# Global Strategy for the conservation and use of Coconut Genetic Resources

## 2018-2028

## Summary Brochure

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Bioversity International

COGENT
Coconut genetic resources for enhanced livelihoods

CGIAR
Research Program on Forests, Trees, and Agroforestry

COGENT is the International Coconut Genetic Resources Network, a network with representatives of national institutions from 39 coconut-producing countries, representing more than 98% of the global production. COGENT aims to strengthen international collaboration in conservation and use of coconut genetic resources; to promote improving coconut production on a sustainable basis, and to boost livelihoods and incomes of coconut stakeholders in developing countries. COGENT was created in 1992 by Bioversity International. www.cogentnetwork.org

This booklet synthesizes the draft full version of the Global Strategy for the Conservation and Use of Coconut Genetic Resources which has been developed by experts both in coconut genetics and breeding, as well as other from along the coconut value chain. COGENT considers that the Global Strategy will provide an informed and realistic foundation for prioritizing coconut research and development. The goal is to use this Strategy to invigorate the commercial coconut sector in a sustained manner, while protecting food security, by encouraging partnerships that increase the impact of research and adoption of technological innovations. COGENT encourages international, regional and national public research organizations, development agencies, NGOs, the private sector and other stakeholders to use the priorities set out herein to guide their activities and investment decisions. The Strategy document will continue evolving as information becomes available.

COGENT would like to thank all those who contributed so far to developing this Global Strategy (see full document annexes for more details of contributors). The layout, design, and editing of this publication were done by Claudine Picq, Vincent Johnson, Ane de la Presa and Alvaro Ullivari. The pictures and plates in this document are authored by Dr Roland Bourdeix, CIRAD; Emmanuel Auguste Issali, CNRA; and Vincent Johnson, Bioversity International. The plates are freely downloadable from the COGENT website.

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# Preface

Grown in around 100 tropical countries, on more than 12 million hectares and by countless homesteads, coconut is culturally and economically important to millions of smallholder households. The future of coconut production and associated livelihoods critically depends on its broad genetic diversity.

Further investment is needed to build coconut stakeholders' capacity and resources across the value-chain, particularly for genetic resources conservation. The Global Strategy for coconut conservation and use (the Strategy hereafter) marks a route to enhanced wellbeing for millions of coconut smallholders across the globe.

In 2014, the world produced around 61 million tonnes of coconuts mainly for copra, oil, fibre, and 'water'. Major producing countries include: India, Indonesia and Philippines.

Over millennia, hundreds of widely diverse coconut varieties have been developed. These genetic resources embrace both rare self-sown populations and planted palms, including genebank accessions and progenies tested in breeders' experiments.

Understanding the dynamics shaping coconut genetic diversity and its uses is critical for its optimal conservation and a better understanding of trait selection will accelerate breeders' progress, helping them to prioritize materials for evaluation.

This document aims to support further discussions to finalize the Strategy. The first two sections introduce the main objectives of the Strategy as well as the context and status of coconut germplasm conservation and use and the third section outlines what remains to be done. The  implementation workplan will be articulated during and beyond the 2017 COGENT Steering Committee meeting.

COGENT Secretariat

# Towards a Revised Strategy

The low commitment to germplasm conservation, as well as to managing emerging pests and diseases, predicted climate extremes, and economic constraints, such as lack of funding and market volatility are major threats to coconut genetic resources.

Since 1991 COGENT has been collaboratively developing the global coconut conservation system and has made this Global Strategy for conservation and use of coconut genetic resources (the Strategy) its top priority.

Most of those involved in coconut improvement and production depend on germplasm from other countries or regions, thus requiring more effective international collaboration.

The Strategy focuses on **seven main objectives**:

1. to reinforce COGENT as a global platform serving Strategy implementation;
2. to strengthen commitment to better conservation and use of coconut genetic resources;
3. to ensure sustainable *ex situ* coconut genetic resources conservation;
4. to develop policies, mechanisms, capacities and resources for safe international germplasm movement;
5. to assess coconut genetic diversity, identify critical gaps in *ex situ* collections, and implement collecting missions;
6. to enhance coconut germplasm use by more effective/comprehensive germplasm characterization and evaluation; and
7. to strengthen *in situ* conservation and ensure that high quality planting material is equitably available and used.

# Vision and goal

The Strategy envisions substantial improvements in the resilience, food security and wealth status of those millions who depend upon coconut. It will optimize the conservation and facilitate the more effective use of coconut genetic resources by bringing together national and international players in both public and private sectors.

Furthermore, it will provide a roadmap towards this more effective germplasm conservation and use, and for engaging support from donors, research organizations and the private sector. The Strategy will be supported by a number of communications initiatives.

Diversity of coconuts © R.Bourdeix

The **outputs of the Strategy** include:

1. the coconut genepool sustainably conserved (*in situ* and *ex situ*);
2. the use of coconut genetic diversity comprehensively documented, valued and strengthened;
3. an efficient global system for the safe and effective exchange of coconut germplasm created; and
4. sufficient commitments to conserve and use coconut genetic resources assured.

Along with Bioversity International (which hosts the COGENT Secretariat) and CIRAD, the CGIAR has helped support developing this Strategy through its research programme "Forest, Trees and Agroforestry" (FTA) aiming to contribute to enhancing income, production and productivity, and biodiversity and ecosystem services.

# Where we are today?

## Coconut genetic diversity

The coconut tree (*Cocos nucifera* L.) is the only known species of the genus *Cocos*. Coconuts are generally classified into two different types: Tall and Dwarf. Two highly differentiated genepools exist: 1) the Pacific genepool which extends from the Pacific coastal areas of tropical America across Oceania and South-east Asia to Madagascar. It embraces many Tall-types; all domesticated self-pollinating Dwarf-types; some Compact Dwarf-types, and a few Semi-Tall-types.; 2) originating in South Asia, the Indo-Atlantic genepool of exclusively Tall-types spreads from the western Indian Ocean to the Atlantic shores. Some of the morphological differences between Indo-Atlantic and Pacific coconuts probably pre-date human intervention.

Coconut is adapted to tropical coastal habitats with high insolation and sandy, saline soils. Its seeds have evolved for natural dispersal by water flotation, although humans have also influenced distribution. Its domestication began in two regions within the Pacific and Indian Oceans respectively.

Complete domestication removes reproductive autonomy, as for the Malayan Dwarf-types. Tall-types are highly variable in their domestication status. Domestication sometimes creates population bottlenecks and reduces coconut genetic diversity. Genomic understanding of phenotypic changes arising from past domestication is important for future coconut breeding.

Coastal coconut landscape © R.Bourdeix

## Information on coconut diversity

Providing access to important information about coconut germplasm is essential to enhance knowledge on coconut diversity, to help rationalize conservation and to improve the use of coconut genetic resources.

**International nomenclature**: Accessions are generally named and coded when they are planted in the genebank, and start to become "international" when the germplasm "passport data"[1] has been transmitted to the Coconut Genetic Resources Database (CGRD) and complies with nomenclature rules. The CGRD data helps comparing accessions and cultivars conserved in different countries.

