Subject: 17th International Cocoa Research Conference, Yaoundé, Cameroon, 15-20 October 2012.

A Global Strategy for the Conservation and Use of Cacao Genetic Resources, As the Foundation for a Sustainable Cocoa Economy

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Abstract

The future of the world cocoa economy depends on the availability of genetic diversity and the sustainable use of this broad genetic base to breed improved varieties. Decreasing cacao genetic diversity (*in situ*, on-farm and conserved in collections) is a serious problem and all its many causes need to be urgently addressed: the destruction of the Amazonian rainforests, changing patterns of land use, the spread of pests and diseases, sudden changes in climate, and threats from natural disasters and extreme weather. These factors are resulting in an irreversible loss of the cacao genetic diversity so essential for farmers, breeders, and consumers. Most of the countries involved in the improvement and production of cacao are highly dependent on genes and varieties characterized and conserved in other countries and regions. Effective management of cacao genetic resources can therefore only be carried out through international collaboration.

A considerable portion of the global cacao diversity is *in situ*, in farmers' fields and held in genebanks around the world, including two international collections maintained at the Cocoa Research Unit of the University of the West Indies (CRU/UWI), Trinidad and Tobago, and at the *Centro Agronómico Tropical de Investigación y Enseñanza* (CATIE), Costa Rica. Unfortunately, much of the genetic resources maintained in national collections is under-used or at risk, and funding remains insufficient and unstable.

The vision of the Global Strategy for the Conservation and Use of Cacao Genetic Resources is to improve the livelihoods of the 5-6 million farmers in developing countries across tropical Africa, Asia and Latin America and the 40-50 million people who depend upon cocoa for their livelihoods. The specific goal is to optimize the conservation and maximize the use of cacao genetic resources as the foundation of a sustainable cocoa economy. This it does by bringing together national and international players in public and private sectors. The expected outputs are: (1) the cacao genepool is conserved *in situ* and *ex situ* for the long term by a global network of partners, (2) the global system for the safe exchange of cacao germplasm is strengthened, (3) the use of cacao genetic diversity is optimized and (4) the effectiveness of global efforts to conserve and use cacao genetic resources is assured. To ensure these outputs are implemented, the first and urgent task will be to secure funding for the existing cacao genetic diversity currently maintained in *ex situ* collections and accessible in the public domain. CacaoNet will work towards the establishment of an endowment fund for the conservation and use of the most valuable resources in perpetuity.

At the centre of the Global Strategy is the Global Strategic Cacao Collection (GSCC): a "virtual genebank" of accessions of highest priority for conservation, wherever they are physically located. The accessions will be selected to capture the greatest range of genetic (allelic) richness and key traits of interest to users. The inclusion of materials in the GSCC will be on the basis that governments concerned will be willing to place them in the public domain, and will take the necessary political and legal steps to do so.

The Global Strategy, developed by the Global Network for Cacao Genetic Resources (CacaoNet), is the result of a consultation process that drew upon the global cocoa community's expertise in all aspects of cacao genetic resources. It provides a clear framework to secure funding for the most urgent needs to ensure that cacao diversity is conserved, used and provides direct benefits to the millions of small-scale cacao farmers around the world.

1. Introduction

The future of the world cocoa economy depends on the availability of genetic diversity and the sustainable use of this broad genetic base to breed improved varieties. Decreasing cacao genetic diversity is a serious problem and all its many causes need to be urgently addressed: the destruction of the Amazonian rainforests, the loss of traditional varieties, and threats from natural disasters and extreme weather to material conserved in genebanks and field collections. This loss of diversity increases the vulnerability of crops such as cacao to sudden changes in climate and to the appearance of new pests and diseases.

Most of the countries involved in the improvement and production of cacao are highly dependent on genes and varieties characterized and conserved in other countries and regions. The efforts necessary to manage cacao genetic resources effectively can therefore only be carried out through international collaboration.

There is now an urgent need for an integrated Global Strategy for the Conservation and Use of Cacao Genetic Resources and the organization of related information by the cacao community. CacaoNet facilitated a series of consultations with a wide group of experts in cacao genetic resources research and management in order to develop a complete Global Strategy.

1.1 Vision, objectives and outputs of the Strategy

The vision of the Global Strategy for the Conservation and Use of Cacao Genetic Resources is to improve the livelihoods of the 5-6 million farmers in developing countries across tropical Africa, Asia and Latin America who produce around 90% of cocoa worldwide, and the 40-50 million people who depend upon cocoa for their livelihoods.

The overall goal of the Global Strategy is to optimize the conservation and facilitate the use of cacao genetic resources, as the foundation of a sustainable cocoa economy, by bringing together national and international players in public and private sectors.

The Global Strategy promotes the rationalization of conservation efforts at regional and global levels by encouraging partnerships and sharing facilities and tasks.

The Global Strategy is intended to be used as a roadmap towards building an efficient and effective global system that focuses on the needs of small-scale producers. The Global Strategy is an important guiding document for donors, international and national research organizations and the private sector, that will facilitate the raising of support by identifying funding priorities that ensure the conservation, availability and use for improvement of cacao genetic diversity worldwide.

The objectives of the Global Strategy are to:

1. Provide a platform for securing funding for the long-term, ensuring the coordination and implementation of priority cacao genetic resources research, breeding and use of improved varieties.
2. Assess the global cacao genetic diversity and identify critical gaps in existing *ex situ* collections and prioritize collecting missions.
3. Ensure the cost-effective long-term conservation of cacao genetic resources and access particularly to poorly-known gene pools.
4. Strengthen the on-farm conservation of landraces and the *in situ* conservation of wild species especially where the natural habitat is threatened.
5. Strengthen the use of the cacao genetic resources by providing support to breeders and key users through improved characterization, evaluation and support to population enhancement programmes as well as distribution of improved varieties.
6. Improve the documentation on cacao germplasm and the sharing of key information of most value to users.
7. Strengthen the distribution mechanism and safe movement of germplasm.
8. Strengthen the networking and partnerships for global collaboration.

