The Centre for Genetic Resources, the Netherlands:

moving from the first 25 years into the future

WAGENINGEN UR
For quality of life

The Centre for Genetic Resources, the Netherlands:

moving from the first 25 years into the future

WAGENINGEN UR
For quality of life

Table of contents

Foreword

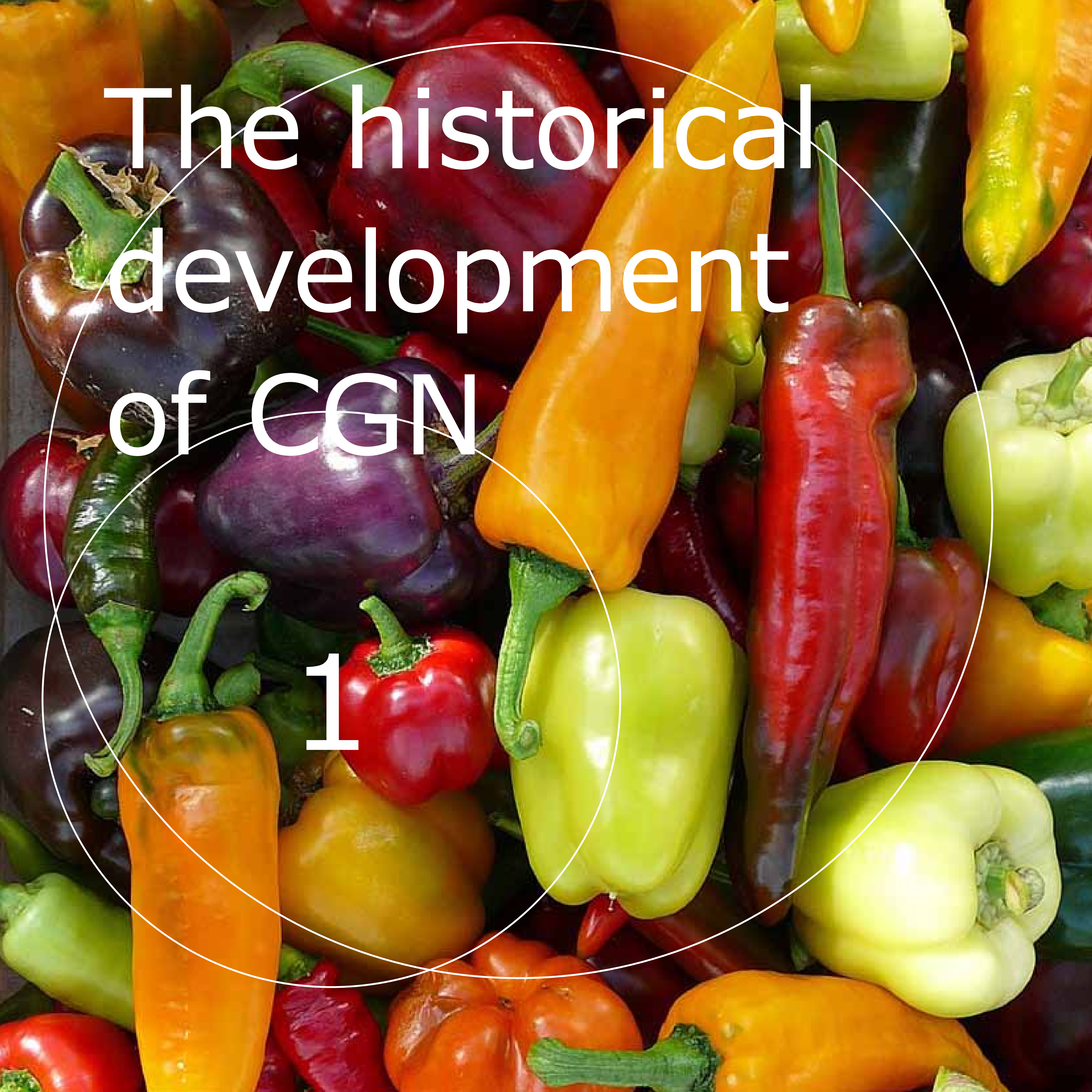
The ambition of this booklet is to show to CGN's stakeholders what its agenda looks like, and why this agenda has developed the way it did. The last chapter gives an outlook into the future. We hope this booklet will be both pleasant and informative to read.

In the book, the work of various CGN staff members has been acknowledged by naming these persons. Here I wish to state that all CGN staff members have been vital for its development and outputs. To emphasize this, photographs of all current staff members, taken at the occasion of CGN's 25th anniversary, have been incorporated in this booklet.

Dr Bert Visser,
Director Centre for Genetic Resources, the Netherlands

The historical development of CGN

1

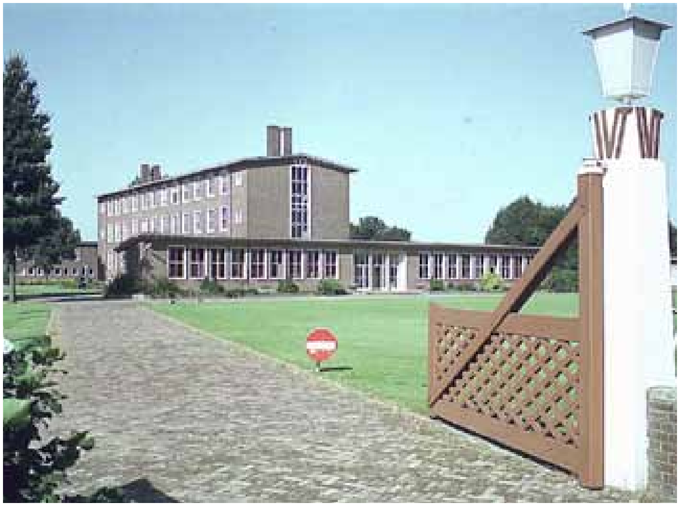


Introduction

The Centre for Genetic Resources, the Netherlands (CGN) was established on 17 July, 1985, as part of the government's agricultural research system DLO, which was later to merge with Wageningen University, as part of Wageningen UR (University & Research centre). At the start CGN was to be a national genebank for plant genetic resources. Its focus would be on food crops. Twenty five years later, in 2010, CGN had established the role of a genetic resources centre with a wider mandate. Its mandate not only encompassed plant genetic resources, but also animal and forest genetic resources. And it focused not only on the building of collections (*ex situ* conservation) but also on the sustainable management of genetic resources in the field (*in situ* conservation). Moreover, it addressed not only technical matters but also policy issues affecting the fulfilment of its mandate, which was to contribute to the conservation and the promotion of the utilization of genetic resources for food and agriculture. Some early features of its programme have remained, i.e. to function as a governmental programme, to cooperate in an international context and to develop rational approaches towards conservation of genetic resources, underpinned by research and innovation. And CGN's programme is still embedded in Wageningen UR. Looking back at CGN's development, these features and conditions have shaped CGN to what it is today. It seems justified to tell the story of CGN's development in more detail, and to provide some more background to its development over these first 25 years, the widening of its mandate, its internationalism, its engagement with policy work, and the role of its host organization, Wageningen UR. This chapter is an introduction; the next chapters provide more detail.

