

**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 Centre of the University of the West Indies (CRC/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 and thus to make this material available to users worldwide.

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. The resources the world cocoa economy depends on

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. Cacao genetic diversity comprise the range of 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.

The loss of cacao genetic diversity (*in situ*, on-farm and to a lesser extent 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.

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.

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.

There was 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. The Global Network for Cacao Genetic Resources (CacaoNet) facilitated consultation with a wide group of experts in cacao genetic resources research and management in order to develop a complete Global Strategy.

## 2. Global Strategy Goal, Outputs and Development

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 goal 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 expected outputs are:

- Output 1: The cacao gene pool 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.

Between 2005 and 2012, several key consultation meetings contributed to the Global Strategy such as the WCF Partnership meeting, the 15<sup>th</sup> and 16<sup>th</sup> International Cocoa Research Conferences organized by COPAL and several CacaoNet meetings. From 2008 to 2012, a 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. Cacao scientists were contacted to solicit technical documentation. Draft sections were reviewed by 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.

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. It 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.

## 3. Cacao production and improvement

Cacao was domesticated at least 3000 years ago in Mesoamerica. The genus *Theobroma* is divided into 22 species, of which *Theobroma cacao* is the most widely known, found in tropical lowland rainforests extending from the Amazon basin through to southern Mexico (18°N to 15°S).

Cocoa is produced mainly on small-scale farms in developing countries across Africa, Asia and Latin America. 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. 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 billion, 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.

Most of the planting material is low yielding, often due to its high susceptibility to prevailing pests and diseases. 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.

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.

Although scientific cacao breeding began more than 70 years ago, only about a quarter of all cacao farms consist currently of improved varieties.

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 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.

According to most collection curators the main limiting factors hindering 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 in collections, (4) few breeding programmes and breeders and (5) the lack of funding for research and breeding programmes.

#### **4. What needs to be done – 8 key Strategic Components**

The future direction of the Global Strategy has the following eight strategic components, illustrated in Figure 1:

1. Securing existing *ex situ* cacao genetic resources and their distribution
2. Developing a Global Strategic Cacao Collection (GSCC)
3. Genetic diversity analysis, gap filling in *ex situ* collections through collecting
4. Ensuring the *in situ* and on-farm conservation of important genetic diversity
5. Strengthening the distribution mechanism and safe movement of germplasm and making the conserved germplasm available to users
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

