A Global Strategy
for the conservation and use of Coconut Genetic Resources
2018-2028

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cirad
LA RECHERCHE AGRONOMIQUE POUR LE DÉVELOPPEMENT

COGENT
Coconut genetic resources for enhanced livelihoods

Bioversity International

Communication with landscapers and the tourism industry

Communication with landscapers will include sending them catalogues of coconut varieties, publishing papers about coconut diversity in their specialized journals, and through direct interaction. In five to ten COGENT member-countries, interns should work on how to integrate coconut conservation in landscaping of both public places and tourism locations. In many tropical cities, the municipality could be engaged in a municipal coconut planting programme from accessions conserved *ex situ* or well-identified varieties from farmers' fields. The city will communicate about its role in conserving genetic resources and will develop a positive and popular image about this role. The same kind of "marketing of genetic resources" could be used for interaction with hundreds of sites and stakeholders including: tourist centres, university campuses, research institute sites, municipal parks, botanical gardens, golf courses, and farms and farmers.

3.1.4. Impact assessment of the communication strategy

The objective of COGENT communication is to increase commitment to conservation and use of coconut genetic resources. For evaluating such a wide objective, impact assessment should be conducted by taking into account the targeted audiences of the communication actions.

Indicators common to all targeted audiences will be those linked to the frequentation of the COGENT website, and of the pictures and videos channels. These indicators will be: numbers of unique visitors; numbers of links from and to other websites; and the number of download of technical documents.

Other indicators to measure the impact of the communication: to the farmers, could be the diversity of planted material in the fields; to the research community would be the number of scientific journal articles citing COGENT; to the media, the number of articles in the press (paper, radio, TV…); to the decision makers, the amount of money dedicated to coconut genetic resources conservation compared to other crops, taking into account the level of importance of the coconut tree cultivation for the country; and to the landscapers, the urban planners and the tourism area, the number of new plantations citing or including coconut trees.

3.2. Revisiting the concept of the Global COGENT coconut collection

The present global system, based on five international genebanks and 19 national genebanks, has been shown to be only partially effective in terms of both germplasm sharing and quality of conservation (as stated in sections 2.6.3 and 2.8). In the 2013 COGENT survey, only 40% respondents agreed that international genebanks are effectively playing their role in distributing germplasm at international level, and 73% believed that the number of international genebanks should be doubled in order to increase the efficiency and number of germplasm movements.

Plate 3.1.

Cultivation of Malayan Dwarf-Types coconut varieties

Wider future variety

1. & 2. Brazilian Green Dwarf cultivated by a Brazilian smallholder with high irrigation and fertilization levels.

3. & 4. Brazilian Green Dwarf planted in an International Genebank and cultivated with low fertilization and no irrigation, during the dry season.

5. Cameroon Red Dwarf cultivated by a Brazilian smallholder with high irrigation and fertilization levels.

6. Cameroon Red Dwarf planted in an International Genebank and cultivated with average fertilization and irrigation levels.

7. Cameroon Red Dwarf planted in an International Genebank and cultivated with low fertilization and no irrigation, during the dry season

. **8.** Pemba Orange Dwarf cultivated in a Tanzanian garden. Pemba Orange Dwarf and Cameroon Red Dwarf are closely related varieties.

9. Huge nursery of Brazilian Green Dwarf in Brazil. Using polybags is strongly recommended when planting Malayan Dwarf-types coconut cultivars.

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Thus, an improved global system will be established to:

- vigorously encourage better quality of conservation and readily sharing of both information and germplasm,
- offer a better protection against threats such as the expansion of lethal diseases, lack of financial resources, land pressure and climate change,
- create new *ex situ* genebanks, either field conservation or cryopreservation of pollen, embryos and embryogenic calluses.

3.2.1 Crucial importance of field genebanks

People commonly reiterate that conserving coconut palms in field genebanks is very costly. However, it should be considered that on the one hand, institutions spend a lot of money on growing coconut palms for conservation purposes; but on the other, farmers are becoming wealthy by planting more or less these same conserved varieties (e.g. in Brazil and Tamil Nadu). *Therefore, with an optimal management, the maintenance of a field genebank could become a financially beneficial affair.*

Fields genebanks are important for many reasons. The conserved germplasm is conserved in a natural environment and thus, continues to evolve in the presence of pests and diseases and other environmental and management factors. Such genebanks remain actually the only way for stakeholders to see the germplasm, and for breeders to characterize and use the material while planted in the field. Tall-type accessions are not clones but heterogeneous populations. There is a need for breeders to see and select the best palms within these accessions. Breeders cannot select the best palms from batches of embryos frozen in liquid nitrogen.