**Descriptors**: Using standardized descriptors (*Descriptors for coconut*, IPGRI 1995) facilitates collaboration, and improves consistency in databases and other documentation, as well as identifying and reducing duplication.

Palm-by-palm data management in an *ex situ* genebank © R.Bourdaix

# Conserving coconut genetic resources

Plant germplasm is, whenever possible, stored as dried seeds and at low temperatures. However, coconuts are recalcitrant, germinating rapidly and naturally using the nut-water. Therefore, coconut germplasm is maintained *in situ* or *ex situ*, as living palms.

Recommended standardized coconut conservation techniques are applied in *ex situ* genebanks to adequately represent genetic diversity and allow consistent characterization and workable regeneration.

Coconut seedlings © R.Bourdeix

***Ex situ* conservation** is crucial to coconut conservation, particularly for varieties disappearing from farmers' fields. It forms a buffer between users and the fast evolving *in situ* genetic diversity. *Ex situ* germplasm conservation and management includes: targeted collecting; establishing and maintaining field collections; regenerating old accessions using controlled hand-pollination; characterization and identity verification studies; evaluation for priority traits; information management; safe exchange of germplasm; and sometimes germplasm pre-breeding. Such conservation relies solely on field genebanks, where the growing material readily provides seednuts or pollen, and is available for distribution, characterization, evaluation and training. Field collections however, remain vulnerable to pests and diseases, to natural disasters and to land pressure.

[1]Passport data includes information on origin, vernacular name and classification.

## The current global *ex situ* conservation system

From top: Controlled pollination, embryo, *in vitro* culture, female flower and coconut transport. © R.Bourdeix

Currently, coconut germplasm is only conserved as accessions in one or more of the 24 *ex situ* field genebanks, comprising local varieties, introductions from other collections, or accessions collected directly abroad by institutions from Côte d'Ivoire, France, India and Jamaica. Brazil, Côte d'Ivoire, India, Indonesia and Papua New Guinea host international coconut genebanks (ICGs). Totalling more than 1700 accessions, the collections are mostly documented by the CGRD.

All 24 institutes managing the *ex situ* collections have a government mandate to carry out national coconut research and conservation activities such as: acting as national repository; maintaining field collections; characterizing and evaluating for important traits; disseminating germplasm information, and providing and exchanging germplasm.

A recent overview of the status of *ex situ* collection management demonstrated wide variations in collection management. Sixty per cent of the collections routinely conduct characterization, all genebanks generate some evaluation and/or characterization data and most collections carry out screening for pest and disease resistance. Few collections manage their information systematically.

Most collections need to combat genetic erosion, where significant losses are often associated with land-use/tenure issues. Ineffectual controlled hand-pollination causes unwanted mixes between accessions, resulting in useless material being conserved and errors being propagated through germplasm transfers around the world. Most collections are yet to rationalize duplicated accessions, and may require international support for this. Self-pollination inbreeding depresses yields of most Tall-type natural progenies.

Without safety duplication, unique accessions are vulnerable to permanent loss. Some cultivars are unique to one genebank while others are found in more than 15 countries. Many genetically similar accessions are conserved under different names. Coconut breeding and seednut production are mainly conducted by farmers and the private sector. COGENT supports farmers in these efforts, which complement those of national institutions or private companies.

## *In vitro* culture

Germplasm is internationally transferred mostly as *in vitro* cultivated embryos and sometimes as seednuts. Farmers mainly receive coconut planting material as seednuts and seedlings.

*In vitro* collections are not yet used for safety duplication of the coconut field collections or for rapid multiplication and dissemination of disease-free planting material. No *in vitro* multiplication protocol exists yet, so constraints such as contamination result in low regeneration rates. The material also demands regular sub-culturing and may be subject to somaclonal variation. In such cases, rejuvenation and verification of the trueness-to-type of the conserved germplasm has to be performed periodically. However, unlike field material, *in vitro* tissues cannot as easily be infected, and can be kept free from bacteria and fungi.

*In vitro* plantlet
© V. Johnson

## *In situ* conservation

I*n situ* conservation dynamically maintains the species' evolutionary processes and traditional varieties in farmers' fields and in nature. However it is vulnerable to social and economic changes that cause genetic erosion. It hosts an important range of landraces and traditional varieties, which are often mixed and where wide variation in fruit characteristics can be seen. It is difficult to distinguish between such mixed landraces, especially when palms are old and tall.

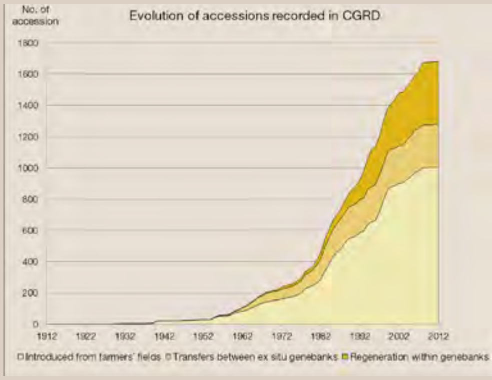
Benefiting local communities and promoting gender equity, sustainable *in situ* conservation requires community participation, control of local land rights, systematically documenting farmers' knowledge of coconut diversity, education, extension and development of environmental awareness.

Coconut conservation-through-use is mainly via producing high value products from specific varieties, seednut production, and ecotourism.

Smallholder farmer in plantation © R. Bourdeix

## Collecting germplasm

The CGRD indicates that 1085 accessions have been collected and successfully transferred to *ex situ* collections. The accessions come from 44 of the 92 coconut producing countries and territories. Additional collecting is strongly encouraged since: a third or less of the existing useful diversity has been adequately transferred to *ex situ* collections; diversity is disappearing from farmers' fields, and currently unavailable diversity is needed for immediate use.




# Coconut information management

Measuring leaf © V. Johnson

Adequate communication and dissemination of reliable information on coconut accessions increases the accessions' value to users of the germplasm, although scientific knowledge or political decisions have also sometimes compromised important traditional knowledge.

Information on morphology, evaluation, origins and locations of accessions conserved *ex situ* is available in the international CGRD developed by CIRAD and released by COGENT into the public domain. The CGRD provides the only means to assess coconut conservation at the global level; access to information on conserved germplasm, and a backup data repository.

The TropGENE database, created by CIRAD, manages genetic information on many tropical crops including coconut, for which it features data on 1293 palms from 160 accessions collected in 34 countries.

The Coconut Data Management (CDM) software created by CIRAD for managing palm-by-palm data is presently used in Côte d'Ivoire, Vanuatu and Jamaica.

The Genesys Global Multicrop portal currently contains data from *ex situ* coconut collections.

Information on *ex situ* germplasm conserved at the global level is available via the databases described above, and in the *Catalogue of Conserved Coconut Germplasm*.

The *Coconut Timeline* is the largest database of scientific literature relevant to coconut genetic resources.