The early years

In 1976 the director of the national agricultural research system DLO established a special committee which was to formulate proposals for the establishment of a national genebank, in which existing collections of plant genetic resources would be incorporated. Only in 1983, this resulted in a discussion paper that provided a road map for the establishment of what was then referred to as 'Genenbank Nederland'. The genebank would take over existing DLO collections, managed by the Foundation for Agricultural Plant Breeding (SVP), the Institute for Horticultural Plant Breeding (IVT), as well as germplasm from the for Plant Breeding department of Wageningen University. Although the Dorschkamp Research Institute for Forestry and Landscape Planning had been involved in the preparations for the national genebank, the proposal focused exclusively on plant genetic resources, and did not address animal and forest genetic resources, herewith following international trends. Plant genetic resources for food and agriculture were considered at risk as a result of modern plant breeding and as exemplified in the 1970s and 1980s by the loss of genetic resources in the Green Revolution. Attention for animal and forest genetic resources was still around the corner.



Institute for Horticultural Plant Breeding (IVT) in the early 1980s. Together with the Foundation for Agricultural Plant Breeding (SVP), IVT would supply the bulk of the CGN collections and staff capacity.

Bert Visser (left) at the farewell drink of Jaap Hardon, CGN's first director (1997).

In 1985, CGN was established as a small separate government institute. Jaap Hardon, a plant breeder employed by DLO became its first director. The two institutes mentioned above transferred approximately 12,000 accessions to the newly established CGN. Additional collection inputs came from the Government Institute for Research on Varieties of Cultivated Plants (RIVRO), the Government Seed Testing Station (RPvZ), the university department for Plant Breeding, and private sector contributors. Already a few years later, it was decided to end the stand alone position of CGN and to integrate it into the larger Centre for Plant Breeding and Reproduction Research (CPRO-DLO), although the independent programme responsibility was retained. The level of autonomy remained an issue, being considered as essential to protect the long-term functions of a genebank against the shorter term needs of a breeding institute.

Not any crop...

The vision of the committee preparing for the establishment of CGN was that for the development of the new genebank not all crops were equal. Some crops would justify more attention in terms of collection building, and other crops less or none. This was based on the recognition that in an international context major collection building had already advanced and that existing efforts should not be duplicated. Furthermore, the new genebank had to serve the Dutch plant breeding industry and should therefore take into account the specific characteristics and needs of this industry, such as its increasing focus on horticultural crops and potato. Therefore, it came as no surprise that the Dutch collections of carrot and green bean were soon transferred to Horticulture Research International (HRI) in Wellesbourne, UK and the international centre for tropical agriculture CIAT in Cali, Colombia, institutes that already managed major collections of these two crops. In addition, task sharing agreements were concluded between the German and Dutch governments, resulting in joint German/Dutch collections of potato, sugar beet and chicory, maintained in Braunschweig by the Institute of Agronomy and Plant Breeding FAL and in Wageningen by CGN. CGN focused heavily on collections of other crops with a strong breeding history in the Netherlands, such as lettuce, cabbages, and later on the fruit legumes tomato, pepper, eggplant and cucumber. Not the (Dutch) origin of the material, but the importance of a crop for the Dutch breeding industry determined what was to be conserved in collections, a strategy that distinguished itself from the strategies and mandates of most other national genebanks. It explains why many CGN collections incorporate crop wild relatives. The notion that these could provide important traits to plant breeders overrode the fact that these often originated from distant countries and continents.

The importance of documentation

From the establishment of CGN, it was clear that the genebank collections should serve (Dutch) plant breeders. Such role could only be accomplished if breeders could be shown which properties were potentially represented in

First location of CGN's plant genetic resources cluster in Wageningen in 1985, with offices at the top floor.

CGN's collections. This meant the need for the establishment of a documentation system that not only served internal management requirements and the aspiration to build collections with as few as possible duplications, but that would also provide plant breeders direct insight in the composition of the collections. The conviction to develop a state-of-the-art documentation system, and – soon after – to use the internet to make the information contained available to near and distant users, characterized CGN's entire programme. Theo van Hintum, still a senior staff member of CGN, took on the task to fulfil that ambition. CGN was the first entity in Wageningen to develop its own website, which came on-line in 1992. The development and application of the concept of core collections in which users are served with a limited selection of accessions that best answer their needs was also motivated by the focus on use of the collections.

In the meantime

Although the mandate of CGN initially did not encompass animal and forest genetic resources, this did not mean that no activities were undertaken in these two domains. Already in 1976 a group of animal scientists took the initiative to establish the Foundation for Rare Domestic Animal Breeds (SZH). The first activity of SZH was to perform an inventory of the status of Dutch local breeds, in close collaboration with the Animal Breeding Group of the Institute for Animal Research 'IVO Schoonoord'. This inventory, coordinated by Durk Minkema, the deputy director of the institute, revealed that native Dutch breeds were threatened, due to a preference of many farmers for more high-yielding breeds. He appealed for a new governmental policy promoting *ex situ* and *in situ* conservation of farm animal genetic diversity. But SZH did not wait until such a new policy was in place, and in the meantime commenced to suggest to farmers and breeding organizations how to use and conserve Dutch native breeds. Durk Minkema himself started a prototype animal genebank in his institute by storing semen of bulls and also some stallions set aside by the breeders and the breeding companies. In the early 1990s, the SZH, the Royal Dutch Cattle Syndicate (NRS) and cattle artificial insemination organization Holland Genetics (HG) took another initiative, i.e. to establish a foundation for the cryo-conservation of farm animal genetic resources, called the 'Stichting Genenbank Landbouwhuisdieren (SGL)'. Although separated from the activities of CGN, and not under government control and responsibility, genetic erosion had spurred activities in the field of animal genetic resources as in the area of plant genetic resources. The goals of both efforts were to contribute to the conservation and utilization of genetic resources taking into account the interests of the breeding industry.

Conserving forest genetic diversity traditionally formed a responsibility of the State Forest Service (Staatsbosbeheer), under which the Dorschkamp Research Institute for Forestry and Landscape resorted before its transfer to DLO. The Dorschkamp had been established in 1947 and was rebuilt and modernized in 1972. The institute established working collections of genetically diverse material to breed new, more productive and

The Hereditary Basis of Livestock Breeding, a key publication by Durk Minkema stressing the importance of long-term animal genetic resources conservation (1977).

disease resistant trees in a number of species. Breeders involved realized how much internationalization of trade in tree seeds and cuttings and recent forest management practices also threatened the survival of forest genetic diversity. At the European level, the Ministerial Conference on the Protection of Forests in Europe provided a regional policy framework for forests and forestry. In this context, attention was called for the need to conserve forest genetic resources both *in situ* and *ex situ*. But it needed new government policies before this realization resulted in the integration of the conservation of forest genetic resources in the Netherlands in CGN's mandate.