Coconut plantations of 100 to 800 hectares, including those maintained by many COGENT coconut research centres, also offer high earning potential. They are often coveted by neighbouring stakeholders, as many genebanks are facing land tenure problems. As pointed out in section 1.1.2, by planting common Dwarf varieties, Brazilian farmers have achieved a yield of 250 nuts per palm per year, generating a gross annual income of US$10,000-14,000 per hectare. *So a first objective for field genebanks could be to generate a gross annual income of at least US$3000 per hectare.*

3.2.2. Diversification of coconut genebanks

As discussed in Section 2.3.5, some of the coconut genebank already practices intercropping. *In the absence of constraints, coconut genebanks should strengthen their involvement in conserving other tree crops.* This option has several advantages, including to:

- Increase the global commitment to promote the importance of these genebanks. If more than one crop is conserved, genebanks will become increasingly mandatory and committed places for conservation of genetic resources.
- Increase the visiting frequency to the genebank. Researchers working in genetic resources of different crops will meet more frequently, exchange more information, and cooperate more closely.

- Make at least part of the genebank closer to the planting systems used locally by farmers, as many of them practice intercropping.
- Ensure a better agronomic management, especially for intercropped fields that often require irrigation facilities and higher fertilization and will serve as demonstration fields.
- Benefit from the multifunctional use of the landscape. Some coconut plantations, especially seed gardens, are generally surrounded by other tree crops for pollen isolation purposes. Instead of planting any tree crops, these buffers areas can also conserve genetic resources of appropriate species.

Conversely, coconut conservation could also be integrated into many other agricultural research centres' programmes within the tropics. Thousands of coconut palms are planted in these research centres without considering genetic resources and diversity aspects. As observed for instance in 2018 in Fiji at the Koronivia research station, which is mainly devoted to cattle breeding, researchers and breeders working on other crops did not know the names of coconut varieties they are planting in their research centres. Thus, developing multifunctional land use is one of the highest priorities, and hence has thus recently been included as a new theme of the CGIAR research program on Forests, Trees and Agroforestry (FTA). As discussed in section 2.2.3, the CNRA is starting to implement this last approach by duplicating accessions of the international coconut collection in Côte d'Ivoire. Coconut germplasm will be planted in isolated small units of about one hectare, each conserving only one Tall-type accession and each planted in reproductive isolation in the middle of other tree-crop plantations, in 5 of the 13 CNRA research centres scattered around the country.

3.2.3 Geostrategy: doubling the number of international genebanks

COGENT will continue to strengthen links between the 24 genebanks of its member-countries, FAO, the Crop Trust, the Governing Body of the International Treaty, CGIAR and other international stakeholders in order to promote the placing of coconut germplasm collections in the public domain under the Treaty's designation. This has already officially been achieved with genebanks in Brazil, Côte d'Ivoire, India, Indonesia and Papua New Guinea. Once coconut accessions have been given public domain status, they can become freely available to *bona fide* users and exchanged legally, transparently and fairly, via a standard material transfer agreement (SMTA). Non-contracting parties to the international Treaty are also encouraged to use SMTAs to facilitate germplasm exchange.

Despite set-up costs, *designating or creating new international coconut genebanks should not been seen as a costly and demanding strategy*. This will often involve using pre-existing facilities and providing them with extra status. Two additional international coconut genebanks (large coconut plantations of minimum 200 ha) could also be *de novo* established. These new genebanks could become profitable and self-funding within a few years. Success regarding self-funding will depend very much on quality and stable management to achieve potential yields, and added value generated from the production of coconut products.