The expected outputs of the Global Strategy are:

- Output 1: The cacao genepool is conserved *in situ* and *ex situ* for the long term by a global network of collections maintaining the most important diversity of cacao germplasm.
- Output 2: The global system for the safe exchange of cacao germplasm is strengthened.
- Output 3: The use of cacao genetic diversity is optimized.
- Output 4: The effectiveness of global efforts to conserve and use cacao genetic resources is assured.

1.2 Strategy development process

This Global Strategy is the result of a long process of consultations involving genetic resource specialists and crop researchers. The Global Strategy will continue to evolve and be dynamic as users' needs evolve. Bridging diverse cultures, philosophies, socio-economic context, approaches to research, development and business, to achieve greater and more sustainable food and agricultural development in the light of increased impact of changing climates are goals that can only be fully achieved together.

In preparation for the establishment of CacaoNet in 2006, a survey was conducted amongst the broader cacao community to gather information on perceived priorities and ideas for the *modus operandi* for CacaoNet. Information on conservation and use from a cacao breeding perspective was also obtained from INGENIC which conducted a survey amongst its members. In July 2011, a consultation meeting was organized in Reading, UK, to review a first draft Global Strategy, involving collection curators, breeders and other experts.

Below is a chronology of meetings and consultations that contributed to the Global Strategy:

- May 2005: Proposal presented at WCF Partnership meeting, Brussels, Belgium
- August 2005: Brainstorming workshop on the establishment of CacaoNet Montpellier, France
- October 2006: 15th International Cocoa Research Conference, San José, Costa Rica
- May 2007: WCF Partnership meeting, Amsterdam, The Netherlands
- December 2007: CacaoNet Steering Committee meeting, Slough, UK
- March 2008: Expert Consultation and CacaoNet Steering Committee meeting, Reading, UK
- March 2009: CacaoNet Steering Committee meeting, Port of Spain, Trinidad and Tobago
- November 2009: 16th International Cocoa Research Conference, Bali, Indonesia
- May 2011: WCF Partnership Meeting & Roundtable, San Francisco, USA
- July 2011: CacaoNet Consultation meeting on the Global Strategy, Reading, UK.

During the period from 2008-2012, a detailed survey was conducted with over 50 cacao germplasm collection holders worldwide to establish a better understanding of the current status of their collections and their future needs. Replies were received from genetic diversity managers from 31 institutions. Based on the proposed outline for the Global Strategy, identified cacao scientists were contacted to solicit technical documentation. Existing drafts of specific sections and other documents available were consolidated and data analyzed from the surveys. The draft sections were reviewed by the key contributors and a first draft for the Global Strategy was developed during the period January to June 2011. A CacaoNet consultation meeting was held in Reading, UK in July 2011 and based on the agreements and recommendations, the second draft Strategy was reviewed by contributors and wider group of stakeholders to be finalized and published in September 2012. It is expected that the continuous review and updating of this Global Strategy will take place within the framework of CacaoNet and this document will serve as the basis for the direction of the global system on the conservation and use of cacao genetic resources.

2. Current status of conservation and use of cacao genetic resources

2.1 Cacao production

Cocoa is produced mainly on small-scale farms in developing countries across Africa, Asia and Latin America. The International Cocoa Organization (ICCO) estimates that 90% of world cocoa production comes from farms with only two to five hectares. According to the World Cocoa Foundation (WCF) there are 5-6 million cocoa farmers worldwide, and the number of people who depend upon cocoa for their livelihood is 40-50 million. Of the total production, 70% comes from Africa (mainly from West Africa), 19% from Asia and Oceania and 11% from the Americas.

Cocoa supply has been characterized by wide fluctuations in production with an average increase in demand of 3% per year (for the past 100 years). Industry experts predict the annual cocoa production in 2020 to rise by some 25%, or 1 million tonnes, to keep pace with the rapidly increasing demand for chocolate in the developing economies of Brazil, China, Eastern Europe and India. The estimated global annual market value of the cocoa crop, according to the ICCO, is between USD 8-10 billions, based on an annual production of 4 million tonnes and a monthly average daily price of cocoa beans between USD 2,264 to 2,359 per tonne. Compared to many other tree crops, there has been little investment in scientific research to improve cacao production, and the number of breeders is very low.

Most of the planting material is low yielding, often due to its high susceptibility to prevailing pests and diseases. However, preliminary evaluation of collections and farmers' populations has shown the existence of wide variation for disease resistance and quality. Furthermore, only a few varieties have been selected for sensory quality aiming at the specialty cocoa market.

2.2 Genetic diversity of cacao

The genus *Theobroma* is divided into 22 species of which *Theobroma cacao* is the most widely known. These *Theobroma* species are found naturally in tropical lowland rainforests extending from the Amazon basin through to southern Mexico (18°N to 15°S). Cacao was domesticated at least 3000 years ago in Mesoamerica. The diverse use of cacao led to it being widely grown in Mesoamerica before the arrival of the Europeans, with further subsequent spread through South America and then globally in the early 18th century.

Hybridization between genetic groups, both natural and as a result of human actions, has resulted in novel hybrid populations and varieties.

Cacao genetic resources comprise the range of genetic variability that provides the raw material for breeding new and improved varieties to achieve a more economically sustainable cocoa production system, thus contributing to the economies of cacao producing countries.