# Using coconut genetic resources

Evaluations show wide variation in coconut germplasm yields, disease resistance and quality. *Ex situ* coconut collections release conserved coconut germplasm on demand to breeders, farmers and other users, mostly Dwarf-types which produce seednuts from natural pollination.

## Coconut breeding

Coconut breeding is lengthy and complex. The first formal coconut hybrids were produced in Fiji in 1926 and first diversity surveys were done in the late 40s. Mass production of hybrid seednuts began in the 70s enabling many farmers to adopt them. Although a global coconut breeding programme network and standardized breeding techniques were created in 1996, most of the national breeding programmes have continued using local cultivars rather than introducing advanced varieties from centres, such as CNRA, Côte d'Ivoire.

Practical coconut breeding activities remain scant. Many have been planting the same hybrids for over 20 years, whilst stakeholders demand new varieties that meet their changing needs. Most breeding programmes are under-resourced and need support to multiply selected varieties. Risks of disease transmission and quarantine restrictions limit seednut exchange. It has proved difficult to engage both decision-makers and coconut breeders to collaborate on common genetic experiments. Breeders prefer to make their own choices according to their countries' needs.

To accelerate the process of breeding, it is crucial to integrate molecular tools in classical breeding.

**Yield** has been the main breeding target in all locations unaffected by lethal diseases. Yield improvement breeding strategies are either intra-varietal selection or inter-varietal hybridization. Experience shows that genetic **disease resistance** may only persist for up to 15 years. Conserving and using germplasm is crucial to enhancing disease tolerance/resistance. Producing **high quality fruit** is a key breeding objective. Overall breeding focus on **quality traits** includes: husk, shell, water and kernel proportions; kernel oil content and fatty acid composition; and coconut water quantity and composition.

Hybrid between Pilipog Green Dwarf x Sri Lanka Green D © R.Bourdeix

Kathi Khao Niao from Makapuno, Thailand © R.Bourdeix

Husk of "Sweet husk" variety (right) and common variety (left) © R.Bourdeix

Regarding **abiotic stresses**, research on **drought tolerance** has demonstrated variability for revival capacity, water-use efficiency, dry matter production and yield. Breeding for cyclone resistance becomes relevant as climate change and frequency of extreme weather events increase. Breeding work for **cold tolerance** addresses a growing potential market in temperate countries.

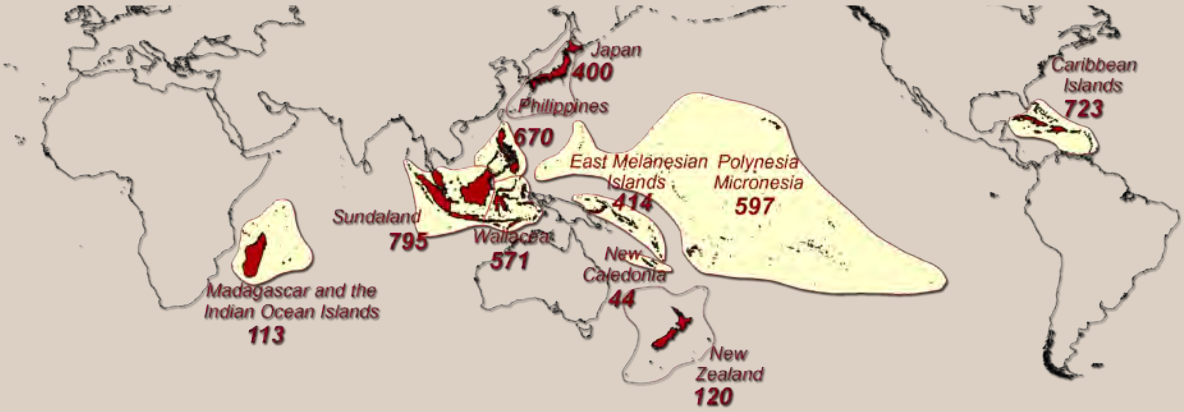
The expanding range and capacity of **molecular and genomics tools** are increasingly used to optimize coconut germplasm conservation and harness its potential. It also complements and enhances traditional breeding approaches and helps to better understand the interactions between genome and environment.

In many countries, few seednuts are made available to farmers and agricultural services often produce a single variety, such as a Dwarf x Tall hybrid, which farmers buy and which then fails to live up to its promise.

**Farmers' roles in seednut production and conservation**: Farmers produce more than 85% of total planting material from the varieties they select and conserve. Farmers' varietal preferences are linked with cultural as well as agronomic and economic values of the planting material, often three to ten cultivars each with few palms, all planted in the same fields.

## Coconut conservation, tourism and ecotourism

**Community-based ecotourism** has become a popular tool for biodiversity conservation and sustainably boosting livelihoods. Coconut palms are starting to be integrated within such conservation and ecotourism initiatives.




Localization of the eight insular biodiversity hotspots which includes important coconut cultivation areas (in pale yellow). Adapted from Bellard *et al.*, 2012.

## Coconut, climate change and coastal areas

**Global warming threatens biodiversity**. Around 180,000 islands enclose a fifth of the world's biodiversity and certainly more than 50% of coconut diversity. At least two thirds of coconut plantations are located in coastal zones and the majority of coconut growing countries are islands. **Growing more resilient varieties** is essential for regions that are projected to be negatively impacted by climate change.

# Coconut germplasm exchange

The coconut genebank network is testament to the importance of coconut germplasm collecting, movement, exchange and conservation.


Stakeholders benefit from better access to a broader range of coconut diversity. Global collaboration in sharing these genetic resources offers numerous benefits including enhanced access to a broader range of germplasm and associated tools, technologies, information and knowledge. However, some countries with coconut germplasm in the public domain have released little or nothing, whereas some countries have bilaterally or multilaterally exchanged a considerable amount of germplasm.

**Moving coconut germplasm may also transfer pests and diseases**. Germplasm is currently transferred only from healthy zones, and using excised embryos or plantlets grown from these embryos. However, many COGENT member-countries need to upgrade their capacity and resources in order to successfully implement and benefit from the embryo transfer protocol. Phytosanitary treatments are systematically applied to internationally transferred material, following the international guidelines.

Transferring *in vitro* cultivated embryos is widely regarded as the safest mode of international germplasm movement, even if not yet proven. Ongoing further researchseeks to dispel a persistent doubt on whether or not lethal yellowing disease can be transferred through embryos.

# Partnerships and networking

Developing this Strategy has strengthened relationships between multiple coconut stakeholders, creating many opportunities to interact and co-publish. The network potentially benefits all relevant institutions involved in managing and using coconut diversity. Six International Thematic Action Groups (ITAGs), gathering expert from public and private sectors are to be created within COGENT. They will be important tools to facilitate networking and partnerships.

COGENT country-members and their representative institutions play a key role in: accessing diverse coconut genetic resources and related information on these resources; building trust; creating awareness; seeking dialogue with decision-makers; developing access and benefit-sharing legislation; safe germplasm movement; and fundraising.