In **Southeast Asia**, the Indonesian international genebank now faces many difficulties. As discussed above, part of the genebank was recently destroyed. The genebank lacks the necessary manpower and budget to conduct controlled hand-pollinations. Until 2012, all the Tall-type allogamous accessions had been regenerated by open pollination, resulting in unwanted varietal mixes. Excepting a few common varieties, the conserved germplasm originated from within Indonesia only. According to the CGRD, no germplasm was released from the ICG to other COGENT countries. Within the region, the Philippines are the most active in exchanging germplasm, and their genebank is more diversified than the Indonesian one. *Considering the constraints encountered in Indonesia, part of those facilities already existing in the Philippines or in another COGENT country from the region could be formally developed as a new ICG, thus doubling the number of international genebanks in the region.*

In **South Asia**, the international genebank located in India is very active for collecting germplasm abroad, as well for breeding and research activities. However, as discussed in section 2.6.3, during the past 15 years, only a few coconut accessions were released by India to other COGENT countries. At the regional level, Sri Lanka is the most active country in term of exchanging germplasm. It has a smaller genebank than the Indian one, but well-managed and efficiently maintained. *Considering constraints faced in India, part of those facilities already existing in Sri Lanka or in another COGENT country from the region could be formally developed as a new ICG, thus doubling the number of international genebanks in the region.*

For **Africa and the Indian Ocean**, the Marc Delorme research centre, based in Côte d'Ivoire, has been the main provider of coconut germplasm worldwide. It is now threatened by urban development[7] and by the spreading of a phytoplasma lethal disease, which is at about 150km from the genebank. Other countries, such as Ghana, Kenya, Mozambique, and Tanzania are also strongly affected by these kinds of diseases. As recently highlighted by a COGENT recommendation[8], Madagascar has unique coconut genetic diversity. Indonesian travellers visited Madagascar more than ten centuries ago, bringing their own coconuts that created exceptional mixes between the Indo-Atlantic and Pacific coconut groups. *Considering the threats faced by the genebank in Côte d'Ivoire, Madagascar could provide a good location for the creation of a second ICG, and could significantly strengthen its role in providing germplasm and planting material at the sub-regional level* - on the condition that the phytosanitary situation of this country is adequate and well documented.

For **Latin America and the Caribbean**, Brazil is the actual international genebank but faces several challenges to reproducing its existing accessions, including: high labour costs, senile palms becoming too tall, lack of manpower, unsafe palm-climbing techniques and land availability issues. It is presently envisioned to regenerate some old Tall-type from material planted by a private company in the north of the country. Up until 2013, no germplasm has been released by Brazil to any other COGENT

[7] CIRAD has conducted a reconnaissance mission in early 2018.

[8] Recommendation 5 in 2012, see URL:
http://www.cogentnetwork.org/images/2012_sc_meeting/cogent_recommendation_5.pdf

member-countries. Also, the Brazilian genebank has yet to succeed in regenerating its own accessions, so producing seednuts by controlled hand-pollination for other countries is currently not practically feasible. In Jamaica, lethal yellowing is spreading and is a concern in regards to the country size. In Mexico, LYD is also very active, especially in Yucatan, where CICY is located. Any other country from the region could host a new ICG - on condition again that the phytosanitary situation is adequate and well documented. *Colombia is an interesting option: national institutions are already conducting coconut research in collaboration with the CGIAR CIAT research centre located in Cali, in the south of this country; this cooperation could be strengthened in the framework of the creation of a new international coconut genebank.*

For the **Pacific region**, the SPC-ACIAR regional coconut meeting held in Samoa in October 2012 endorsed SPC to be the focal point leading a negotiation role with technical assistance from the COGENT secretariat and linked with APCC. The current international genebank is located in Madang, Papua New Guinea. Although it needs to be duplicated to escape Bogia disease[9], it may not be able continue to serve as the international genebank because of the disease. It will continue to play a crucial role for screening coconut varieties for tolerance to the Bogia disease. Considering these constraints, the scenarios envisioned are for *Fiji and/or Samoa, or another country of the region, to host (a) new international coconut genebank(s)*. The UK Darwin Initiative has funded work to expand the ICG-SP to include sites in Fiji and Samoa. Transferring coconut genetic resources from Madang will need to be carefully assessed and subject to biosecurity protocols of the selected countries. As pointed out in section 3.6.3, the creation of quarantine centres appears as a real necessity.

COGENT will continue to strengthen links between the 24 genebanks of its member-countries, FAO, the Global Crop Diversity Trust, the Governing Body of the International Treaty and other stakeholders, in order to promote the placing of coconut germplasm collections in the public domain through designation under the Treaty. This has already been achieved with genebanks in Côte d'Ivoire and Papua New Guinea. Once coconut accessions have been given public domain status, they can become freely available to *bona fide* users and exchanged legally, transparently and fairly, via a standard material transfer agreement (SMTA).

