on account of a combination of criteria (see box) relating to germplasm accessibility, genetic diversity, status of threat, use and willingness to collaborate (table 4). Prioritized collections in Sub-Saharan Africa are those which are already recognised to have regionally representative collections and expertise. No prioritization has yet taken place in Latin America and the Caribbean or in the Pacific.

In a rationalized system, collections will receive support according to the roles and activities for which they assume responsibility within the region or sub-region—including the maintenance of any accessions they may hold as part of the decentralized international field collection, but by no means limited to this role. Therefore, it is not expected that all listed collections will receive support but that a selection process would take place according to quality and appropriateness of submitted proposals. In the evaluation carried out for the strategy development, no single collection fulfilled all criteria. Where shortfalls exist (e.g. commitment to long-term conservation, strategy to improve coverage of indigenous genetic diversity, etc.) detailed statements of intent or strategies should accompany proposals.

Table 4. Collections prioritized through evaluation against agreed criteria in Asia and Pacific and through existing

Asia and the Pacific	
Australia	DPI&F Maroochy and South Johnstone
Maroochy: Sharon Hamill Department of Primary Industries & Fisheries, Maroochy Research Station, PO Box 5083, SCMC, Nambour, 4560, Australia Sharon.Hamill@dpi.qld.gov.au South Johnstone: Jeff Daniells Queensland DPI&F, PO Box 20, South Johnstone 4859, Australia danieljw@dpi.qld.gov.au	Field (South Johnstone) and *in vitro* (Maroochy) collection, containing 204 accessions in the field (only one plant per accession) and 350-550 *in vitro*, supplying farmers, breeders and researchers nationally and internationally. Also provides quarantine services for the country and Pacific region. Important role in breeding and entirely supported through government by Australian banana industry.
China	GDAAS &/or SCAU
Lin Bing Xu Guangdong Academy of Agricultural Sciences, Pomology Institute, Wushan, Guangzhou, China 510640 xulinbing@163.net Houbin Chen South China Agricultural University, Wushan, Guangzhou, China hbchen@scau.edu.cn	Field and *in vitro* collection and multiplication centre, containing 220 accessions in the field and *in vitro*, supplying farmers, horticulturists, breeders and researchers in China and internationally. Also concerned with breeding. Field and *in vitro* collection and multiplication centre, containing >350 mats of 130 accessions, supplying farmers, horticulturists, breeders and researchers in China. Main concern is breeding.
India	National Research Centre on Banana - NRCB
Uma Subbaraya National Research Centre for Banana, Thayanur Post, Thogamalai Road, Trichy 62-1-2, India umabinit@yahoo.co.in	Field and *in vitro* collection, containing 4505 mats of 901 accessions in the field and 72 accessions in the lab, supplying farmers, horticulturists and breeders in India. Botanical potential of the collection for breeding is evident.
Indonesia	Solok (Sumani & Aripan) Germplasm Collection
Agus Sutanto Indonesian Fruit Research Institute, Jl. Raya Solok-Aripan Km. 8 Solok, West Sumatera bagusutanto@plasa.com	Field and *in vitro* collection, containing 800 mats of 202 (197) accessions in the field and 70 accessions in the lab, supplying farmers and breeders in Indonesia.
Malaysia	MARDI
Siti Hawa Jamaluddin Horticulture Research Centre Malaysian Agricultural Research and Development Institute (MARDI) P.O. Box 12301, GPO 50774 Kuala Lumpur, Malaysia sitihawa@mardi.my	Field and *in vitro* collection, containing 250 accessions in the field (2 or 3 plants each) and around half that number in *vitro*. Used mainly for breeding.
Pacific Islands	
To be defined	