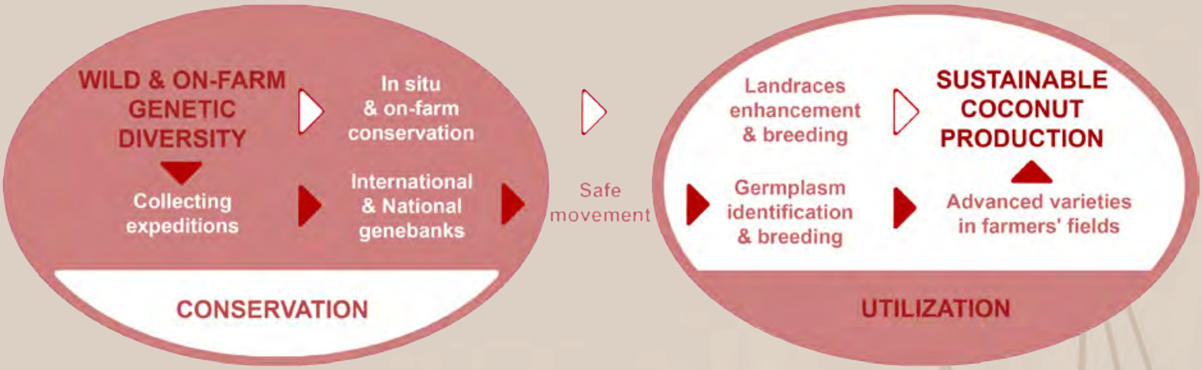
# Plans to better secure and use diversity

This document aims to support further discussions to develop the Strategy implementation workplan.

Growers want easy access to precocious, reliable, high-yielding varieties, adapted to market needs. To help meet these needs, ideally this Strategy aims have conserved around 600 existing and new coconut cultivars by 2027, including rationalizing the present system and collecting new germplasm. Such rationalization should reduce total palm numbers and simultaneously increase their genetic diversity. Researchers will select up to 300 of these cultivars to be newly conserved.

The Strategy has the following strategic components:

1. Reinforce COGENT as a global platform;
2. Strengthen overall commitment to identify, collect, and more effectively conserve, document and use coconut genetic resources;
3. Collaboratively optimize the organization of the COGENT coconut collections;
4. Develop mechanisms, procedures and resources for safe and effective international germplasm movements;
5. Identify genetic and geographical gaps in existing *ex situ* collections and launch collecting missions to boost local conservation;
6. Improve coconut germplasm databases and information sharing;
7. Secure conservation and distribution of existing *ex situ* coconut genetic resources;
8. Integrate genomics-based understanding in conservation and use;
9. Strengthen use of coconut genetic resources by enhancing characterization and evaluation, sharing of breeding results and marketing of improved varieties;
10. Promote and strengthen *in situ* conservation of landraces and dissemination by local stakeholders (using a gendered approach).




# Securing existing *ex situ* coconut genetic resources

## Extending the duration of field-based accessions

Keeping field accessions over a longer period could halve accession maintenance costs. Most expenses are incurred during the first twelve years. Ensuring palm longevity, improving palm-climbing techniques, and reducing palm height will all contribute. Provided safe climbing tools, are available, an accession could be regenerated even when it is 50-years old for Tall varieties and 40 years old for Dwarf, or when more than 20% of its palms are dead, or when annual palm yield is less than 20 fruits during each of 2 successive years.

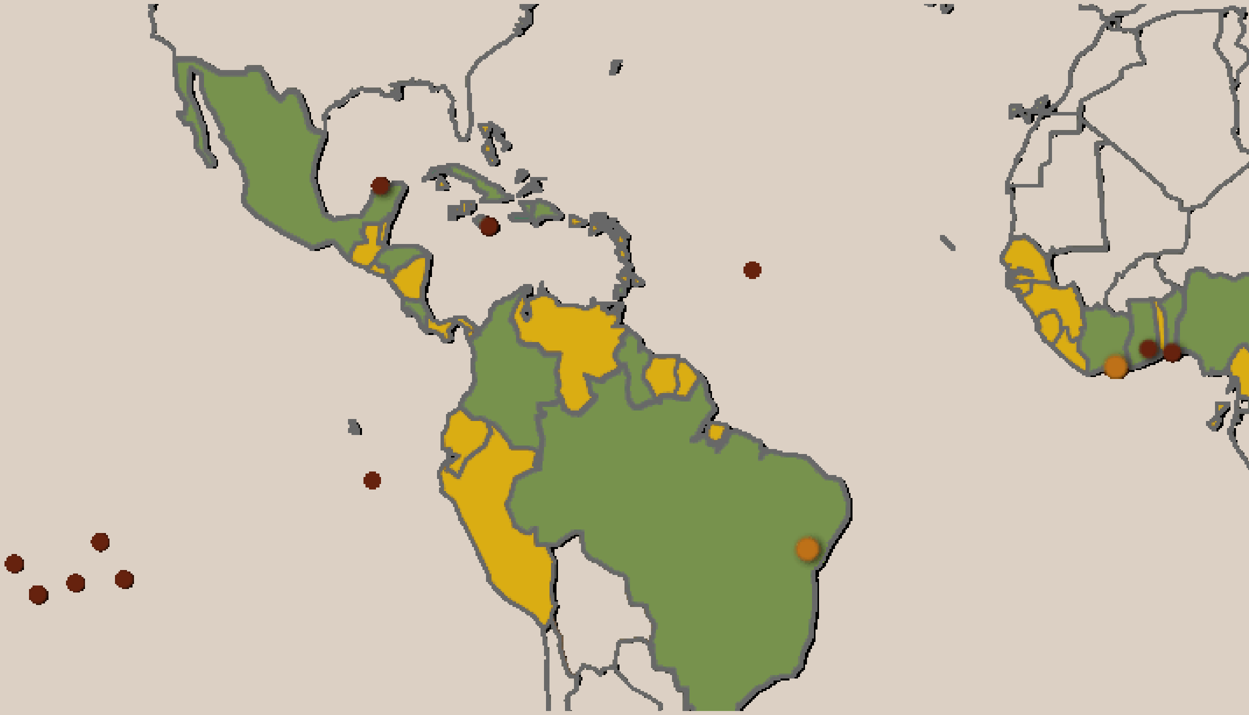
## Germplasm backup

Each coconut cultivar should be conserved in at least two countries in different regions either in two *ex situ* field genebanks or in one field genebank plus one cryobank if techniques and equipment are available. Some believe that aiming for cultivar triplication, involving one extra genebank is needed. The decision to triplicate certain rare accessions will be made on a case by case basis, each considered by the ITAG on *ex situ* conservation and then put to the vote by the COGENT Steering Committee. Accession-level conservation seems the most globally efficient approach. The specificities and history of each accession must be meticulously considered. To achieve effective backup, the ICGs' capacity for international transfer needs upgrading.