Today, the existing ICGs face challenges which constrain their capacity to share their germplasm and these constraints need to be addressed as COGENT envisions upgrading selected genebanks' status (from national to international) or increasing the number of international genebanks, or both.

COGENT proposes a certification system to be managed in a similar manner to a Quality Management System for the ICGs. This label should be renewed at

[9] This genebank was very recently threatened by the rapid expansion of the Bogia disease (caused by phytoplasma) which has now spread to an area less than 15 km from the collection. The genebank is isolated from both geographic and scientific points of view. It never had the facility for making controlled pollination, so coconut breeding remains limited. Except for a few common Dwarf and Tall varieties, all the conserved germplasm originates within Papua New Guinea. During the past ten years, many commercial coconut hybrids were planted in the centre, but the accessions of the genebank were not rejuvenated. These accessions have become very tall. Technicians rarely climb tall palms, and the only way they do it is using ladders, which are now too short to reach the inflorescences.

appropriately frequent and regular intervals. To maintain funding from the Trust or other international donors, genebanks should comply with any specific rules defined by within the certification system. These rules should be defined by and within COGENT member countries.

The COGENT Secretariat will promote the establishment of a concerted set of criteria for the quality management system of the international genebanks. **These "COGENT Standards for ICG management" will be adapted for use by coconut field collections** from those standards already published by FAO, the Treaty and the Trust or other institutions conserving germplasm.

Criteria for funding the conservation of accessions by international agencies could include the following:

- Accessions placed in the public domain and available for international germplasm transfer or which can be simply exchanged using a multilateral system.
- Size of accession reaching the standard (45 living palms for Dwarf and 92 for Tall).
- Quality of conservation: accession reproduced with a reliable technique; field observations done; passport and characterization data available in the CGRD and secured in two different sites; off-types well detected and removed from the fields.
- Quality of management = training session and planning for staff, safety measures in place for coconut climbers.
- Quality of equipment = good maintenance of the equipment (field, laboratory, computer, and vehicles), along with adequate regular investments.
- Accessions available in a zone free of those lethal diseases that are transmissible by embryos.
- Accessions preferably conserved first in their country of origin,
- Then preferably conserved by the genebank that shared most of this germplasm at the international level,
- Then in a cryobank if feasible.

Other criteria will be proposed by a group of experts in charge of presenting the "COGENT standard for ICG management" at the SC meeting, followed by discussion and endorsement.

Based on this quality baseline, **the international genebanks will be regularly audited in order to maintain their international status.** National genebanks will also be able to apply for such audits. These regular audits will help the genebank curator and the Director of station to plan and evaluate the cost of the investments, the capacity building of the staff, anticipate the regeneration period, etc.

Within this system, some existing national genebanks could graduate to international status, as using pre-existing facilities and providing them with extra status will provide cost-savings.

Maintaining efficient genebanks, including developing cryobanking facilities, doubling the number of international genebanks will probably require more than the decade covered by this Strategy. *On the other hand, for some of the already existing coconut genebanks, evolving from national to international status could be achieved at much lower cost.*

3.2.4 Sharing international resources between genebanks

Activities for conserving and using coconut genetic resources are currently funded by the many national research institutes, with no help from industry and almost no help from international organizations. Even the funding for the five international collections is assumed by national governments. Presently, network structures for genetic resources conservation seem to be under-valued within the CGIAR system. Thus, crops having their genetic resources under the mandate and management of one of the CGIAR centres seem to have huge advantages when compared to species like the coconut palm for which no CGIAR centre has taken such responsibility. Therefore, it is proposed to bring this imbalance to the attention of the Funding Council.

As a first priority, *the Strategy calls for the development of an endowment fund (or similar sustainable funding mechanism) dedicated to the conservation and use of coconut genetic resources.* The Crop Trust[10] has been established to do so for the crops included in Annex I of the Treaty. Such an endowment would ensure that coconut conservation is placed on a firm financial foundation for the foreseeable future. This section discusses the questions about how such an endowment could help to improve conservation and the sharing of responsibilities between genebanks, and about how the revenues of this endowment could be shared between genebanks.