PNG	Laloki Collection
Mrs Rose Kambuou & Mrs Janet Paofa National Agricultural Research Institute	Field collection of approx. 928 plants of 230 accessions. At least 3 additional working collections also managed in contrasting environmental zones (esp Highlands), one in vitro collection of IMTP materials & 2 small working collections used for trial & commercial planting.
Philippines	**Southeast Asian Banana and Plantain Germplasm Resource Center &/or National Plant Genetic Resources Laboratory *Musa* Germplasm Collection**
Lorna Herradura Bureau of Plant Industry – Davao National Crop Research and Development Center, Bago-Oshiro Davoa City, Philippines Lorna_herradura@yahoo.com Maria Lea Villavicencio Institute of Plant Breeding, College of Agriculture, University of the Philippines at Los Baños, College, Laguna 4031, Philippines	Field and *in vitro* collection, containing 217 accessions, of which 871 mats are in the field and 72 accessions are in the lab; used to supply farmers, horticulturists, breeders and researchers in the Philippines. Field and *in vitro* collection and multiplication centre, containing 234 accessions, of which 800 mats are in the field and 137 accessions are in vitro; used to supply non-commercial farmers, horticulturists, breeders and researchers in the Philippines.
Vietnam	**VASI/Phu Ho Fruit Research Center**
Le Dinh Danh (Phu Ho Fruit Research Center) Ho Huu Nhi (VASI) Vietnam Agricultural Science Institute, Thanh tri, Hanoi, Vietnam nhibiovasi@fpt.vn	Field and *in vitro* collection and multiplication centre of 151 accessions (86 in field - 5 plants/accession and 70 accessions *in* vitro) supplying farmers, breeders and researchers in Vietnam.
SubSaharan Africa	
Burundi	**IRAZ**
F. Ngezahayo Institut de recherches agronomiques et zootechnique CEPGL BP 91 Gitega, Burundi iraz@cbinf.com	Field collection of some 250 cultivars, with some held additionally *in vitro*, with regional responsibility mainly to countries of the Economic Community of the Great Lakes Countries (CEPGL), from which it collects and to which it supplies germplasm, for the use of farmers and researchers.
Cameroon	**CARBAP**
Kodjo Tomekpe Centre africain de recherches sur bananiers et plantains BP 832, Njombe-Douala Cameroon tomekpe@carbap-africa.org	Field and *in vitro* collection containing 2105 mats of 422 accessions and 55 accessions *in vitro*, supplying Cameroon and the region. Regional mandate for germplasm multiplication and distribution. Major concern is plantain breeding.

Nigeria	IITA
Abdou Tenkouano IITA, IITA High Rainfall Station (Onne), PMB008 Nichia-Eleme (Port Harcourt),Rivers State, Nigeria a.tenkouano@cgiar.org or a.tenkouano@stratosmail.net	Field and *in vitro* collection in two locations with 2400 mats of 598 accessions (of which 270 improved hybrids), supplying farmers, breeders and researchers nationally and internationally. Specialised in *Musa* genetics and genetic improvement of AAB-Plantain.
Uganda	NARO
W. Tushemereirwe National Agricultural Research Organization – Kawanda Agricultural Research Institute, P.O. Box 7065, Kampala, Uganda banana@imul.com	Field collection and active multiplication (*in vitro*) centre, containing 2160mats of 253-262 accessions, supplying farmers, horticulturists, breeders and researchers in Uganda and internationally. Provides biodiversity for breeding.
Latin America & Caribbean	
To be defined	

6. Next steps

This conservation strategy for *Musa* remains incomplete in certain areas. It is envisaged as a *working* document to be elaborated and modified as the outcome of activities, events, meetings and experiences are understood and internalized. One important step which will help to give more solid ground and detail to the strategy is the formation of the TAG, which will meet for the first time in May 2006, to develop a road map and agree milestones on the implementation of the strategy. Further activities are planned in the coming months depending on the availability of funding sources, as follows:

- Completion and testing of the third version of MGIS and setting up the web-based interface;
- Training and development of an innovation systems approach to promote the use of diversity in collections in the Pacific;
- Implementation of the initiative to improve and promote standard characterization practices as agreed by TAG, commencing in the Asia and Pacific region;
- Development of agreed strategies to address bottlenecks in exchange of clean germplasm and provision of clean planting material (to be pursued in *Musa* regional network meetings, with input from appropriate stakeholders);
- Analysis of results from field verification of ITC accessions;
- Development of pre-indexing facility at the University of Gembloux;
- Development and testing of pest and disease management strategies for field collections;
- Seek and assure financial support for long-term sustainability of the ITC.