Relating to the private sector

The Netherlands harbours a plant breeding and animal breeding sector of major economic importance. High quality genetic material produced by Dutch breeding efforts is distributed globally. This circumstance formed a major motive for the Dutch government to fund a genetic resources programme. At the same time, the Dutch government expected a contribution from the private sector to this programme by way of proof for its value to the industry. This government position fostered close links between CGN and the animal and plant breeding sectors. To a limited extent, this contribution came in the form of plant germplasm collections transferred to CGN. Examples are substantial contributions to CGN's spinach, cabbage and onion collections. But more importantly, the private plant breeding sector collaborated with CGN in the evaluation of collections for interesting traits, in particular resistance traits, in the regeneration of its collections, and co-financed a number of CGN's collecting missions.
The animal breeding sector agreed to provide CGN with stocks of older breeding materials as well as semen – so called 'snap shots' – from donor animals selected in current breeding programmes. Furthermore, the animal breeding sector contributed financially to the maintenance costs of the gene bank collections. The SGL collections that were later transferred to CGN had already been stored at CGN's premises from the start.
CGN benefited to a major extent from the presence of this strong breeding industry, and in turn tried to facilitate the use of its plant collection materials to the maximum extent possible. Until now, animal gene bank materials were only used for necessary support of breeding programmes of endangered Dutch cattle breeds. Various consultation platforms between the private sector and CGN were established that influenced CGN's priority setting and collection strategies.

A government policy on genetic resources

In Leipzig in 1996, at the Fourth International Workshop on Plant Genetic Resources, the State of the World on Plant Genetic Resources was adopted, alongside the

Global Plan of Action. This Plan called for the establishment of national plans and programmes. In addition, the coming into force of the Convention on Biological Diversity in 1994, led to a discussion whether national legal measures, including on access and benefit-sharing[1] would be necessary, a discussion that was amplified by the negotiations and later adoption of the International Treaty on Plant Genetic Resources for Food and Agriculture in 2001.

At the national level, increasing pressure from organizations in the domain of animal genetic resources contributed to the initiatives, taken by officers in the Direction of International Affairs of the Ministry of Agriculture, Nature Management and Fisheries to come to a government policy on genetic resources. In 2002, CGN's efforts became embedded in a new national genetic resources strategy elaborated in the government policy document *Sources of Existence: Conservation and the sustainable use of genetic diversity* (Bronnen van ons bestaan). The policy document Sources of Existence formed a consolidated point of reference for policy development and implementation on genetic resources management for the years to come. The document specified that CGN would have to take on responsibilities with regard to advice on the development and implementation of international policies on genetic resources conservation, exchange and use in various international forums. In addition, the document stated that CGN would act as the national focal point on genetic resources activities in the Netherlands. Both Bert Visser, who had taken over as CGN's director in 1997, and Kor Oldenbroek, who had continued the work on animal genetic resources within DLO, contributed to the development of this policy document.

In situ and *ex situ* approaches towards the conservation of diversity

Since the FAO Conference on Plant Genetic Resources in 1967 discussions on the most effective and justified approaches towards conservation of genetic diversity had continued. Although in the 1970s and 1980s *ex situ* approaches had prevailed, it became increasingly evident that *ex situ* and *in situ* conservation were both needed, since each strategy exhibited some obvious advantages and disadvantages. Whereas in CGN's early years, based on its original mandate, *ex situ* approaches had dominated, the influence of agreed policies, stressing the complementarity of both approaches or even the primacy of *in situ* conservation changed this situation. From 1994 CGN got engaged in the development of on-farm management strategies in developing countries. The recognition that *in situ* approaches could not be missed even became more obvious after animal genetic resources had become a component of CGN's programme in 2000: from the start it had been clear that a successful animal genetic diversity conservation strategy would never be feasible without *in situ* conservation of rare animal breeds and without promoting the maintenance of genetic variation in breeding programmes of both widely used and rare breeds. While CGN had started as an *ex situ* enterprise, only focusing on the establishment of crop collections in a national genebank, the addition of the domain of forest genetic diversity in 2003 finally settled the issue: full recognition of the need of *in situ* approaches within CGN was finally a fact.

The integration of plant, animal and forest genetic resources agendas

Plant breeding, animal breeding and forest management are often worlds apart. Attention for the need to conserve genetic resources therefore arose separately in each of these domains and interactions were often sparse. Only at the international policy level, in FAO and in the context of the CBD, stakeholders met. So, it was not immediately

1 Access and benefit sharing measures intend to regulate the (international) exchange of genetic resources.

obvious to integrate plant, animal and forest genetic resources into a single programme and a single centre. And fair enough, not all work could be integrated or needed to be integrated given the differences in conservation options and strategies. Collection management is quite different between these domains. Whether to manage a seed bank, semen in liquid nitrogen, or living trees in an in vivo genebank requires different expertise and skills, spread over the plant sciences, animal sciences and environmental sciences groups. But other aspects of the work in each of these domains convene: the analysis of genetic diversity and erosion, the need for proper documentation and information systems, policy advice, the use of molecular technologies to understand the genetics of populations and the relationship between accessions, are all issues equally relevant to each of these domains.

At the merger between the work on animal and plant genetic resources in 2000 and the later addition of the work in forest genetic resources, it was decided not to physically integrate the activities and facilities, so that the work could make best use of available expertise and facilities within Wageningen. In practice, integration of these three domains certainly showed to have merits, but also had its limitations. Being located in three different sites and hosted by three different institutes, and the animal genetic resources cluster being situated at a 100 km distance, meant that full integration was not possible. However, improved cooperation and exchange also convinced CGN's current leaders, Bert Visser, Sipke Joost Hiemstra and Sven de Vries, that combining the work in these three domains into a single centre provided gains in impact and efficiency.

Parallel to the integration of these three work areas in CGN, other genetic resources centres, notably the Nordic genebank Nordgen, went through a similar integration process.

CGN's globalism

CGN's first director Jaap Hardon was born in Indonesia and worked as a plant breeder in Malaysia. This background made him acquainted with the features of small-scale agriculture in the tropics and the role that diversity between and within crops played in the sustainability of these systems. Convinced of the options to maintain genetic diversity in these systems and the need to improve these systems to keep them sustainable, he agreed with a number of other stakeholders who participated in the Keystone Dialogue on Plant Genetic Resources to develop a global programme that was to show that farmers could select and breed new varieties and in this way maintain genetic diversity. Intensive discussions resulted in the development of the Community Biodiversity Development and Conservation programme, since 1995 executed by a NGO-driven consortium of 15 partners from South-East Asia, Latin America and

Overview of CGN's stakeholders in genetic resources, presented to plant breeders. The environment for animal and forest genetic resources is highly similar.

tropical Africa. The programme was funded by the like-minded donors IDRC (Canada), SIDA (Sweden), and DGIS (the Netherlands), later on joined by the Norwegian Development Fund. From then on, CGN would remain involved in on-farm management of plant genetic resources in tropical countries, and this involvement often presented challenges. Most partners in such collaborations would be oriented towards community development and were not used to measure impact on diversity. Donors often requested proof for the feasibility of the approach and results for their investments (how many new crops and varieties in how many farms and communities?). This often presented a challenge to which not all partners could easily live up to. The genebank community at large was often mistrusted by these partners under the assumption that this community might misappropriate small-scale farmers' richness. And many scientists in the genebank community doubted the feasibility or effectiveness of on-farm approaches, and did not want to become associated with 'politically inspired' initiatives. For CGN, the big advantage of this engagement was that it acquired first-hand experiences with the strengths and weaknesses of both *ex situ* and *in situ* approaches and with the circumstances under which genetic diversity in small-scale agriculture in the tropics could be maintained. This experience showed to be a tremendous advantage in policy development and implementation in the context of the International Treaty and the FAO Commission on Genetic Resources for Food and Agriculture.
A similar international outlook typified the work on animal genetic resources. CGN played an international vanguard role in disseminating effective approaches and strategies for the conservation of animal genetic resources *in situ* and *ex situ* through influential books and workshops.