COGENT estimates that more than 500 accessions need to be internationally moved based on the COGENT list of conserved coconut cultivars. Based on trait evaluations, cultivars with no genetic merit should be excluded from such transfer. Where countries receive germplasm from abroad in bilateral exchange with their own cultivars, international germplasm sharing could increase.

To avoid unnecessary duplications, COGENT proposes to: update CGRD data; strengthen accession characterization and evaluation; and better facilitate germplasm movements.

COGENT coconut producing countries (green), other coconut producing countries (yellow) and national (brown dots) and international (orange



The procedure for releasing germplasm into the public domain should be optimized and published as international guidelines. This would help avoid any technological and legal constraints to germplasm exchange when promoting the International Treaty[2] .

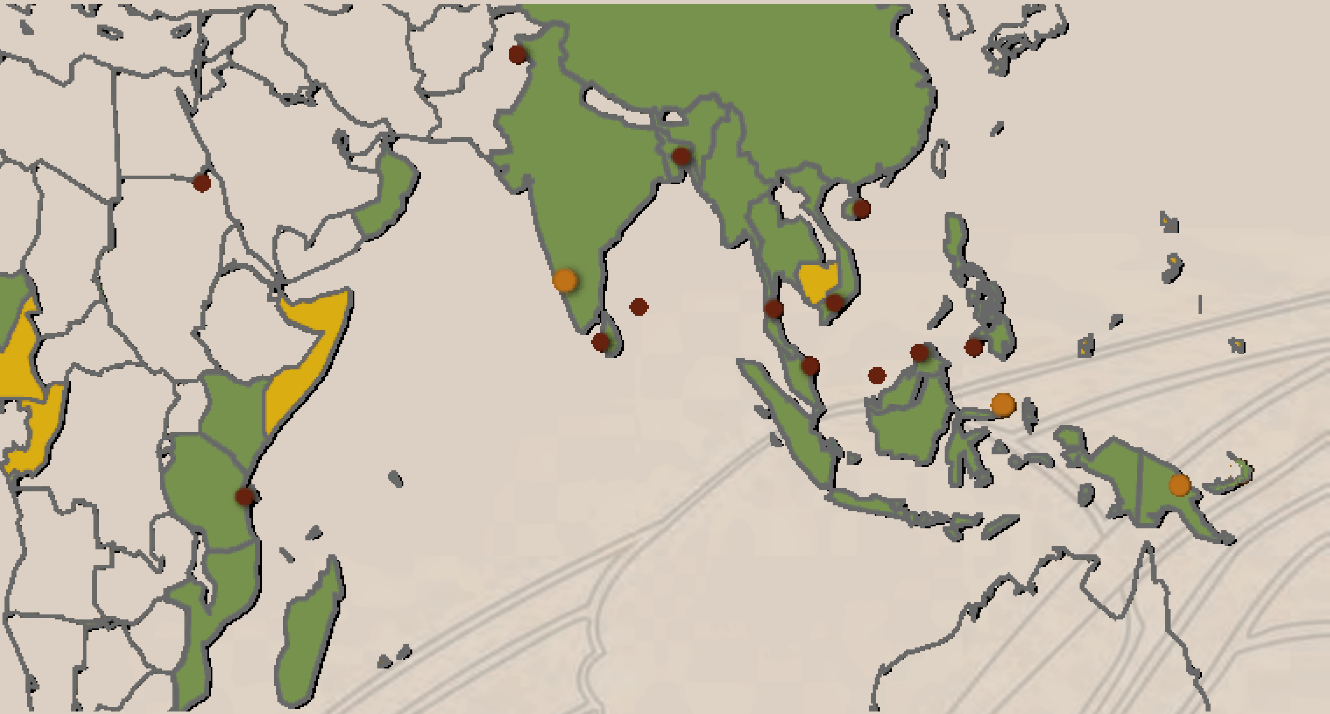
Global multiplication needs to be precisely quantified but could aim to move about 250 accessions within 10 years. Donor countries could pay for preparing and sending the germplasm, and recipient countries could cover other costs.

In coordinating and implementing germplasm transfers the system will need to consider:

- Engaging countries' willingness to place germplasm in the public domain and to share it,
- Upgrading extent and availability of curators' and breeders' germplasm knowledge,
- Understanding what accessions curators' and breeders' want to receive,
- Assessing for each accession: the palm numbers, disease, characterization and evaluation data status, and conservation requirements (the system would not sanction an accession to be conserved in more than three countries).

[2] The International Treaty on Plant Genetic Resources for Food and Agriculture. The objectives of the International Treaty are the conservation and sustainable use of plant genetic resources for food and agriculture and the fair and equitable sharing of benefits derived from their use, in harmony with the Convention on Biological Diversity, for sustainable agriculture and food security.

dots) coconut genebank collections. By de la Presa, A.



## Cryo genebanking

Cryopreservation increasingly offers an attractive means for germplasm conservation, although still poses challenges. Cultivars could be cryopreserved as plantlets, embryos, pollen or tissue, although cryobanking will be costly, partly due to the higher number of embryos needed. Conversely storage costs are low. It may be ultimately cheaper than *in vitro* or field maintenance, except where material needs regular distribution. Frozen pollen would only maintain the father-palm's genetic identity. Pollen could be easily and cheaply harvested and immediately cryoconserved when the accessions are young and short, serving for any subsequent controlled hand-pollinations and successive regenerations.

An embryo cryobank could provide an additional important conservation resource. The embryos from any surplus seednuts could be cryopreserved with little extra cost, thus slowly constituting an embryo cryobank during field regenerations and germplasm exchanges.

Access to effective cloning methods would significantly enhance conservation, allowing conserving tissue able to produce thousands of plants. COGENT has thus recommended using slow growing and/or cryopreserved embryogenic calluses, and continuing research on *in vitro* somatic embryogenesis and cryopreservation of embryogenic callus and zygotic embryos.

If the coconut cloning from embryo plumules method becomes widely available, cryopreservation of embryogenic calluses will also be applied when collecting germplasm in farmers' fields.

COGENT proposes that the more vulnerable on-farm cultivars be preferentially cryoconserved. In return, recipient genebanks could offer double the pollen and/or seedlings from the next generation.

COGENT representatives agree that, if economically feasible, each genebank should have a small cryopreservation unit. Located anywhere, a centralized cryobank could also be established preferably from an already existing cryobank for other crop species. It could also be located outside the coconut cultivation zone to simplify quarantine processes, serving as cryobank, disease indexing centre, and export facility for *in vitro* cultivated embryos and plantlets. Any centralized cryobank would need to: devote funding; develop consistent capabilities; ensure availability, safe conservation and transfer of the germplasm; and preferably serve as a disease-indexing centre.

### Business plans for genebanks

Peri-urban genebanks are threatened by urbanization. A coconut genebank should be acknowledged for its public green spaces available to citizens, thereby reducing land pressure.

New insights on how to integrate these highly valuable green spaces in peri-urban areas should be cultivated and contribute to the sustainable development of megacities of the future.