2.3 Conservation of diversity

Conservation and management of cacao genetic resources includes: targeted collecting, maintenance of field collections, effective characterization and identification, evaluation for important traits, information management, effective and safe exchange of germplasm and related information, and in some cases germplasm enhancement.

Since the early part of the 20th century, numerous missions have been undertaken to collect and conserve cacao *ex situ* in genebanks. The catastrophic impact of cacao diseases led to the expeditions to collect disease resistant germplasm from the Upper Amazon region in the 1930s, but in recent years more emphasis has been placed on systematic collections to capture genetic diversity.

There are many national collections in the Americas, the centre of origin, and in other cacao producing countries. Over 40 collections maintain in excess of 24,370 accessions of cacao.

Of these, two are international collections managed by the Cocoa Research Unit of the University of the West Indies (CRU/UWI), Trinidad and Tobago and the *Centro Agronómico Tropical de Investigación y Enseñanza* (CATIE), Costa Rica. These two institutes have entered agreements with the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) to maintain global collections of cacao genetic resources for the long term and to make this germplasm freely available to any professionally qualified institution or individual. This strong international commitment requires sustainable funding to ensure these resources are conserved in perpetuity.

Although the international collections at CATIE and CRU/UWI have been supported by public and industry sources for many years, this support has not yet been secured for the long term.

Most collections have some degree of duplication, internally and with other collections. At the same time, only a few have a strategic safety duplication of their unique materials at a different site to guard against natural disasters. Misidentification of trees within collections, which can be as high as 30%, is also an important problem.

In surveys of collection curators, the main limiting factors they mention that hinder the use of germplasm in breeding, are:

1) Lack of information and knowledge (particularly evaluation) about the materials.
2) Constraints in accessing materials (quarantine and policies).
3) Relatively narrow genetic base available.
4) Few breeding programmes and breeders.
5) Lack of funding for research and breeding programmes.
6) Current funding of most institutes is inadequate.

2.4 Improvement of cacao

Although scientific cacao breeding began more than 70 years ago, only about a quarter of all cacao farms consist currently of improved varieties. Cacao has always been plagued by serious losses from pests and diseases, with estimates of losses as high as 30% to 40% of global production (USD 1-2 billion).

Scientists worldwide are looking for ways to produce cacao trees that can resist evolving pests and diseases, tolerate droughts, meet manufacturer's needs, and produce higher yields. These programmes depend on the availability of substantial genetic diversity together with an understanding of how best to use it, and powerful new technologies, such as molecular genetics, genomics, proteomics and eco-geographical remote-sensing techniques, have increased the value of these genetic resources.

The preliminary sequencing of the cacao genome is a promising step in advancing breeders' ability to deliver improved trees to farmers, and advances in informatics have also markedly increased the capacity to use, analyse and communicate related data and information.

2.5 Movement of germplasm

Exchange of cacao germplasm and related information is an essential condition for use in research, plant breeding and agricultural development.

Although national and international genebanks hold a considerable range of cacao genetic diversity, access to these resources and information is often restricted by the lack of a clear legal and policy framework at institutional, national and regional levels. National laws that restrict access and use of plant genetic resources have emerged in many countries. Partly as a result, current global arrangements for the exchange of cacao genetic resources rely heavily on the two international collections held by CATIE and CRU/UWI. With the exception of these collections, there is little transfer of germplasm between countries.

Movement of cacao germplasm brings with it the potential risk of transfer of pests and diseases. The risk is particularly acute when germplasm is moved between cacao-growing regions that have different endemic diseases. Currently the safe global movement of germplasm, including testing for the presence of viruses, is through the International Cocoa Quarantine Centre at the University of Reading UK, (ICQC,R). The USDA/ARS facility in Miami, USA, offers quarantine facilities for regional transfers.

It is essential that users have access to the latest information highlighting the risks associated with pests and diseases and recommendations on appropriate quarantine measures. The 2011 updated Safe Movement Guidelines for Cacao (2010, End, M.J.; Daymond, A.J.; Hadley, P.), compiled under the auspices of CacaoNet, includes descriptions and information on an extensive range of pests and diseases and information on quarantine measures.

2.6 Information on diversity

Providing access to important information about cacao germplasm is an essential component of the Global Strategy. The main purpose of conserving the genetic diversity is so that it can be used, but a key factor in its utilization is the availability of related useful data.

Information on morphology, evaluation, origins and locations of a large number of cacao varieties (genotypes) can be found in the International Cocoa Germplasm Database (ICGD) (www.icgd.reading.ac.uk), developed for the cocoa community at the University of Reading UK, and genetic information is available online through TropGENE (http://tropgenedb.cirad.fr/tropgene/JSP/interface.jsp?module=COCOA), hosted by CIRAD in France. ICGD and TropGENE contain information related to clonal material or varieties. And although they link some information to individual trees or accessions, they are not designed to be germplasm management tools.

Genebank curators recognize the need for information management systems to manage their collections and to provide access to data and images. The two international collections have adequate systems, but a lack of local expertise, time and funding are major constraints that prevent progress in many other collections. The resulting lack of adequate documentation systems for cacao collections restricts the further development of a global cacao genetic resources information system.