While policies matter

Over the years CGN has developed its own agenda in policy issues, and its entire senior staff has become involved. Whereas policy development per se has never been part of its mandate, it was regarded important to provide proper advice to policy makers and follow-up to policy decisions from an implementation perspective.
CGN has tried to offer an added value and comparative advantage by combining expertise in the technical aspects of genetic diversity with commitment to policy development and implementation. CGN took this approach since it noted that the impact of the results of policy makers on the actual management of genetic resources was large and still increasing, that policy makers needed to be well informed and that the genetic resources community would depend on proper decisions, policy instruments, and legal measures. In CGN's vision, proper policies on access and benefit-sharing will determine to which extent international exchange of genetic resources will remain feasible; proper seed legislation will determine to which extent genetic diversity can be maintained in farmers' fields; proper animal health control regulations will determine if living populations of rare breeds can survive at the occurrence of a disease outbreak; proper intellectual property rights regimes will determine if genetic resources will be accessible to all who need it; and proper implementation of the concept of farmers' rights and livestock keepers' rights will determine if farmers and pastoralists will benefit from their role in managing and developing genetic resources. Engagement in these agendas, like in the North-South agenda, has often required a balancing act, and attempts to thoroughly understand the interests of all stakeholders in the issues involved.

Final remarks

The next chapters provide more detail on the topics addressed above. The reader is invited to inform him/herself about CGN's history and to better understand the issues with which a genetic resources centre has been confronted with so far, and will have to address in the future.

The combination of *ex situ* and *in situ* approaches

2

History

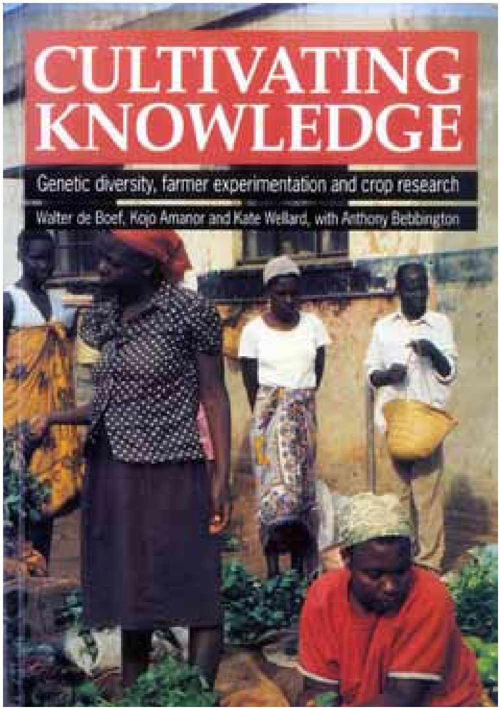
Probably the fiercest debate ever to take place in the wider community engaged in genetic resources was the debate in the plant domain on the primacy of *ex situ* approaches (involving genebanks and other collections) or *in situ* approaches (diversity maintained by farmers, in living populations or in nature). The discussion developed in the late 1960s and in fact continued, possibly until today, although at a much slower pace and with a much milder tone. Certainly, this issue presented not only a technical discussion, but also a political discussion. Why it soon became a political discussion, was because the different approaches required different actors and benefited different stakeholders. The main aim of genebanks is to conserve genetic diversity and to provide access to this genetic material to serve breeders and researchers, today and in future generations. Gene bank collections are run by specialised professionals, often linked to breeding programmes and governments. In the *in situ* management of genetic resources farmers, breeders and increasingly hobbyists contribute to maintenance and use of genetic diversity, each group motivated by its own reasons. Arguments in favour of *ex situ* approaches listed reliable conservation, easy availability, good documentation, distinct identity and good quality as major advantages. Major arguments supporting *in situ* and in particular on-farm approaches considered that farmers have easier access to the diversity, that more diversity could be conserved, that genetic resources could adapt to changing circumstances, and that knowledge associated with genetic resources could be maintained by keeping it used in the farming and breeding systems. And last but not least, many *ex situ* plant collections were maintained by OECD countries whereas the majority of on-farm genetic diversity could be found in farmers' fields in developing countries.

The first two FAO International Conferences on Plant Genetic Resources for Food and Agriculture provided a forum for this debate. Although no consensus was reached, the 1970s and 1980s witnessed the establishment of many new genebanks, the start of the International Board on Plant Genetic Resources under the umbrella of FAO, and a strong increase in collecting missions. It seems that more investments were made in *ex situ* approaches. However, when *ex situ* efforts increased, the limitations of *ex situ* approaches also became increasingly visible. The tide changed again, and when, in 1992, the Convention on Biological Diversity became adopted, it covered *in situ* approaches in Article 8, and *ex situ* approaches in Article 9, "predominantly for the purpose of complementing *in situ* measures". When the conservation of other domains of genetic resources for food and agriculture, notably animal and forest genetic resources, started to receive increased attention, this reinforced the notion that *in situ* approaches would have to play a major part, given the difficulties and much higher investments needed associated with the *ex situ* conservation of these resources compared to those of plants.

Let it suffice to say here that both approaches are complementary and that both are needed in each of the domains and across the globe.

The role of *ex situ* and *in situ* approaches in CGN's agenda

CGN evolved from plant breeding institutes, in a country where agricultural practice had shifted from small-scale to large scale and intensive many decades ago. In the first years, CGN was identical to a genebank. It took many years before the notion took on that CGN was to be a genetic resources centre, operating collections, as well as undertaking other activities to contribute to the conservation and sustainable use of genetic resources. Even when it was understood and acknowledged that in developing countries major diversity remained in farmers' fields, still the understanding was that *in situ* approaches

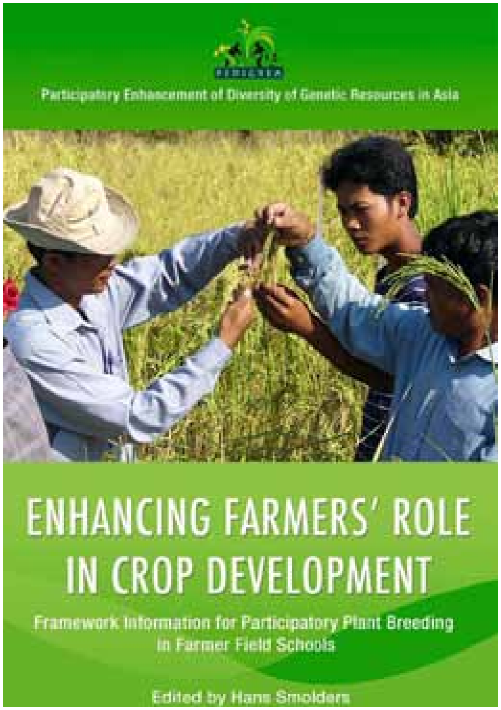


The publication Cultivating Knowledge: Genetic diversity, farmer experimentation and crop research (1993), product of CGN's involvement with on-farm management of genetic resources.