A proposal is being developed for submission to the Global Crop Diversity Trust that embodies these priority activities.

7. Acronyms

BPI	Bureau of Plant Industry, Philippines
CARBAP	Centre Africain de Recherches sur Bananiers et Plantains, Cameroon
CGIAR	Consultative Group on International Agricultural Research
CIRAD	Centre de Coopération internationale en recherche agronomique pour le développement, France
DPI&F	Department of Plant Industry & Fisheries, Australia
FHIA	Fundación Hondureña de Investigación Agricola, Honduras
GDAAS	Guangdong Academy of Agricultural Sciences, China
INIBAP	International Network for the Improvement of Banana and Plantain, France
IPGRI	International Plant Genetic Resources Institute, Rome
IRAZ	Institut de recherche agronomique et zootechnique de la Communauté économique des pays des grands lacs, Burundi
IITA	International Institute of Tropical Agriculture, Nigeria
IMTP	International *Musa* Testing Programme
ITC	INIBAP Transit Centre, Belgium
ITSC	Institute of Tropical and Subtropical Crops, South Africa
KULeuven	Katholieke Universiteit Leuven, Belgium
MGIS	*Musa* Germplasm Information System
NARO	National Agriculture Research Organization, Uganda
NRCB	National Research Centre on Banana, India
NRMDC	National Repository, Multiplication and Dissemination Centres, various Asian countries
PPRI	Plant Protection Research Institute, South Africa
RAPD	random amplified polymorphic DNA
RFLP	restriction fragment length polymorphism
SCAU	South China University, China
SINGER	System-wide Information Network for Genetic Resources
SPC	Secretariat of the Pacific Community, Fiji
STMS	sequence-tagged microsatellite
TWG	technical working group for *Musa* conservation

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Annex – Respondents to the survey of collections