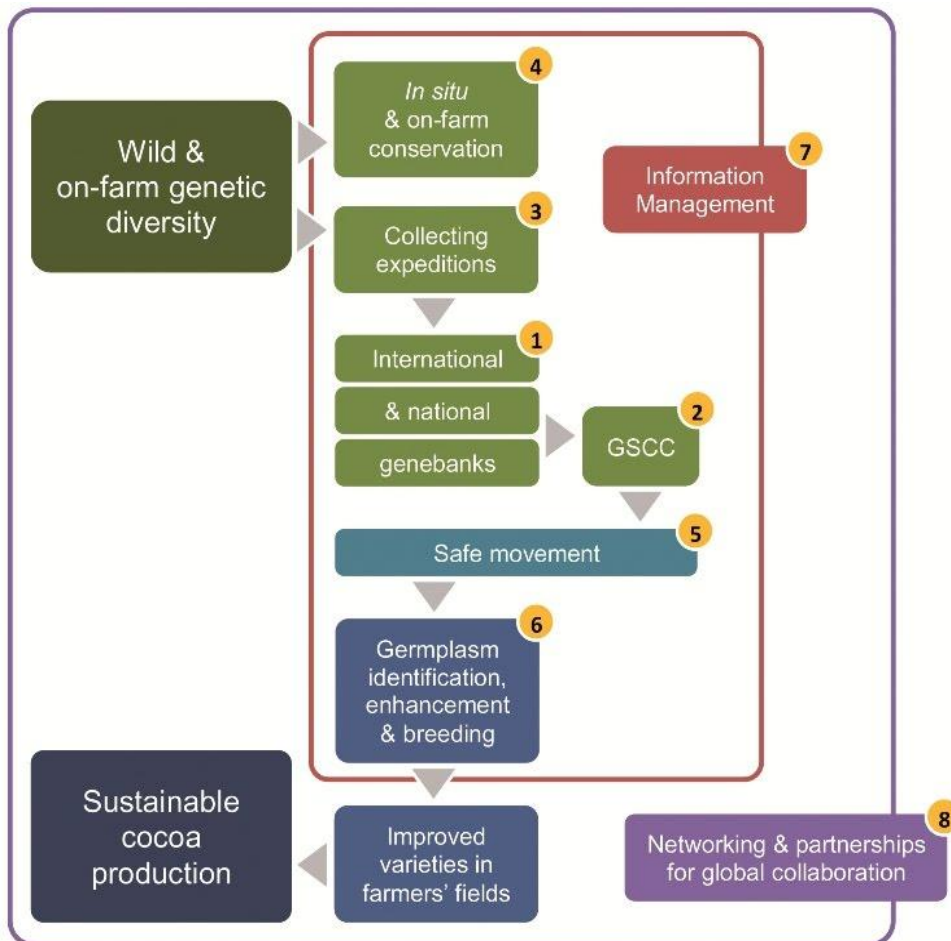


Figure.1 Strategic components from genetic diversity to sustainable cocoa production © C. Turnbull

#### 4.1 Securing existing ex situ cacao genetic resources

Over 40 collections maintain over 24,000 accessions of cacao. Of these, two are international collections managed by the Cocoa Research Centre of the University of the West Indies (CRC/UWI), Trinidad and Tobago and the *Centro Agronómico Tropical de Investigación y Enseñanza* (CATIE), Costa Rica. These two institutes have concluded 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.

The immediate priority of the Global Strategy is to secure the conservation and accessibility to all users of genetic diversity currently in *ex situ* collections, particularly those held in the public domain. 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 of the two international collections at CATIE and CRC/UWI and the International Cocoa Quarantine Centre (ICQC, R) is only a 3-year planning basis, is not guaranteed and therefore their sustainability is not secured over the long-term. This strong international commitment requires sustainable funding to ensure these resources are conserved in perpetuity.

The Global Strategy provides a clear framework for public and private sector investment. It 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.

#### 4.2 Developing a Global Strategic Cacao Collection - GSCC

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

The Global Strategy calls for the development of a Global Strategic Cacao Collection (GSCC), a dynamic and geographically dispersed 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 development of the GSCC will be based on a thorough assessment of the diversity currently conserved in *ex situ* international and national collections and the identification of those unique accessions for use by breeders and researchers. The backbone will consist of accessions from the international collections managed by CATIE and CRC/UWI, for which considerable characterization and evaluation data are available in the public domain, complemented with priority accessions from national collections.

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 formation of the GSCC will require a coordinated effort to characterize and rationalize available cacao genetic resources.

Partners will agree on how to share responsibilities for conserving and distributing material from the GSCC, and long-term funding will be discussed with donors and the private sector. CacaoNet will ensure the continuing development of the GSCC in consultation with all its members.