3. Strategic components

Based on the constraints affecting the current systems and the general recommendations made by the cacao genetic resources community, the future direction of the Global Strategy has the following eight strategic components, also illustrated in Figure 1 hereafter:

1. Securing existing *ex situ* cacao genetic resources and their distribution
2. Developing a Global Strategic Cacao Collection (GSCC)
3. Genetic diversity gap filling in *ex situ* collections and collecting
4. Ensuring the *in situ* and on-farm conservation of important genetic diversity
5. Strengthening the distribution mechanism and safe movement of germplasm
6. Strengthening the use of the cacao genetic resources by providing support to breeders and key users through improved characterization, evaluation within collections and supporting population enhancement programmes
7. Improving documentation and sharing of information on germplasm
8. Strengthening the networking and partnerships for global collaboration

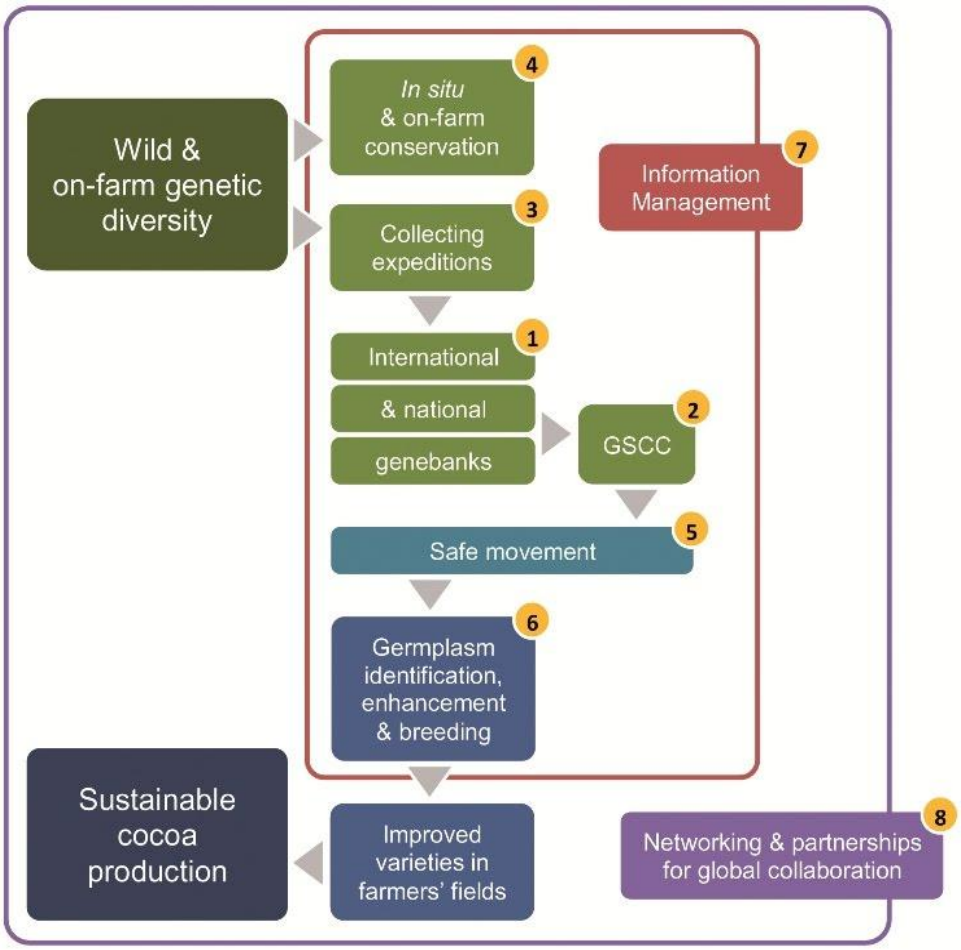


Figure.1 Strategic components from genetic diversity to sustainable cocoa production © C. Turnbull

3.1 Securing existing ex situ *cacao genetic resources*

The immediate priority of the Global Strategy is to secure the conservation and accessibility of genetic diversity currently in *ex situ* collections to all users, particularly those held in the public domain. This diversity is critical to ensure the future of the world cocoa production to generate improved planting materials to face new challenges of pests and diseases, climate change, agronomic conditions, and changing consumer preferences.

The Global Strategy provides a clear framework for public and private sector investment. The current funding of cacao conservation and use activities is born by the many national research institutes with the help of industry and international organisations and is below optimal levels. Many national collections are struggling to keep their material alive. Even the funding to the two international collections at CATIE and CRU/UWI and the

ICQC,R is only a 3-year planning basis, is not guaranteed and therefore their sustainability is not secured over the long-term.

The Global Strategy calls for the development of an endowment fund (or similar sustainable funding mechanism) dedicated to the conservation and use of cacao genetic resources. Such a fund would secure valuable genetic resources in the public domain, forever, by: (1) securing its conservation and availability (including safety-duplication), (2) promoting participation of all partners through support for collecting to fill gaps, characterisation and evaluation, documentation systems, and promoting access to and use of materials and (3) increasing efficiency and effectiveness to reduce costs and increase sustainability.

3.2 Developing a Global Strategic Cacao Collection

The Global Strategy calls for a Global Strategic Cacao Collection (GSCC) to be established as a virtual collection of materials that have been identified as unique and interesting, which each of the participating institutes agrees to maintain in the public domain and make readily available to any bona fide user. The formation of the GSCC will require a coordinated effort to characterize and rationalize available cacao genetic resources.

The development of the GSCC will be based on a thorough assessment of the cacao genetic diversity currently conserved in *ex situ* collections and the identification of those unique accessions for use by breeders and researchers, available in the international and national collections. It will be a dynamic and geographically dispersed collection composed mainly of wild accessions and landraces. The backbone will consist of accessions from the international collections managed by CATIE and CRU/UWI collections, for which considerable characterization and evaluation data are already available in the public domain, complemented with priority accessions from national collections.