for crops were less effective in a country like the Netherlands with its agricultural policies aiming at maximizing production and productivity levels. In the words of CGN's first director, who was convinced about the need of *in situ* approaches only in developing countries, 'the Netherlands could be put under asphalt without losing a single part of plant genetic diversity'. And a number of CGN staff regarded money spent on *in situ* approaches on crop genetic diversity as lost money. Such attitude can be partly explained by the relatively late recognition for traditional food and hence traditional crops and crop varieties in the Dutch culture, the late and slow growth of interest in organic production requiring a different genetic diversity, and the consequently limited efforts and low levels of organization of stakeholders interested in traditional plant genetic resources or the introduction and development of novel diversity. Here, it must be admitted that for many years the hobby gardeners, that maintained many traditional crop varieties formed a community largely unrecognized by CGN.

To a considerable extent the discussion juxtaposing *ex situ* and *in situ* approaches and associated attitudes have been foreign to the animal and forest genetic resources communities. First of all, for animal breeders, maintenance of genetic variation in breeding programs or breeding populations (*in situ*) is an important objective, in addition to genetic improvement objectives. *Ex situ* conservation is indeed a complementary approach to minimize risks of losing genetic diversity because of genetic drift, eradication of populations by diseases and other reasons. Moreover, native breeds of farm animals have long been considered as national heritage that needed protection, probably explained by their characteristic features. Public interest in traditional breeds had always kept *in situ* approaches as a major component of conservation efforts in the animal and forest genetic resources domains. In fact, investments in *in situ* approaches predated the establishment of *ex situ* collections of animal and forest genetic resources in the Netherlands, and such investments first took off without any involvement of CGN.

In contrast to the low profile of *in situ* crop conservation in the Netherlands and CGN's slow uptake of that agenda, since the 1990s CGN has played a role in on-farm conservation and management efforts in developing countries through a number of succeeding programmes and projects. Walter de Boef and Conny Almekinders have been instrumental in developing this agenda. CGN was one of the founders of the Community Biodiversity and Conservation programme in 1995 and remained active in this programme to some extent until finally its African



PEDIGREA Manual on Framework information for Participatory Plant Breeding in Farmer Field Schools (2006).

branch stopped to exist in 2008. During the implementation of the programme conviction grew that farmer field schools could form a vehicle for participatory approaches. The PEDIGREA project that started in 2002 and involved NGOs in Cambodia, Indonesia and the Philippines placed the development of farmer field school curricula central. Still later, the Community Climate Change project, operating in Ethiopia, Zimbabwe and Indonesia, built on these results and attempted to take the impact of climate change on genetic resources into account.

CGN's role in *in situ* and *ex situ* approaches

Whereas CGN is itself responsible for the *ex situ* conservation of genetic resources, it can only play a support role in the maintenance of genetic resources *in situ*. Farmers, breeders, breed societies, hobby gardeners, hobby breeders of farm animals, and landscape and nature management organizations sit in the driver seat, and hence the visibility of genetic resources in farmers' fields and our landscapes and the maintenance of genetic variation in on-going breeding efforts depends on them. At the request of the government, CGN has supported *in situ* conservation efforts in the Netherlands through development of guidelines and technical advice to avoid inbreeding, provision of germplasm, regeneration of seeds, advice on appropriate tree genetic resources, and by providing logistical and management support. In particular, CGN has gained wide recognition for its practical advice regarding the maintenance of genetic variation in populations of (rare) farm animal breeds. Through *in situ* conservation efforts, breeds and the wonders of genetic diversity are exposed to the wider public and the message is conveyed that genetic diversity is not only instrumental for breeding, but also appealing to look at and fine to taste. Also, these efforts are able to link genetic diversity to the food plate of the consumer. At the same time, all these efforts remain highly dependent on volunteers and relatively few farmers and breeders, and this situation forms a continuous threat to their longer-term sustainability.

Indicators for CGN's output

Past and current investment levels and budgets provide a reliable source to estimate efforts in *ex situ* and *in situ* approaches. A simple overview of investments that can be attributed to one of both approaches is revealing. Furthermore, *ex situ* collection sizes are provided as indicators for CGN's outputs in *ex situ* activities over time. In 1985, 100% of all CGN's investments were directed to *ex situ* approaches in plant genetic resources, whereas in 2010 figures showed that on average 15% of all of CGN's spendings were directly devoted to *in situ* conservation,

A view of the CGN plant genetic resources storage facility in Wageningen.

composed of 3% in plant genetic resources conservation, 13% in animal conservation and 45% in forest genetic resources conservation. Although the forest genetic resource genebank is managed by the State Forest Service, CGN has contributed intensely to its establishment, as well as its current scope and focus, and CGN's investments in this living genebank make for a substantial share in CGN's overall spendings in forest genetic resources.

Over the years, CGN's collection sizes have grown substantially. From an initial size at uptake of plant collections in 1985 of 12,000 accessions, the total size of plant collections increased to 18,000 in the year 1995 and 24,000 in the year 2010. Over this period, for 14 crops, new collections were added. In 2010, the total number of farm animal breeds or breeding lines conserved in CGN's *ex situ* collections had grown to almost 70, whereas in 2000 the number of breeds concerned amounted to only 20. In parallel, the total number of animal breed samples increased from around 100.000 doses in 2000 to more than 300,000 samples in 2010. Finally, the number of tree species and provenances included in the field genebank rose from 3500 samples of 50 species at the time of its opening to 3700 samples of 62 species in 2011. Pioneers in these activities have been Loek van Soest, Ietje Boukema, Sipke Joost Hiemstra and Sven de Vries.

Perhaps more important, distribution figures for collection materials have been high and increasing. The semen of rare breeds in the cattle collections has been used to strengthen and restore some of the Dutch rare breeds. Distribution from the crop collections has increased to more than 4,000 samples per year and helped to introduce new resistances in novel crop cultivars.

Current in-country collaborations and coalitions in conservation

Historically, the animal genetic resources community has been well organized. In particular, the Dutch Foundation for Rare Farm Animal Breeds (SZH) has played a major role in efforts contributing to the maintenance of farm animal diversity in the Netherlands. Since its integration into CGN, the animal genetic resources work has involved close collaboration with the SZH. SZH was one of the founders of the Foundation Genebank Farm Animals, which collections were later taken over by CGN. In addition, CGN is in contact with a large number of hobby organizations, breeding organizations and breed societies, through direct contact and in collaboration with SZH.

Activities involving plant genetic resources conservation have been more fragmented, although some long-term efforts have played an important role, in particular surrounding the initiative Eeuwig Moes, which took over earlier work by the Oerakker and its driving force Ruurd Walrecht, devoted at traditional varieties in a number of mainly vegetable species. As an exception, conservation of traditional apple varieties and some other fruits traditionally has flourished. Dutch traditional apple varieties are well kept and have been extensively studied by a number of Dutch organizations, in particular the Noordhollandse Pomologische Vereniging and the Noordelijke Pomologische Vereniging.