Marc Delorme Coconut Research Centre (Côte d'Ivoire). © R.Bourdeix

COGENT proposes socio-economic studies on conservation costing, increasing self-funding and multifunctional land management. Genebank diversification could include multiple species' conservation; conservation in municipal landscapes, and conservation-linked ecotourism initiatives.

## Strengthening conservation beyond *ex situ* genebanks

### Conservation through use

Coconut conservation-through-use will continue to include producing high value products from specific varieties, seednut production, and ecotourism. The branding of coconut products by origin or variety could be promoted. Farmers producing coconut-planting material could be registered to help them market their seednuts and seedlings. The 'Polymotu' concept (see box) is one of the approaches that could be evaluated and possibly brought to scale. COGENT will further promote on-farm conservation studies to better understand the socio-economic factors influencing farmers' decisions regarding local conservation and varietal preferences. Early warning systems to identify genetic vulnerability should be developed, highlighting threats to *in situ* conservation of traditional varieties.

Participative landscaping of Nuusafee Island in Samoa using the Polymoyu concept © R.Bourdeix

### Revisiting the classical delineation between *in situ* and *ex situ* conservation

The Polymotu concept uses geographical isolation for conserving and reproducing individual varieties. When a small isolated island or inland site is planted with a single variety, breeding occurs only within this variety and "certified" seednuts are naturally produced, if protected from pollen contamination. More than one variety per crop species can be conserved in each location, if genetic markers are available to differentiate between progenies at the nursery stage. Such multifunctional land management strengthens links between people, landscape and biodiversity. Using this concept, there would be no need for palm climbing and the accession lifespan would be extended. Open-pollination provides true-to-type and cheap seednuts.

## Multifunctional landscape management

Coconut germplasm conservation could be better integrated within multifunctional landscapes. COGENT recommends testing new designs for conserving traditional varieties, producing advanced planting material and developing ecotourism and/or business-related activities, preferably with strong involvement of local stakeholders and beyond *ex situ* genebanks. The Strategy quotes examples of such integrated conservation in Côte d'Ivoire, Fiji, French Polynesia, Indonesia, Thailand, and Vanuatu.

## Botanists, ecologists and the coconut palm

To understand the dynamics of *in situ* conservation, COGENT recommends broader collaboration with botanists and ecologists. Sustainable, synchronous conservation of both endemic species and coconut palms is possible.

# Collecting and filling gaps in *ex situ* collections

COGENT aims to secure adequate funding for collecting missions and for subsequent establishment of the collected materials in ex situ collections. Priority should be given to the endangered landraces, threatened by climate change, biotic stress and/or land pressure. To generate synergies, missions should both collect germplasm and strengthen links between local *in situ* and *ex situ* conservation.

COGENT will facilitate germplasm sharing. Germplasm types and locations have already been prioritized for collection over the next decade as described below. However, in a rapidly changing world, this prioritization could be reconsidered at any time according to requests from the COGENT SC members.

## Collecting compact Dwarfs and other special varieties

COGENT's recommendations for the Pacific include the ICGs in Brazil, India and PNG organizing surveys to collect crucial traditional varieties such as compact Dwarfs, Sweet husk, Makapuno and others.

Cultivation of Dwarf coconut varieties is rapidly expanding on a narrow genetic base. COGENT will promote the preservation of more resilient compact Dwarfs and/or related crosses within the global system, and the associated pollen collection.

The rapid expansion of Dwarf-types could threaten Tall-type diversity. Rare types already disappearing need to be prioritized for collecting. The search for quality traits of coconut fruit, kernel and water should be intensified, together with research to clearly define quality criteria.

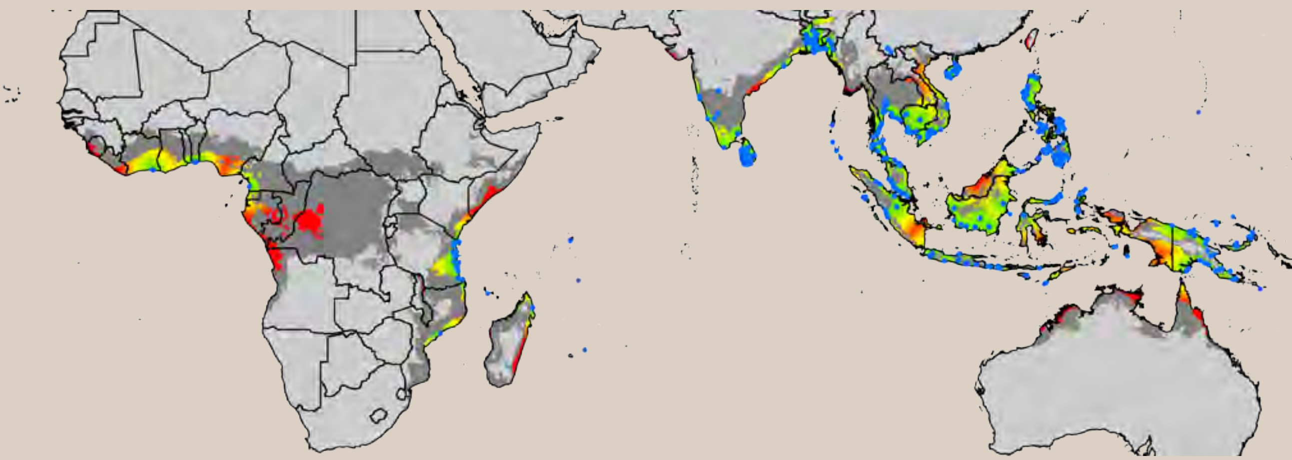
Productive coconuts with suckers have been observed. Such novel germplasm needs safeguarding and studying for *in vitro* propagation.

Within the next decade, the Strategy aims to identify and begin to collect (including from farmers'fields) up to 100 varieties or populations with novel, valuable traits. Multidisciplinary positive selection will help reduce total sample size per population.

Compact Dwarf © R.Bourdeix

## Filling geographical gaps

Gap analysis will be further applied to mapping coconut distribution and agro-climatic preferences. Geographic Information Systems (GIS) tools will increasingly help analyse spatial distribution of different coconut populations. Prioritization will consider size and isolation status of targeted areas. Ethno-biological literature and predicted allelic diversity will also be taken in account. The Strategy aims to collect about 100 populations to help fill existing geographical gaps in existing collections.



Collecting sites corresponding to georeferenced CGRD accessions (blue dots), on a background of climaticaly marginal (medium distance to the nearest colecting site. © Coppens d'Esckenbrugge G., Ullivarri A. & Komba P.

## Collecting for pest and disease tolerance

Collecting missions may focus on areas where disease resistance is expected to be found, even if these areas are not subject to disease pressure. Such surveys often consist of collecting those few surviving palms in a pathogen-devastated zone, although collecting before this 'dead-stem' stage avoids pests spreading to even those disease tolerant palms. In such missions, phytosanitary precautions are crucial to minimize risks of transmitting pathogens along with germplasm. Within the next decade, the Strategy aims to collect about 100 populations having putative pest tolerances.