The GSCC has agreed criteria that will be used to identify priority accessions. A first set of accessions will be selected on the basis of capturing the greatest possible genetic diversity (in the form of allelic richness) held in *ex situ* collections worldwide. A further set of accessions will be selected on the basis of key traits of interest to breeders and farmers, such as yield, flavour characteristics and disease resistance. The allelic richness component of the GSCC will be relatively static, with new accessions introduced as they are made available from national collections or if unique material is found during collecting missions. The trait component of the GSCC, however, will be more dynamic and subject to a process of rationalization, where existing accessions may give way to new material that expresses a given trait more highly or has a better combination of traits.

Partners will agree on how to share responsibilities for conserving and distributing material from the GSCC, and long-term funding will be discussed with the Global Crop Diversity Trust, other international donors and with the private sector. CacaoNet will continue to facilitate the dialogue between the ITPGRFA and the countries that are maintaining cacao materials targeted by the GSCC, in order to encourage countries to follow the example of CATIE and CRU/UWI and place selected accessions under the Treaty. CacaoNet will also ensure the continuing development of the GSCC in consultation with all its members.

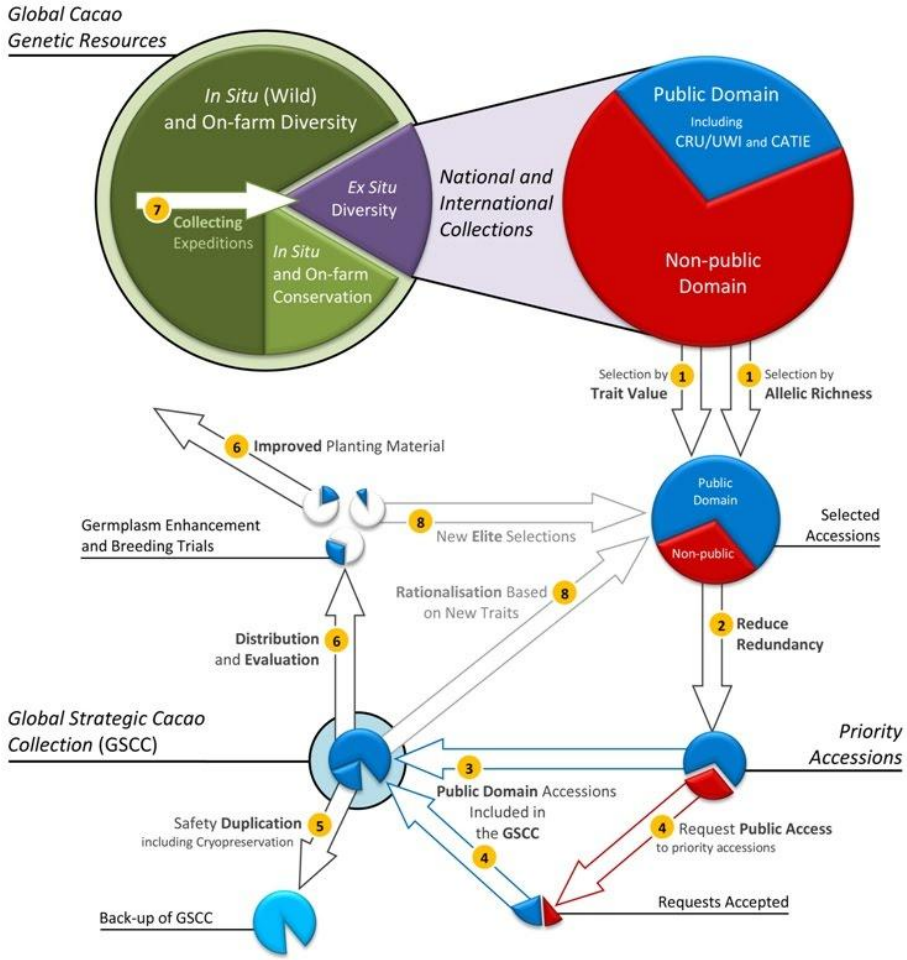


Figure.2 Global system for the conservation and utilization of cacao genetic resources © C. *Turnbull*

3.3 Diversity gap filling in ex situ *collections and collecting*

Analysing the status of the cacao genepool in its centre of diversity (Upper Amazon and Mesoamerica) is a priority for the Global Strategy in order to promote the development of early warning systems for endangered diversity and to understand the threats of genetic erosion.

Geographic Information Systems (GIS) will be used to map the spatial distribution of different cacao populations, using additional information about genetic diversity in wild cacao populations to guide future collecting missions. In addition, collecting will be directed to places where one might reasonably expect to find a higher frequency of desirable traits, such as disease resistance. The main priority for collecting will be to fill gaps in *ex situ* collections, with a focus on threatened wild relatives of cacao and landraces, to facilitate use.

The research will be carried out by a network of experts with complementary skills in taxonomy, diversity analysis and conservation of genetic resources, especially *in situ* conservation. CacaoNet will play a role in ensuring the participation of key stakeholders and to build capacity in diversity analysis in the partners responsible for conservation of cacao in its centre of diversity.

3.4 Ensuring the in situ *and on-farm conservation of important diversity*

In situ and on-farm conservation is influenced by complex social, political and biological factors. Habitats suitable for wild *Theobroma* species are increasingly degraded and fragmented and the drivers and consequences of these changes are currently not well understood. On-farm conservation depends ultimately on farmers as the final decision makers, choosing particular varieties they wish to use and conserve. The traditional cacao varieties that many farmers prefer often have lower yields, but recently some of these have acquired a reputation for high quality and are increasingly coveted by specialty gourmet markets. Some of these landraces

can also be important sources of pest and disease resistance valuable to breeders. It is therefore critical to understand the social and economic factors that influence farmers' decisions to maintain cacao diversity, and to assess the implications of these factors for the design of *in situ* and on-farm conservation strategies.