The development by CGN of an Orange List at the initiative of Chris Kik, CGN's head curator, featuring all traditional crop varieties in the Netherlands, has helped to provide a better overview of the status and trends in traditional plant genetic resources in the Netherlands.

Finally, through its long-time work for the Board of Plant Varieties (Raad voor plantenrassen) CGN has influenced planting policies by a number of Dutch landscape and nature organizations, in particular the provincial landscape organizations. The realization that conserving and utilising indigenous diversity was highly necessary did not come easy and required years of investments from Sven de Vries and his CGN colleagues at Alterra.

Final remarks

Both *in situ* and *ex situ* approaches are needed. Final wisdom, at the national and international level, is that they are complementary, and that both play a role in an integral genetic resources conservation programme. *Ex situ* approaches will probably continue to dominate conservation efforts in the plant domain in the Netherlands, given the state of agriculture in our country and the relatively low-cost facilities needed. In the animal and forest domain *in situ* approaches will remain to prevail. However, most stakeholders realize that a combination of *ex situ* and *in situ* approaches is essential and as a result decisions on the best approaches have gradually become less politicised and cooperation between stakeholders has grown to be natural and self-evident. Therefore, both *ex situ* and *in situ* efforts will remain on CGN's agenda.

Sipke Joost Hiemstra and Henk Sulkers in the storage facilities for the CGN animal genetic resources collections in Lelystad.

3

The cooperation with the private and civil sectors

Background

Cooperation with the private sector has been one of CGN's major features. CGN was well-placed to seek collaboration with the private sector, given the strong presence of both the plant and animal breeding sectors in the Netherlands. At the global level, the country is one of the largest exporters of vegetable seeds and animal sperm. Gentle political pressure by the government has successfully reminded the plant breeding sector of the expectation that the sector, if it really valued the existence and governmental support for a national genetic resources programme, should provide proof by support for the programme complementary to government sources. In a contrasting development, SZH and the animal breeding industry took themselves the initiative to establish an animal genebank and subsequently approached the government for additional funding. After the incorporation of these activities in CGN, the animal breeding industry and SZH still contribute to the activities of CGN. Lack of a sizable private forest effort has prevented CGN from engaging with this sector in a similar fashion.

After World War II, the Wageningen plant breeding institutes SVP (Foundation for Plant Breeding) and IVT (Institute for Horticultural Plant Breeding) focused on the development of breeding populations to study the genetic basis of agronomically important traits and to provide breeding products to the breeding sector. The knowledge generated was made available to the rather small, often family-owned Dutch commercial seed companies of the time for further breeding into actual varieties. In the 1980s and 1990s this service gradually became less important as merged and much larger private breeding companies started pre-breeding activities themselves. These changes also influenced the collaboration with CGN.

In seeking cooperation with the commercial sectors it was important for CGN to remain independent and impartial. This demand was also articulated in the special conditions governing the execution of the national genetic resources programme, which would prevent CGN from engaging private contracts with individual breeding companies. The strategy that CGN hence developed in its cooperation with the plant breeding sector was to only engage in collaboration with the private sector in the form of open-ended, project-based consortia in which any company that wished so could join, to exclude long-term confidentiality of project results, and to secure long-term access to its collections for all users. These latter conditions can also be recognized in the International Treaty, and in particular in the conditions of its Standard Material Transfer Agreement.

For the major species in the animal genetic resources domain, the private sector was well represented in the Foundation Gene Bank Farm Animals SGL, and this provided a platform for public-private collaboration. After transfer of responsibility and collections from SGL to CGN, CGN continued to collaborate with a variety of breeding organizations and breed societies. Over the last decade, cooperation with the private sector has largely taken the form of in-kind contributions, although financial contributions or payments for services have also been made. On average, these contributions have provided 15% approximately of CGN's programme budget, based on market prices, both in the plant and animal domain.

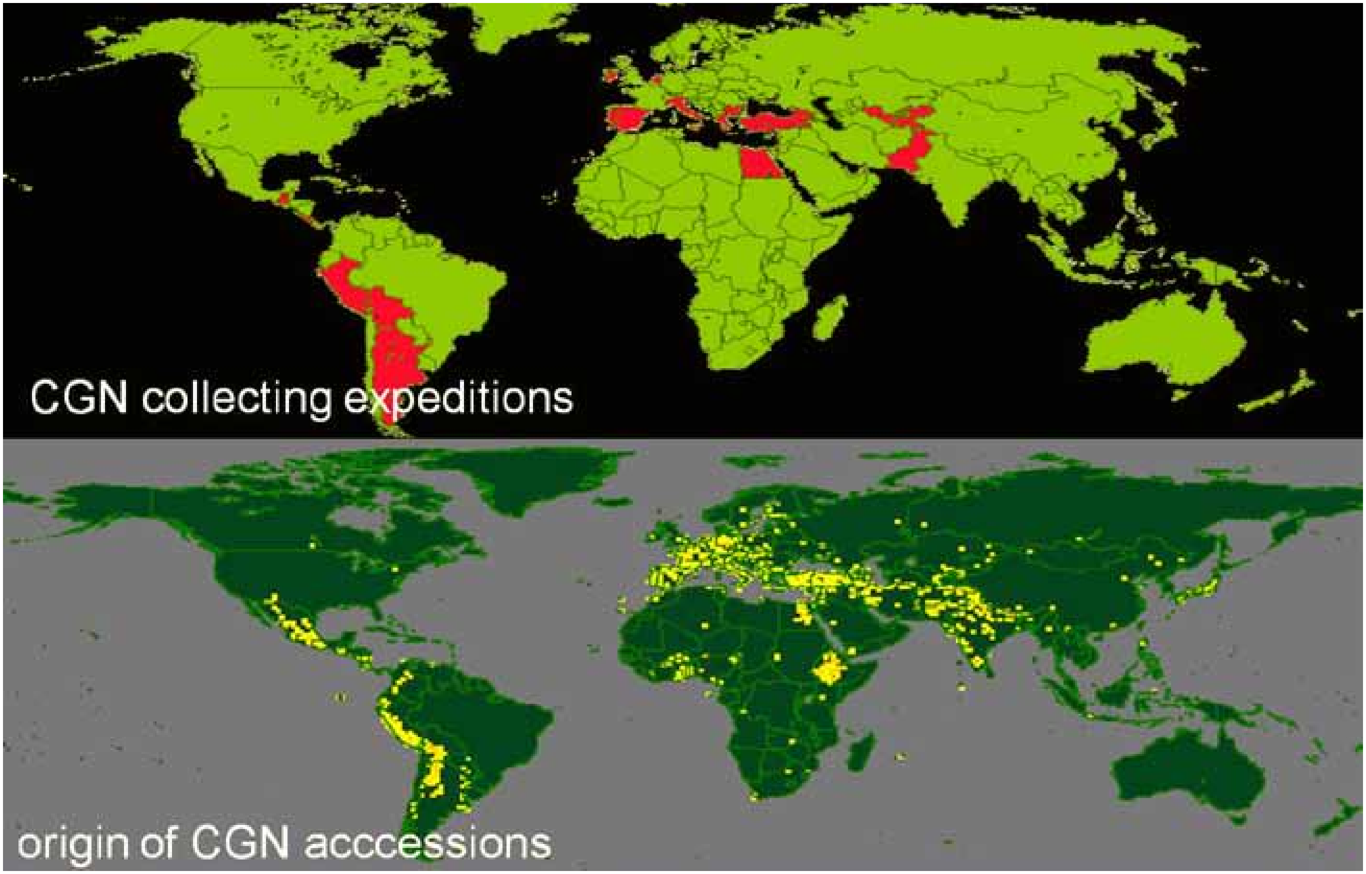
Over time, collaboration with the plant breeding sector included evaluation and increasingly regeneration of collections, as well as sponsoring of collecting missions. Joint participation in EU-funded projects, and lately the production of joint publications completed the gamma of cooperation. Advice by CGN on the selection of most appropriate genebank accessions in its own and sometimes in other collections has been another major feature of the collaboration.