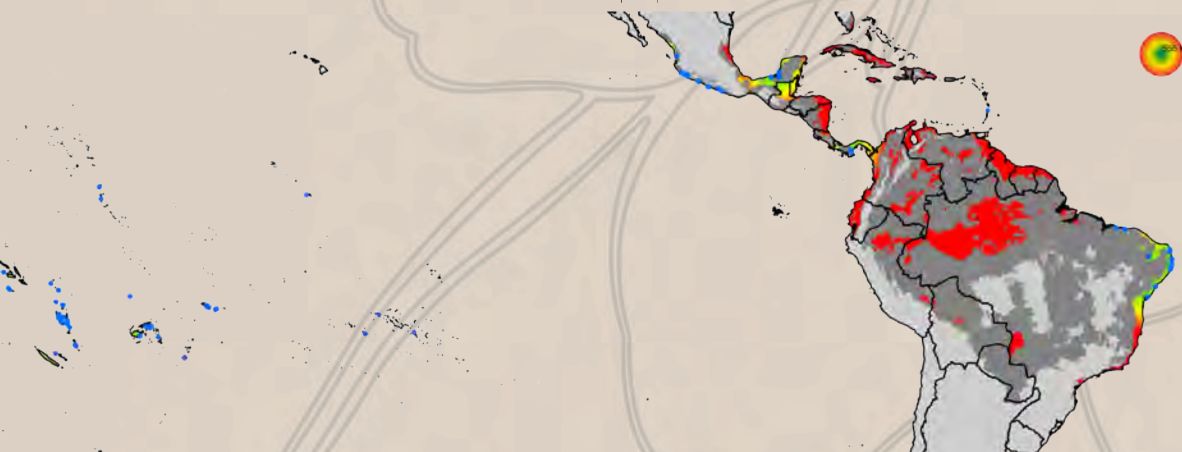
Diseased palms © R.Bourdeix

## Collecting from islands most isolated and/or endangered by climate change

Genetic diversity can be split into that concerned with adaptive variation and other diversity with neutral divergence caused by isolation. Different evolutionary processes suggest alternative collecting strategies. Planning should prioritize protecting historically isolated lineages because these cannot be recovered.

Isolated islands would be selected based on the following key criteria: 1) most endangered by climate change; 2) most geographically remote but preferably inhabited; 3) where copra was never produced; 4) where coconut was or is culturally important; 5) where other crop species of concern coincide.

An ethno-biologist will collect historical information from old planters' communities. Island selection will also take in account host government willingness to conserve germplasm. Based on population genetics, the Strategy aims to collect embryos and pollen from 100 to 200 characterized and screened populations.



grey) of favourable (green to red) areas. The green to red colour scale (see reference circle in upper right corner) indicates the

# Revisiting the concept of the Global COGENT coconut collection

## Diversifying coconut genebanks

When germplasm is conserved in a field genebank environment it continues to evolve, where it can be directly observed and selected. However genebanks are costly, so costs could be offset by generating extra income from surplus production sales. Some coconut genebanks already practice intercropping. This could be extended to strengthen their involvement in conserving other crops. This would increase critical mass, develop economies of scale and other synergies in reciprocal/shared services, and emulate local farming systems.

Coconut conservation could also be integrated into those other agricultural research centres' programmes, where thousands of palms are planted with no conservation role, as currently planned by CNRA Côte d'Ivoire.

## Geostrategy: adjust the number of international genebanks

To promote placing coconut germplasm in the public domain under the International Treaty, COGENT will strengthen links between the genebanks and FAO, the Global Crop Diversity Trust, the International Treaty, CGIAR and other international stakeholders.

COGENT will promote the establishment of a concerted set of criteria for the qualitymanagement system of the international genebanks. These "COGENT Standards for an ICG"will be adapted to coconut field collections, from those standards already published by FAO, the Treaty and the Trust. Based on this quality baseline, the international genebanks will be regularly audited in order to maintain their international status.

The existing ICGs face challenges which constrain their capacity to share their germplasm and these constraints need to be addressed. Maintening efficient genebanks, including developing cryobanks, will probably require more than the decade covered by this Strategy. However, some existing national genebanks could evolve to international status more quickly and at lower cost.

## Sharing international resources between genebanks

A type of endowment fund for optimizing the conservation of coconut diversity at the global level is needed. As a 'Treaty Annex 1' crop, coconut could be eligible for long term funding support from the Trust. Such funding could help: strengthen conservation quality, data sharing and self-funding capacity; develop and apply conservation techniques and phytosanitary measures; and safely duplicate internationally agreed accessions. Funds could be equitably provided by both exchanging countries and a donors' endowment for priority accessions. Funding could be partially allocated on an accession basis. Funding would prioritize securing currently held genetic diversity and facilitating its distribution.

## Towards a “networked” or “virtual” coconut collection

A networked or virtual collection is located at more than one geographical/institutional site; embracing the genetic diversity of a species and gathering mutually interested conservation stakeholders. Each accession could be conserved at a distinct site. Such a collection would involve more countries, sites and stakeholders than in the global coconut conservation system.

Criteria for including an accession in a networked collection may include: uniqueness, representativeness, ability to reproduce trueness-to-type, and policy considerations, providing conservation standards have been met.

The Strategy can only prepare for assembling such a collection as it will take many years.

Fences made from coconut leaves © R.Bourdeix

# Strengthening the distribution and the safe movement of germplasm

## Policies for international germplasm transfers

To effectively formalize germplasm movement, the legal framework for accessing coconut germplasm needs to be optimized by raising awareness and disseminating information. Improved benefit-sharing and legislation will support a more sustainable coconut industry.

Administrative authorization for collecting germplasm must be secured, and local communities need to understand the mission objectives, including their contribution to strengthening local conservation at local level. Local stakeholders also might facilitate more meaningful communication.

Where countries are unable or unwilling to place genetic resources in the global public domain, they could consider exchanging accessions with *ex situ* genebanks under an SMTA, even where exchanging countries have not signed the International Treaty.

The COGENT ITAG on Phytopathology and coconut germplasm movements could be responsible for updating safe movement guidelines, which should then be formally reviewed every 5-10 years. Without ensuring such safe movement, illicit germplasm movements are more likely to spread pests and diseases.

## Transfer of germplasm via embryo culture and pollen

Protocols for embryo culture and transfer need further review, particularly regarding adherence, together with concerted capacity building. Further support is needed to build such capacity and resources within many coconut genebanks.

Research is also needed to optimize international pollen transfer, the cheapest way to share germplasm and the fastest way to include it in breeding programmes.

## Disease indexing and quarantine centres

Germplasm should preferably transit via a quarantine centre, where it could be grown into plantlets, screened for pathogens and then securely transferred. COGENT will support developing such quarantine centres in areas preferably free from lethal coconut disease. Merging quarantine centres with cryopreservation facilities will generate economies of scale. Feasibility studies are needed to assess the various options.