The Global Strategy calls for a greater effort to understand and conserve the diversity of cacao and its wild relatives, using a variety of initiatives such as national forest reserves, wildlife refuges, and private reserves, all of which can help preserve natural plant communities. Partnerships with governmental agencies with responsibility for forestry and environmental issues and local-level authorities in target countries, plus national and international conservation NGOs, forestry research institutes, farmer communities and civil society organizations, as well as the private sector, will be needed for successful *in situ* and on-farm conservation.

3.5 Strengthening the distribution and safe movement of germplasm

Risks associated with pests and diseases need to be minimised before cacao diversity can be freely accessible and used by different research institutes around the world. The safe movement of cacao germplasm will be promoted through the updated 2011 safe movement guidelines, available to download on the CacaoNet website (www.cacaonet.org), can also be disseminated as printed copies to relevant institutes and to plant health authorities. The guidelines will be translated into French and Spanish and will be updated as new information becomes available.

CacaoNet will work with the International Plant Protection Convention (IPPC) and its regional organizations to ensure that the updated guidelines are widely available to those responsible for the phytosanitary systems in cocoa-producing countries. Part of this will involve developing effective ways to raise awareness of the importance of safe movement of germplasm to the cacao community, working closely with groupings such as INGENIC and COPAL.

The Global Strategy will strengthen the current system of germplasm distribution through the ICQC,R and support the development of new quarantine centres in each of the three regions (Americas, Africa and Asia) to facilitate the safe movement of germplasm within regions.

3.6 Strengthening the use of cacao genetic resources

The use of accessions in the GSCC should start with their further evaluation for economically important traits. Accessions that possess the required traits can then be sent to quarantine before distribution to requesting countries. The Global Strategy will collaborate closely with INGENIC's regional breeding networks and other partners to develop a network of field trials that will evaluate GSCC materials at multiple sites. The network of evaluation sites will develop reliable and standardized methods and share evaluation information publically through CANGIS.

To facilitate the selection of new accessions to be introduced by user countries, a list of the main traits of accessions held in the ICQC,R will be compiled, which will help breeders identify materials of potential interest that are currently available for international distribution. Moreover, information in the GSCC Information Portal will assist them in prioritizing material from local and international genebanks for inclusion in their breeding trials following appropriate quarantine procedures. This work will be done in collaboration with INGENIC and the regional breeding networks where CacaoNet will play a coordination role.

The identification of the most useful GSCC germplasm for distribution, adapting to the evolving needs of breeding programmes, will continue. Germplasm of current interest includes the material from the CFC/ICCO/Bioversity project, materials from the black pod and witches' broom enhancement programmes in CRU/UWI and genotypes with frosty pod resistance identified in CATIE.

3.7 Improving documentation and sharing of information

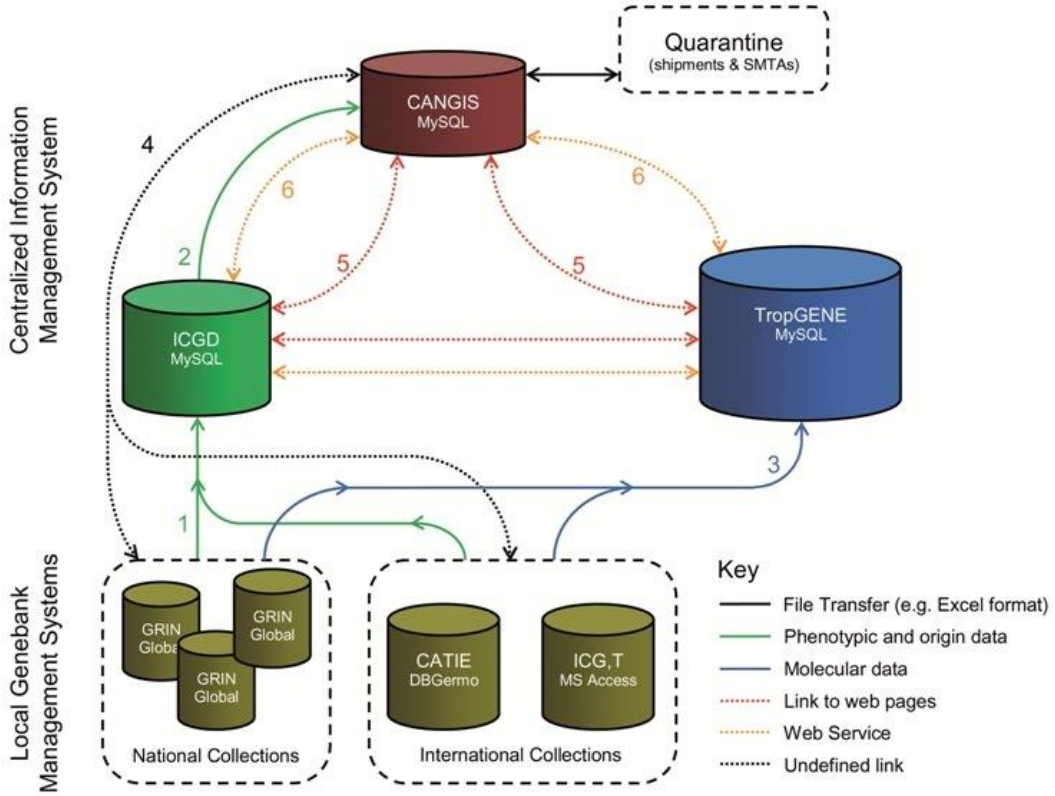
A simple yet robust information management system, that combines comprehensive and accurate information on the origins, conservation locations, availability and characteristics of individual accessions, will be the portal to accessing all relevant information and be a key component in the establishment, management and use of the Global Strategic Cacao Collection (GSCC).