Regeneration activities are essential given the fact that CGN distributes at least 4,000 samples and often far more each year, and that for some accessions seed deterioration does occur. In-kind contributions to the regeneration of CGN collections form a major and increasing component of CGN's collaboration with the private breeding industry.

Collaboration with the animal breeding sector has included the free provision of semen samples for a large part of CGN's collection, and payments for the maintenance of germplasm in the CGN storage locations.

The private sector and promoting the use of the plant collections

It has often been argued that conservation of genetic resources for its own sake has limited value if any, and that the real value stems from the use of the collections developed. Genebanks should not become museums. In turn, use depends to a very large extent on the information that can be provided on the germplasm in the collections. Therefore, evaluation in various forms and for a number of traits forms an important element of CGN's programme. Two major conditions govern CGN's



Location of CGN collecting missions and origin of CGN's accessions.

CGN Publication Variation in livestock (2010), emphasizing the importance of genetic diversity occurring in domestic breeds.

evaluation work. In the first place, CGN will only determine traits for evaluation in direct consultation with the breeding sector, to secure that information obtained will really promote use of the collections. Secondly, CGN will only engage itself in evaluation experiments in direct cooperation with private partners if project funds from third parties, such as the EU, can be obtained to carry out the evaluations. The bottom-line is that evaluations, whereas essential for the promotion of use, will not be paid from core programme financial sources, but only from dedicated projects or through contributions in-kind by private partners.

Embargos as an instrument to foster cooperation between CGN and the private sector

CGN operates under a policy of free germplasm availability and free information sharing. At the same time, investments of industry in evaluations or in collecting missions are often only sufficiently interesting for industry if it provides the partners with an advantage over other users that could act as 'free riders'. Such advantage would lack if a free information and availability policy would be pursued in an absolute way. Therefore, CGN has decided to agree on an embargo period of five years maximally before the data of an evaluation project are made publicly accessible through CGN's website, or germplasm from sponsored collecting missions is made available to all third parties.

The agreed embargo period provides an incentive for the private breeding companies to invest in these joint evaluation and collecting efforts by offering them a modest R&D gain over competitors, while at the same time guaranteeing to all users the long-term availability of all the results. Sharing evaluation data within the consortium offers another advantage in this approach, since joint data will provide more information, when compared with evaluation results made by an individual user.

Embargos over a much longer time frame operate for animal germplasm donated by private industry. Usually, it is agreed that such germplasm will only become available for use by third parties after a number of generations, in order for the donating party to reap the full commercial benefit from the germplasm provided. Embargo periods may extend to as many as 20 years for cattle, pigs or horses.

Supporting *in situ* management

Non-governmental organizations and hobbyists play a major role in the *in situ* management of genetic resources. Many of these organizations depend on volunteers, who are very committed, but often lack certain technical capacities. CGN has attempted to support the work of these organizations and individuals by filling in the lack of technical capacity through organizing workshops and giving lectures. In particular, a strong tradition of cooperation exists in the animal domain, where the Foundation for Rare Animal Breeds SZH and CGN have collaborated closely from the start. As one of its activities, CGN distributes semen from the farm animal gene bank to breeders of endangered breeds of cattle to support their breeding programmes, and in particular to avoid inbreeding. In the area of plant genetic resources, CGN stores back-ups of collections of traditional varieties maintained in the framework of Eeuwig Moes, and also supports the regeneration of some of these materials.

CGN highly values the work undertaken by these NGOs that perform tasks in maintaining diversity on-farm that CGN cannot take on board, and that have much better options to reach out to the wider public and undertake awareness raising regarding the importance and attractiveness of genetic diversity.

Filling gaps in existing crop collections

Even before the establishment of CGN in 1985, collecting missions were carried out by the Wageningen-based breeding institutes SVP and IVT. Already in 1955 a first collecting mission on primitive potato varieties took place in Peru. With the participation of CGN, in the persons of Loek van Soest, Roel Hoekstra and Chris Kik, 19 collecting missions were performed since 1985. Collecting potatoes (wild relatives and landraces) remained a major focus, as seven missions in Central and South America were dedicated to this crop only. In more recent years, collecting efforts have shifted to other vegetables. Expeditions took place in Central Asia (Uzbekistan, Tajikistan) and in the Caucasus (Azerbaijan, Georgia and Armenia) and focused on crop wild relatives of spinach, whereas an expedition in Greece focused on the collecting of wild relatives of leek. All later expeditions were undertaken on the basis of gap analyses carried out by CGN and on requests from the breeding sector which observed a lack of variation potentially hampering their breeding activities. In addition, collecting missions have taken place in support of research projects, such as a project to monitor and sample diversity in old grasslands in the Netherlands. Approximately 5000 accessions of food and fodder crops were sampled in CGN collecting missions since 1985.

Collecting wild relatives of leek by Chris Kik (CGN).

Semen provided to build up the farm animal genebank

Since 2003, CGN has conserved both materials for commercial breeding (mainly cattle and pigs) and for diversity, hobby and/or cultural purposes.
In the 1960s and 1970s, noting the rapid replacement of native livestock species (notably the Fries-Hollands and the Maas-Rijn-IJssel cattle), Durk Minkema realized the importance of conserving native genetic diversity for the maintenance of genetic variation. At the same time he knew from experience that private animal breeding organizations tended to discard parts of their sperm collections in order to decrease management costs. This inspired Minkema to store sperm in a single nitrogen vessel located in the basement of IVO headquarters. A few years later, in 1994, this vessel formed the basis of the SGL animal genebank, which tasks were taken over by CGN in 2003.
In the 1990s, SGL started to collect 50 doses of semen of all young bulls entering artificial insemination schemes. In addition, cattle breeding companies also provided semen

Flock of indigenous heath sheep, semen incorporated in CGN's collections.