a) Respondents who completed survey forms

1	Australia	Sharon Hamill	Department of Primary Industries & Fisheries (DPI&F), Maroochy
2	Australia	Jeff Daniells	DPI&F-South Johnstone
3	Belgium	Ines van den Houwe	INIBAP Transit Center (ITC)
4	Brazil	Sebastiao de Oliveira e Silva	Empresa Brasiliera de Pesquisa Agropecuaria (EMBRAPA)
5	Cameroon	Kodjo Tomekpe	Centre africain de recherche sur bananes et plantains (CARBAP-NYOMBE)
6	China	Chen Houbin	South China Agricultural University, Tropical and Subtropical Fruit Research Laboratory (SCAU)
7	China	Xu Linbing	Guangdong Academy of Agricultural Sciences, Fruit Tree Research Institute (GAAS-FTRI)
8	Colombia	Joreg Alberto Valendia Montoya	Corporacíon Colombiana de Investigacíon Agropecuaria (CORPOICA-Armenia)
9	Congo	Ferdinand Mouketo	Centre de Recherche Agronomique de Loudima (CRAL)
10	Costa Rica	Miguel Gonzalez	Corporación Bananera Nacional S.A. (CORBANA-LA RITA)
11	Cote d'Ivoire	Simplice Kouassi Koffi	Centre National de Recherche Agronomique, Côte d'Ivoire (CNRA)
12	Cuba	Lianet Gonzales Diaz	Instituto de Investigaciones en Viandas Tropicales (INIVIT)
13	D.R.Congo	Benoit Dhed'a Djailo	Univerisity of Kisangani
14	Guadeloupe	Christophe Jenny	Centre de coopération internationale en recherche agronomique pour le développement (CIRAD-FLHOR, Guadeloupe)
15	Honduras	Juan Ferndando Aguilar	Fundación Hondureña de Investigación Agrícola (FHIA)
16	India	Subbaraya Uma	National Research Centre on Banana (ICAR-NRCB)
17	Indonesia	Agus Sutanto	Indonesian Center for Horticulture Research and Development (ICHORD-IFRURI)
18	Kenya	Margaret Onyango	Kenya Agricultural Research Institute (KARI)
19	Malawi	Dickson Benda	Department of Agricultural Research & Technical Services (DARTS)
20	New Caledonia	Valérie Kagy	CIRAD-FLHOR (New Calendonia)
21	Nigeria	Abdou Tenkouano	International Institute of Tropical Agriculture (IITA (ONNE))
22	Philippines	Maria Lea Villavicencio	Institute of Plant Breeding (IPB, Los Banos)
23	Philippines	Lorna Herradura	Bureau of Plant Industry-Davao National Crop Research and Development Centre (BPI)
24	Rwanda	Antoine Nsabimana	Institut des Sciences Agronomiques du Rwanda (ISAR)
25	South Africa	Connie Frazer	Institute for Tropical and Sub-Tropical Crops (ARC-ITSC)
26	Tanzania	Mgenzi Byabachwezi	Agricultural Research and Development Institute (ARDI)
27	Uganda	Deborah Karamura & Wilberforce Tushemereirwe	National Agricultural Research Organization - Kawanda Agricultural Research Institute (NARO-KARI, KAWANDA)
28	Venezuela	Gilberto Haddad	Facultad de Agronomía Universidad Central de Venezuela
29	Viet Nam	Ho Huu Nhi	Vietnam Agricultural Science Institute (VASI (HANOI))

b) Respondents who provided responses subsequent to the survey

1	Bangladesh	Sahadad Hussain	Bangladesh Agricultural Research Institute (BARI)
2	Burundi	Ferdinand Ngezahayo	Institut de recherches agronomiques et zootechnique (IRAZ)
3	Cambodia	Sakhan Sophay & Pith Khon Hel	Cambodian Agricultural Research and Development Institute (CARDI)
4	Malaysia	Siti Hawa Jamaluddin	Horticulture Research Centre, Malaysian Agricultural Research and Development Institute (MARDI)
5	Micronesia, F.S. - Pohnpei State	Adelino Lorens & Lois Englberger	Pilot Farm, Madolenihmw Municipality
6	Mozambique	Cecilia Ruth Bila	To be confirmed
7	Myanmar	U. Aye Tun	Vegetable and Fruit Research and Development Centre (MASDAP)
8	Pacific Islands	Mary Taylor	Regional Germplasm Centre, Secretariat of the Pacific Community (SPC)
9	Papua New Guinea	Rosa Kambou & Janet Paofa	National Agricultural Research Institute (NARI)
10	Samoa	Laisene Samuelu	Ministry of Agriculture and Fisheries
11	Solomon Is	Francis Wehi, Dorothy Tamasia & Tony Jansen	Manivovo and Central Bauro Highlands collections, Makira Province
12	Sri Lanka	I. J. de Zoysa	Plant Genetic Resource Centre - Horticultural Crop Research and Development Institute (PGRC-HORDI)
13	Sudan	Eltah Ebrahim Mohamed & Salah Babiker Bakhiet	Agriculture Research Corporation (ARC)
14	Taiwan	Chi-Hon Chen	Taiwan Banana Research Institute (TBRI)
15	Tongo	Manaia Halafihi	Research and Extension Division, Ministry of Agriculture and Food
16	Zanibar Island, Tanzania	Khadijah Rajab	Plant Protection Division