As part of the GSCC information portal, a central database, CANGIS (CacaoNet Germplasm Information System), will bring together all the genebanks and other service providers that collectively form the GSCC and facilitate their effective management. CANGIS will maintain specific, high quality data (including passport

descriptors and the characters supporting an accession's inclusion in the GSCC) on all the individual accessions (trees located at specific sites) that make up the GSCC, and provide a means for users to access this germplasm. CANGIS will coordinate the compilation of characterization and evaluation data from all collections, supported by the molecular verification of the accessions to which the data pertain. CANGIS will link to existing international databases, such as ICGD and TropGENE, in order to access additional information that is of interest to potential users of the germplasm.

Mechanisms will be developed to link the GSCC to information and local knowledge on *in situ* and on-farm genetic resources. These databases will be linked over time to multicrop global information systems, such as GENESYS, as they are developed.

The development of CANGIS will be coordinated by CacaoNet and work closely with national programmes, and collections that do not have a local information management system already in place will be encouraged to adopt GRIN-Global (a freely available genebank management tool and information system developed by the USDA and partners).



1. Characterisation and evaluation data are sent to ICGD (includes non-CacaoNet accessions and information).
2. Once checked and standardized, information on the Global Strategic Cacao Collection accessions is entered into CANGIS.
3. Molecular data are sent to TropGENE (includes non-CacaoNet accessions and information).
4. A degree of direct networking between Global Strategic Cacao Collection IMS and the local genebank management systems is required for monitoring/tracking accessions in the base and active collections. The form this will take will largely depend on the genebank management systems that are adopted (e.g. GRIN-Global).
5. In order to access additional information available from one of the other databases, the user can be linked directly to the relevant page on the collaborating website (all of the databases use the same variety identification codes).
6. Web services allow an information management system to query distributed databases and integrate the results with its own output, removing the need to physically transfer the user to the other database.

Figure.3 Components of the GSCC Information Portal © C. Turnbull

3.8 Strengthening partnerships for global collaboration

All countries with an interest in cacao, i.e. producers, processors and, of course, consumers, will have to collaborate if the goal of the Global Strategy is to be realized.

National cocoa research institutes and their governments will play a key role in ensuring access to a wide range of diverse genetic resources and related information, facilitating the rationalization of collections and building trust among partners. There will have to be dialogue with decision-making political and administrative bodies in each country, not least to facilitate implementation of agreed regulations for cacao quarantine. Capacity building will need to provide training and equipment support to the collections in the GSCC, with particular reference to genebank management, germplasm evaluation, information management and data analysis, and policy and legal aspects of germplasm exchange.

CacaoNet will play an important part in these efforts. It will ensure agreement on the establishment of the GSCC and oversee its development on behalf of all its members, and will actively engage in fund-raising for the implementation of the Global Strategy. CacaoNet will also encourage collaboration with national collections, FAO and the ITPGRFA to help ensure that germplasm, particularly accessions identified for inclusion in the GSCC, is placed in the public domain.

4. Resources required for full implementation of the Strategy

Funding for the conservation and use of cacao genetic resources is currently provided by the many national research institutes (with the help of the cocoa industry, public funds from consuming countries, and international organisations) and is below optimal levels. Support for the two international collections at CATIE and CRU/UWI and to the ICQC,R is offered on a 3-year cycle and is not secure over the long term. Many national collections are struggling to keep their material alive.

In order to safeguard the security of cacao diversity, on which the world depends for cocoa production now and in the future, and to ensure its accessibility and sustainable use, the Global Strategy has estimated the cost of annual recurrent management activities at 1,832,736 USD. It is anticipated that these costs will be significantly reduced over time as the size and composition of the GCSS are refined as a result of the proposed genetic diversity analysis and improvements to the efficiency with which germplasm can be conserved and distributed following research on in vitro methodologies and as new priorities for germplasm distribution come into effect.

The costs for the initial research on the most efficient and effective conservation and management standards, and the resources needed to bring the capacity of partners up to a state where they can play an international role, is approximately 1,350,000 USD for a 3-year period. The workplans and budgets for each of the eight strategic components are detailed in the long version of the Global Strategy available on the CacaoNet website.

The annual recurrent management activities are the following:

- Support for the on-going maintenance of the GSCC.
- Emergency support to safeguard threatened material.
- Management of the GSCC information portal.
- Maintenance of the cacao safe movement network (quarantine facilities).
- Support for priority collecting missions.
- Network of field evaluation trials of priority GSCC materials.
- Training and capacity building for GSCC partners.
- Global partnerships towards the Strategy implementation.

The research and capacity building activities over the first 3-years:

- Support for the GSCC partners to link their *ex situ* collections to the GSCC Information Portal.
- Development of *in situ* and on-farm conservation strategies.
- Diversity analysis to complement existing knowledge and to identify gaps for priority collecting.
- Research on tissue culture methods for safe movement of germplasm.
- Establishment of the regional quarantine network.