# Promoting the use of coconut genetic resources

## Germplasm characterization and evaluation

The Strategy aims to digitize and disseminate important historical data. The use of accessions depends on their evaluation. The 1995 international coconut descriptors list needs to be revised and completed, to embrace a more comprehensive range of traits, including wind and drought tolerance, and establishment vigour for thriving in changing climates. Mechanisms determining resilience during natural calamities should be integrated within the descriptor list and existing databases. COGENT recommends a revision of the standard descriptors every 5 years and new protocols be annexed to new versions of standard descriptors lists.

Measuring leaf © V. Johnson

## International breeding trials

It is argued that a globally coordinated coconut breeding programme is needed. If some member-countries want to exchange breeding progenies, COGENT will continue to support them. The main challenge will be to obtain stakeholder commitment to exchange this sensitive material.

COGENT will promote concerted breeding programmes to collaborate with the private sector and development partners, through a networking approach mainly at the regional level. Private companies and farmers will be encouraged to be more involved in coconut breeding by hosting at least half the field experiments, with their preferences considered.

## Coconut reproduction patterns

Coconut's complex breeding modes and context require greater study, especially effective pollination distances for optimizing seednut production for certified varieties isolation. The reproduction mode of Dwarf x Tall hybrids needs further assessment to better understand the consequences of this popular crossing. More studies on coconut palm ecology will provide better understanding of its natural reproduction pattern, thus enhancing conservation and seednut production.

## Global objectives in terms of planting material

Considering that farmers are not only 'diversity users', but are central to coconut breeding and seednut production COGENT will focus on: 1) encouraging contexts where farmers have more choice; 2) helping farmers to preserve and increase their knowledge of coconut diversity and breeding, and 3) understanding farmers' and consumers' preferences.

## Promoting farmer-produced planting material

Governments and researchers need to interact more with farmers' organizations to improve breeding and seednut production. Information on farmers and the seednuts they produce should be collected and compiled in a dedicated database.

Farmers and other stakeholders need to also produce their own seedlings. Local traditional knowledge should be preserved and shared. On-farm conservation could be strengthened by participatory varietal selection. Scientific and technical knowledge produced by researchers should be made more accessible, understandable and user-friendly to farmers. Such coconut research could be combined with that of other tree crops.

## Coconut clones, the next revolution?

Farmers could benefit from clones, whose production needs further study. They are produced from somatic embryogenesis (very difficult); shoot multiplication (until now not possible) and suckering (very rare).

Cloning could apply to selecting for any traits, especially phytoplasma tolerance. It could also apply to both the material existing in farmers' fields, and to breeders' best progenies, although scaling-out will take time.

# Genome studies

Genomics will be increasingly applied to coconut germplasm conservation and to associated pathogen and soils studies. Landscape genomics could also enhance understanding of coconut adaptations in relation to climate change. Studies and tools can elucidate environmental interactions and select and breed "adapted" genotypes. In parallel more effective data management and analysis are required. It is hoped that the COGENT genomics ITAG will help coordinate such initiatives.

## Sequencing the coconut genome

Having a high-quality whole genome sequence is the first step in deciphering the coconut genome. This provides the basis for mapping and characterizing key genes for important traits. A mapping population is available in the ICG-AIO in Côte d'Ivoire. It is the basis for further genomic studies. More collaborative projects between Côte d'Ivoire and other COGENT member countries are needed to make the best use of this population.

## Preparing for marker-assisted breeding

Work will concentrate on four sets of populations: Indo-Atlantic Talls, Pacific Talls, Pacific Dwarfs and introgressed Talls respectively. Associated trait data characterization should be undertaken as early as possible. Genes involved in essential processes will be first deciphered. New phenotyping methods are likely to be introduced.

## DNA analysis for more effective conservation

Marker kits will evolve or be replaced by another technique to improve genetic diversity appraisals. Globally, accessions previously analysed with insufficient individuals will be re-sampled. Molecular analysis will help to better understand genetic diversity and to efficiently select the most diverse germplasm to be conserved.

# Improving databases and information sharing

To improve accessibility and interpretation of data, the existing germplasm information systems need more support.

## Data management in genebanks

All collected data should remain available and securely stored. Most genebanks need to install and/or improve local information management systems and data sharing. Characterization and evaluation data from genebanks and breeding trials should be computerized and systematically duplicated in a geographically different location. COGENT has already helped safeguard data thanks to CGRD and CDM software. This role could be extended with respect to intellectual property.

The CDM and CGRD software is becoming obsolete. More complete and modern software are developed for managing palm-by-palm data and the accessions' characterization data. A reliable field palm numbering technique needs to be applied. Technologies such as GPS and bar-coding, or any other fingerprinting technique are becoming increasingly important in managing genetic resources. In order to adapt genebank practices to efficient management of palm-by-palm data and controlled pollinations, COGENT anticipates an upgrade/rewriting of the CGRD software to comply with the new operating systems.

## International databases on *ex situ* conservation

Data from all COGENT *ex situ* Coconut Collections may eventually be included in the Genesys Global Multicrop Portal. The coconut germplasm information system COCOGIS needs further development.

A data-sharing agreement (DSA) will be established between each COGENT country-member (data provider), and the COGENT Secretariat (data receiver), to increase legal protection of the data and acknowledge the stake of each COGENT member-country.

## Farmer linked databases

COGENT proposes an information management system for farmers that will provide comprehensive and updated information on coconut planting material. Simple and accurate documentation should also be made available for those with limited Internet access, perhaps in conjunction with member-country websites. This multilingual online database will be accessible under the section "Seednuts for farmers" on the COGENT website.

Woman farmer next to a Dwarf palm © R.Bourdeix

# Strengthening communication on coconut genetic resources

COGENT's communication strategy aims to increase overall commitment to conservation and use of coconut genetic resources. It will target local stakeholders/farmers, media representatives, decision-makers, consumers and processors, landscapers, and the tourism industry mainly through the key conduit of the COGENT website.

Communication between research institutions and development stakeholders will be strengthened, notably through participatory training events where local knowledge will benefit researchers. COGENT will also target official communication channels, including for an "early warning system" on germplasm threats.

# Enhancing networking and partnerships

Strengthening international cooperation under the Treaty will help rationalize coconut collections, and reduce risks of spreading diseases. COGENT will engage with the International Plant Protection Convention and its Regional Plant Protection Organizations to enhance safe germplasm movement, assisted by collaboration in risk analysis and policy making to avoid pest transmission. The level of interaction in ITAGs needs boosting, via more frequent/regular contact. Capacity building, including training, is needed to allow genebank curators to adopt new conservation and breeding technologies. COGENT should help the coconut genebank curators and staff to benefit from training sessions organized at the regional or global level by international organizations. For coconut germplasm, COGENT supports and strengthens conservation, distribution, legal and technical information and knowledge, collaboration and advocacy.

Harvesting Niu Afa coconut variety. © R.Bourdeix

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