COGENT proposes creating a label to be managed along the lines of a Quality Management System for the ICG. This labelling should be reviewed or audited on a regular basis. To maintain funding from the Trust or other international donors, genebanks should comply with specific rules defined under this label. These rules should be defined by and within COGENT member countries. This approach has already been launched thanks to the 2012 Crop Trust project "Upgrading Genebanks"[11] and was approved by recommendation No. 5 of the COGENT Steering Committee in November 2017[12] on Genebanks Audit.

The specific interests of countries may sometimes differ from the global conservation approach, for justified reasons. For instance, if the objective, in its strictest sense, is to optimize conservation at the global level, there is no need to conserve the Brazilian Green Dwarf (BGD)[13] by using 20 accessions located in 9 genebanks and totalling 2690

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[10] The Crop Trust was founded by the United Nations Food and Agriculture Organization (FAO) and Bioversity International, acting on behalf of the foremost international research organizations in this field (CGIAR).

[11] See the URL: http://www.cogentnetwork.org/network-projects/past-projects/upgrading-genebanks

[12] See the URL: http://www.cogentnetwork.org/meetings/steering-committee-meetings/18th-cogent-sc-meeting-and-workshop-fiji

[13] Brazilian Green Dwarf (BGD) remains presently also referenced in some genebanks under another cultivar name (Equatorial Guinea Green Dwarf). In Côte d'Ivoire which is the collecting country, the cultivar "Equatorial Guinea Green Dwarf" was renamed as a population of BGD: Brazilian Green Dwarf *Equatorial Guinea*. In other genebanks, this renaming is yet to be fully achieved.

palms. Three replications of 45 palms are sufficient to ensure an efficient global conservation of this cultivar.

Conversely, many researchers from other countries may also be interested to introduce the BGD in their breeding programmes. If COGENT ensures that BGD remains fully available to these countries, the cost of transferring BGD to another country (and subsequent conservation costs) will no longer be covered by the international system, because BGD is already adequately conserved at global level.

The future endowment fund should be devoted to optimizing the conservation of the species at the global level. Its sharing may result in articulating donor requirements and collective wishes of COGENT country-members as described below; *the future endowment fund could be used for the following priority activities*:

- Helping genebanks to comply with the COGENT standards for ICG management and authorize regular audits by independent experts.
- Strengthening conservation quality. For instance, it seems inappropriate to fund Tall-type accessions which have been rejuvenated by open pollination within an *ex situ* genebank (even if at an international genebank). These accessions are mixing when reproduced by open pollination.
- Favouring the observation and the sharing of passport and characterization data. Those compliant genebanks who effectively release their data to the CGRD should be prioritized.
- Developing and applying genebanks' capabilities regarding controlled hand-pollination, *in vitro* cultivation of coconut embryos, and all techniques for extending the lifespan of field-based accessions.
- Helping genebanks to improve their self-funding capability.
- Conducting phytosanitary measures that would avoid the spread of pests and diseases along with the germplasm.
- Safely duplicating internationally agreed accessions in another genebank in a country of a different continent.

To re-iterate the example of the Brazilian Green Dwarf (BGD), there is a need to identify the three accessions of BGD located in three genebanks which would best serve global conservation and which could be supported by a putative endowment fund. Criteria for choosing these accessions could be the following:

- Accession placed in the public domain and effectively available for international germplasm transfer or which can be exchanged using a bilateral or multilateral system.
- Size of accession reaching the minimum standard (i.e. at least 45 living palms).
- Quality of conservation: accession reproduced with a reliable technique; field observations being carried out; passport and characterization data available in the CGRD; off-types within the variety well detected and removed from the fields.

- Accession available in a zone free of lethal diseases transmittable by embryos.
- Preferably conserved in its country of origin: in this particular case, Brazil.
- Then preferably conserved by another genebank that shares readily its germplasm at the international level: in this case, Côte d'Ivoire.
- Then in yet another genebank. BGD is also conserved in Ghana, Sri Lanka, Tanzania, Vanuatu, Vietnam, Ghana and the Philippines. Three countries, namely Ghana, Tanzania and Vanuatu suffer under high pressure of lethal-diseases and cannot be considered for global conservation activities. So the third accession could be conserved in one of these other countries chosen according the criteria list given above and preferably based in yet another continent.