Partners and acknowledgements

CacaoNet is grateful to the following individuals who have contributed their expertise to the development of the Global Strategy and to CacaoNet's Working Groups: Yaw Adu-Ampomah (Cocobod), Peter Aikpokpodion (CRIN), A. Alias (MCB), Frank Amoah (CRIG), Freddy Amores (INIAP), Fabio Aranzazu (FEDECACAO), Enrique Arévalo Gardini (ICT), Elizabeth Arnaud (Bioversity), I. Azhar (MCB), V.C. Baligar (USDA), Frances Bekele (CRU/UWI), DM Botello (FEDECACAO), NGR Braz (UESC), Peter Bretting (USDA), David Butler (consultant, formerly of CRU/UWI), Colin Campbell (consultant to ICQC,R), Manuel Canto-Saenz (UNA la Molina), Julio Cascardo (UESC), Nanga Coulibaly (COPAL), Nicholas Cryer (Kraft Foods, formerly of the University of Reading), Andrew Daymond (University of Reading), AA de Paiva Custódio (UFLA), Michel Ducamp (CIRAD), Henry Dzahini-Obiatey (CRIG), Andreas Ebert (AVRDC, formerly of CATIE), Michelle End (CRA Ltd.), Jan Engels (Bioversity), Bertus Eskes (Bioversity), Julie Flood (CABI), Martin Gilmour (Mars Inc.), Karina Gramacho (CEPLAC/CEPEC), Bill Guyton (WCF), Paul Hadley (University of Reading), Brian Irish (USDA), Maria Kolesnikova-Allen (formerly of IITA), Philippe Lachenaud (CIRAD), Brigitte Laliberté (Bioversity), Smilja Lambert (Mars Inc.), Kelvin Lamin (MCB), Claire Lanaud (CIRAD), Tony Lass (CRA Ltd.), Betsabe Leon-Ttacca (ICT), Rob Lockwood (consultant), Uilson Lopes (CEPEC/CEPLAC), Bob Lumsden (consultant to WCF), Edna Luz (CEPEC/CEPLAC), Richard Markham (ACIAR, formerly of Bioversity), Juan Carlos Motamayor (Mars Inc.), Claire Nicklin (CCD), Salomon Nyassé (IRAD), Wilbert Phillips (CATIE), Désiré Pokou (CNRA), Mario Resende (UFLA), Eric Rosenquist (consultant to WCF, formerly USDA), Max Ruas (Bioversity), Binti Bakar Saripah (MCB), Ray Schnell (Mars Inc. formerly USDA), Stela DVM Silva (CEPEC/CEPLAC), Carmen Suarez (INIAP), Surendra Surujdeo-Maharaj (CRU/UWI), Martijn ten Hoopen (CIRAD), Jean-Marc Thévenin (CIRAD), Mike Thresh (consultant to ICQC,R), Chris Turnbull (University of Reading), Pathmanathan Umaharan (CRU/UWI), Jay Wallace (CEPEC/CEPLAC), Stephan Weise (Bioversity), Andrew Wetten (University of Reading) and Dapeng Zhang (USDA).

CacaoNet would like to thank the Task Force that compiled the Global Strategy: Brigitte Laliberté (Bioversity), Michelle End (CRA Ltd.), Martin Gilmour (Mars Inc.) and Stephan Weise (Bioversity). CacaoNet is grateful to Bioversity, CIRAD, COPAL, ICCO, Mars, University of Reading and WCF for providing the opportunities and facilities which have enabled its Steering Committee and Working Groups to meet. CacaoNet would like to thank all those cacao germplasm collection managers for their collaboration in providing detailed information on the status of their collection and these are from the following organisations:

- Benin - Centre de Recherches Agricoles Sud Bénin (CRA-SB)
- Brazil - Comissão Executiva do Plano da Lavoura Cacaueira (CEPLAC) and Instituto Agronômico de Campinas (ICA)
- Costa Rica - Centro Agronómico Tropical de Investigación y Enseñanza (CATIE)
- Côte d'Ivoire - Centre National de Recherche Agronomique (CNRA)
- Cuba - Estación de Investigaciones de Cacao (EIC-ECICC)
- Dominican Republic - Instituto Dominicano de Investigaciones Agropecuarias y Forestales (IDIAF)
- Ecuador - Instituto Nacional Autónomo de Investigaciones Agropecuarias (INIAP)
- France and French Guiana - Centre de Coopération internationale en recherche agronomique pour le développement (CIRAD)
- Ghana - Cocoa Research Institute of Ghana (CRIG)
- Guyana - Mabaruma/Hosororo Organic Cocoa Growers Association (MHOCGA)
- Honduras - Fundación Hondureña de Investigación Agrícola (FHIA)
- India - Central Plantation Crops Research Institute (CPCRI)
- Indonesia - Indonesian Coffee and Cocoa Research Institute (ICCRI) and Bah Lias Research Station, Sumatra
- Malaysia - Malaysian Cocoa Board (MCB)
- Nicaragua - Laboratorio de BIOciencia, UNAN-Managua
- Nigeria - Cocoa Research Institute of Nigeria (CRIN)
- Papua New Guinea - Cocoa and Coconut Institute (CCI)
- Peru - Central Piurana de Cafetaleros (CEPICAFE), Instituto de Cultivos Tropicales (ICT), Universidad Nacional Agraria de la Selva (UNAS) and Universidad Nacional de San Antonio Abad del Cusco (UNSAAC)
- Thailand - Chumphon Horticultural Research Centre (CHRC)
- Togo - Centre de Recherche Agronomique de la zone Forestière (CRAF)
- Trinidad and Tobago - Cocoa Research Unit of the University of the West Indies (CRU/UWI)
- UK - International Cocoa Quarantine Centre, University of Reading (ICQC,R)
- USA - United States Department of Agriculture (USDA)

- Venezuela – Instituto Nacional de Investigaciones Agrícolas (INIA)

The development of the Strategy was supported by financial and in-kind contributions from the Cocoa Research Association Ltd., UK (CRA Ltd.) Mars Inc, the U.S. Department of Agriculture, Agricultural Research Service (USDA/ARS), World Cocoa Foundation (WCF), Bioversity International and the CGIAR Research Programme on Forests, Trees and Agroforestry.

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