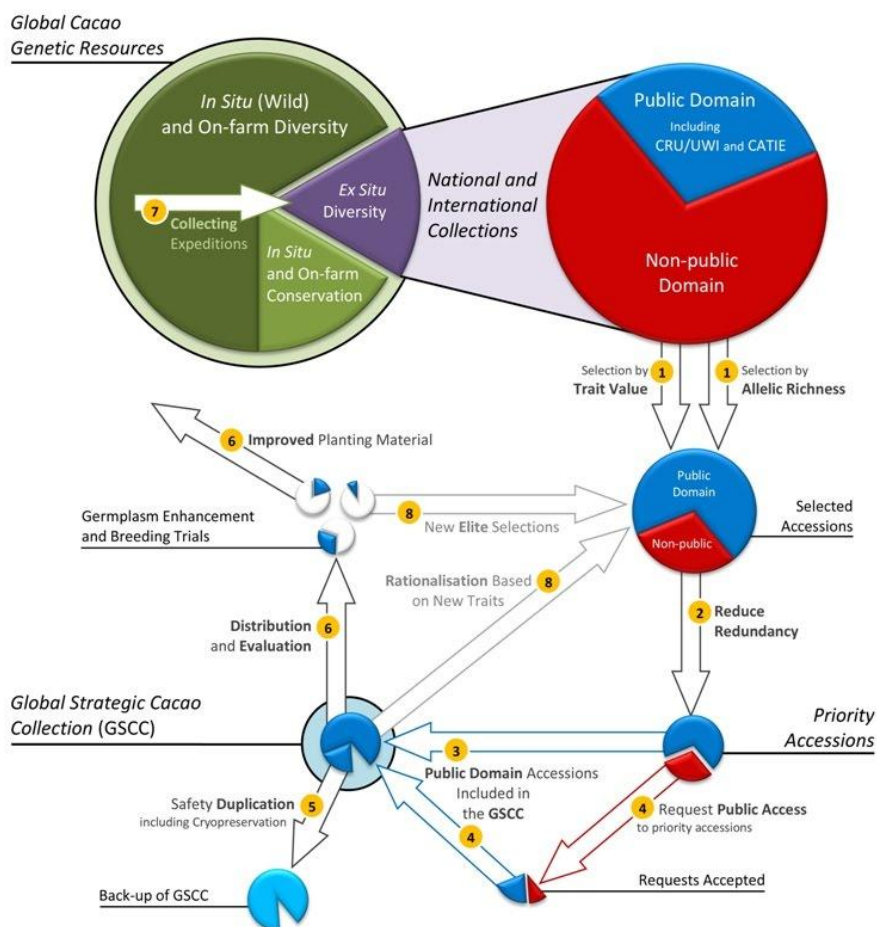


Figure.2 Global system for the conservation and utilization of cacao genetic resources © C. Turnbull

#### 4.3 Diversity gap filling in *ex situ* collections and collecting

Analysing the status of the cacao gene pool 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 priority for collecting to fill gaps in *ex situ* collections and facilitate use, will focus on threatened cacao wild relatives and landraces. 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.

#### ***4.4 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.

#### ***4.5 Strengthening the distribution and safe movement of germplasm***

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. 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.

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, compiled under the auspices of CacaoNet, include descriptions and information on an extensive range of pests and diseases and information on quarantine measures. The guidelines, available on the CacaoNet website, are being disseminated to relevant institutes and to plant health authorities. The guidelines will be translated into French and Spanish and updated as new information becomes available.

CacaoNet will work with the International Plant Protection Convention (IPPC) and its regional organizations to ensure that the 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.

#### ***4.6 Strengthening the use of cacao genetic resources***

The use of accessions in the GSCC should start with their further evaluation for economically important traits. 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.

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 in prioritizing material from local and international genebanks for inclusion in breeding trials following appropriate quarantine procedures. This work will be done in collaboration with INGENIC and the regional breeding networks.

#### ***3.7 Improving documentation and sharing of information***

Exchange of cacao germplasm and related information is an essential condition for use in research, plant breeding and agricultural development. 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), developed for the cocoa community at the University of Reading UK, and genetic information is available online through TropGENE, 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.

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 GSCC. As part of the GSCC information portal, CANGIS (CacaoNet Germplasm Information System), a central database, 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 on all the individual accessions that make up the GSCC, and provide a means for users to access this germplasm. The compilation of characterization and evaluation data from all collections will be coordinated and supported by the molecular verification. 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 multi-crop accession-level 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).

#### **4.8 Strengthening partnerships for global collaboration**

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. Capacity building (training and equipment) will be provided to support the collections in the GSCC, particularly on genebank management, evaluation, information management and data analysis.

CacaoNet 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.

## **5. Implementation of the Global 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. 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 developed detailed workplans and budgets for each of the eight strategic components. The main activities are summarised here:

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.

For more information, please consult the CacaoNet website at: [www.cacaonet.org](http://www.cacaonet.org)