The responsibility of funding such a global system could be shared by participating countries (who could provide part of the infrastructural costs) and by donors (through an endowment fund focusing on improvement of ex situ *conservation of priority accessions).* In order to improve the quality of conservation, funding could be partially allocated on an accession basis, according to expert evaluation conducted collectively by the COGENT network (Bourdeix et al 2009a). The cost of managing such an organization should not exceed 10% of the total amount of available funding.

Building such an endowment fund and securing funding for all the components of the Strategy will certainly take time. The highest priority will be to secure the conservation of the genetic diversity currently held in the public domain in *ex situ* collections and facilitate its distribution.

3.2.5 Towards a concept of a "networked" or "virtual" coconut collection

A networked collection, also called a virtual collection, is located at more than one geographical/institutional site; it spans the genetic diversity of a given species (genepool) and gathers stakeholders having a mutual interest for rationally conserving and exchanging germplasm (Bourdeix et al. 2009b). In the extreme application of this concept, each accession could be conserved at a distinct site, as illustrated by the CNRA project in Côte d'Ivoire described in section 2.2.3 and the recent planting of two small islands in Samoa. All intermediate strategies are thus conceivable.

The establishment of a networked collection would involve more countries, sites and stakeholders in the global coconut conservation system. Because most coconut varieties are allogamous, the main limiting factor to effective conservation is the regeneration of true-to-type accessions via controlled hand-pollination. In the case of coconut, this regeneration technique is very costly, requiring a well-equipped laboratory, well-trained technicians able to climb the palms, and considerable manpower. Not all genebanks can yet afford this. In order to overcome this limiting factor, the *Polymotu* concept involving reproductive isolation (see section 2.2.3) is being proposed as a new approach and will have to be fully evaluated. Several coconut accessions could be planted, each in a distinct, isolated site. These sites could be islets near bigger inhabited islands, insulated valleys, large plantations of a unique variety, large urban facilities such as university campus or golf course, or any other designs

using a pollen barrier. Reproductive isolation will ensure true-to-type breeding of the crop varieties through free and natural pollination.

The criteria for an accession to be included in a possible networked collection have been discussed: germplasm uniqueness, genetic representativeness, ability to reproduce its trueness-to-type and policy considerations.

There is no plan to push the global system of coconut conservation into a networked/virtual collection over the next decade. Gathering accessions held in international genebanks (in the same legal framework, network and database) poses the biggest challenge, including those accessions conserved on islets owned by municipalities, islanders' clans or tourism enterprises. This possible future approach could lead to the modification of the classical delineation between *in situ* and *ex situ* conservation.

3.3. Securing existing *ex situ* coconut genetic resources

The immediate priority of the Strategy is to rationalize and secure the conservation and accessibility of existing and valuable genetic diversity currently maintained in *ex situ* collections worldwide. The following sections present possible solutions to reduce threats to *ex situ* genebanks and to the accessions maintained within them.

3.3.1. Business plans for genebanks

Coconut genebanks could greatly increase their capability for self-funding

An international project should help COGENT genebanks to increase their profitability, in order to secure conservation of coconut genetic resources. *Socio-economist internships should be conducted in at least ten COGENT member-countries for costing conservation activities*, for increasing self-funding of genebanks and for integrating coconut conservation in landscaping of both public places and tourism locations, using a multifunctional land management approach.

Many genebanks and research centres have been established close to cities which are now rapidly expanding. Land pressure on these genebanks is mounting. For instance in India, the CPCRI genebank is now surrounded by Kasaragod residential areas. In Côte d'Ivoire, the ICG-AIO genebank will soon be completely engulfed by popular residential areas of Abidjan, the capital city. Some genebanks will soon remain the main or only green space available in their respective areas. *The status of the coconut genebank should evolve towards and be recognized as a higher benefit for neighbouring citizens*. Genebanks might no longer be seen as exclusive spaces reserved only for researchers. They could evolve towards a kind of botanical garden, public park or green space, open to citizens and where researchers work as well. As citizens will benefit from sharing these spaces, land pressure should decrease.

The first opportunity for self-funding is by selling coconuts produced by the genebanks. A factor limiting genebank fruit yield is often linked to the organization of host institutions. Curators do not have clear interests to increase the level of