from Dutch bulls of native breeds no longer widely used. Nowadays, CGN still obtains semen from all young bulls entering AI schemes at no costs based on an agreement with the breeding industry. In addition, CGN actively collects semen of rare breeds in close collaboration with private breeders and the SZH.
In the pig breeding sector, many mergers of breeding companies took place resulting in a substantial culling of breeding lines to decrease maintenance costs. In the year 2000, breeding companies donated fresh semen from 15 lines at risk of culling for free to CGN.
With regard to poultry, semen was collected by CGN from more than 20 native Dutch breeds. SZH organized the identification and selection of breeding cocks that were then donated in their last phase of life to CGN.
In addition, from seven Dutch native sheep breeds semen was donated and frozen. During an outbreak of foot-and-mouth disease in 2001 a flock of the rare ‘Veluwse Moorland’ sheep had to be culled. In response, CGN developed a method to collect sperm of this flock in order to preserve genetic material for future breeding. Rams were slaughtered and directly thereafter testes were removed. In the laboratory epididymis-derived semen was frozen. In a test trial the semen appeared to be highly viable after storage. Ewes inseminated with this semen produced litters of normal size.
Semen stored from rare breeds is used to improve *in situ* conservation programmes by bringing in 'fresh blood', or genetically speaking by decreasing the relationship between the animals in the population. For such rare breeds, the livestock keeper or breeders are requested to raise a male and to donate semen to CGN in case it is needed to replenish the semen of the sire.

Final Remarks

Industry has often expressed that it regarded the existence of national genetic resources collections as important if not indispensable for its long-term access to genetic resources to enable its breeding programmes. CGN has always acknowledged the opportunities and indeed challenges that the presence of a strong plant and animal breeding industry in the Netherlands provided. In practice, this has resulted in multiple forms of cooperation from which both sides benefit.
In a similar vein, cooperation with the civil sector organizations has evolved. In particular, the SZH has successfully twinned with CGN to organize the collecting of semen of rare breeds for uptake in the genebank stocks. Without this cooperation with the private and civil sectors, CGN could never have achieved the collections it currently has under its management.

4 CGN as a centre of expertise and innovation

Background

Since its foundation in 1986, CGN has been able to take on a role as knowledge provider regarding genetic resources for food and agriculture in each of the three domains of plant, animal and forest genetic resources, as requested by the government. Over time CGN has become the major knowledge centre in the area of genetic resources for food and agriculture in the Netherlands. In developing its programme, CGN became convinced that innovative conservation and gene bank management approaches are needed to render investments in creating and accessing gene bank collections and information as effective as possible. This chapter provides details on the substance addressed, the expertise provided to other stakeholders and the innovative approaches developed by CGN.

Innovations in genetic resources management

Innovations in conservation methods form an major challenge that can benefit collection quality and can save money. Best management practices aim to maximize genetic diversity in gene bank collections, they should conserve the original properties of accessions, guarantee the quality and prolong the life time of the collections to the maximum extent, provide highly reliable genetic material to users, and all this at minimal costs. These goals can only be achieved when genetic resources management is based on state-of-the-art science and technology.

Novel scientific findings and technologies have not only allowed continuous improvement of genetic resources management, but also revolutionized the thinking about the principles underlying genetic resources management. In particular genomics allows us to monitor in great detail the genetic diversity retained in gene banks, the properties of individual plants, trees and animals, and to understand the roles of individual genes. High throughput sequencing and information technology allows us to document this information in a new dimension of detail. The genomic revolution will not only change breeding approaches and structures, but conservation and collection concepts and ways of collection management will also be different in the future.

CGN has not yet embarked on this road but realizes that such developments in genomics will profoundly change collection management and change the use of genetic resources collections.

TÜV Nederland

Stichting DLO, WOT-unit CGN
with the departments PGR and FGR **Wageningen**
with the department AnGR **Lelystad**

Has demonstrated it has a documented and implemented quality management system that conforms to the standard

NEN-EN-ISO 9001:2008

The quality management system has been evaluated in accordance with the procedures for systems certification of TÜV Nederland for the scope of activity:

Conservation of genetic material of plants and animals
Documentation of associated data
Promotion of use of genetic resources
Supportive research

This certification is subjected to an annual evaluation by TÜV Nederland.

Certificate registration number : 14952/2.2
Valid till : 18-11-2013
Date of issue : 18-11-2010
Date of first certification : 18-11-2007

Managing Director

ISO 9001: 2000 certificate.CGN acquired certification in 2003, which was renewed in 2008.

Theo van Hintum and Koen Purimahua (CGN) at a regeneration of selected Chinese barley landraces (1992).

The diversity level makes the value of a collection

Collections that are not used are only museum pieces and not very different from stamp collections. The only justification for *ex situ* genetic resources collections lies in their current or future use. *Ex situ* genetic resources collections will only be used if valuable information on the germplasm in these collections is available. Such information includes traits of agricultural importance as well as the genetic relationships between the accessions or individuals represented in these collections.

From the start CGN has discarded the concept of *ex situ* collections of maximum size, expecting that it would become financially too burdensome to maintain such ever-growing collections in the long term and questioning the added value of unlimited additions to collections. Instead, CGN has attempted to economize on the size of its crop collections by only including in its collections the most useful and divergent segment of crop genetic resources and by lumping accessions showing a great deal of genetic overlap and a joint breeding and development history. Only 10% of commercial lettuce varieties taken from the market and offered to CGN is included in the lettuce collection, and early in its development the Brassica collection was reduced by 30 % based on major overlaps between accessions.

Obviously, manageable animal genetic resources collections require a continuous evaluation of the added genetic value of new genetic material of a particular breed or breeding line. For the living genebank of indigenous trees and shrubs, a similar challenge is to estimate whether material taken from another location may add substantial genetic diversity to the existing collection.

Genomics and bio-informatics will also allow the improved management of animal genetic resources, both *ex situ* and *in situ*. Whereas for many crop species diversity in collections is mainly found between accessions and plant varieties, animal genetic diversity is found between and within breeds. In fact, roughly 50% of the genetic variation in farm animal species can be found within breeds, and the other 50% between breeds. On the one hand, the challenge for conservation of animal genetic diversity is to at least conserve breeds or populations which have a substantial contribution to total genetic diversity of a particular species (prioritization of breeds). On the other hand, it may be even more important to maintain and sustainably use the genetic variation that can be found within breeds or populations. In the recent past only phenotypic and pedigree data were available to detect breed differences and to manage within-breed diversity. Fast developments in the genomics and bio-informatics area however make it possible to assess genetic diversity at the nucleotide level. Over the last decade the full sequence of all major farm animal species has become available and high density SNP chips have been developed to analyse genomic diversity between and within breeds. Bio-informatics and statistical genetics are

Progress in conservation and population genetics

From the start in 2000 the work on animal genetic resources has been embedded in the animal breeding and reproduction group of the Animal Science Group in Lelystad. In this environment new breeding strategies and technological solutions aimed at the conservation of genetic diversity have been developed, often as part of PhD studies. At the end of the 1990s, Theo Meuwissen developed a computer simulation program (Gencont) that was able to select those sires and dams being most suitable mating partners to prevent genetic erosion and that could determine the optimal number of offspring per parent in such a way that genetic progress was maximized while inbreeding was limited. Shortly thereafter Anna Sonesson developed optimal mating schemes based on Gencont taking into account overlapping generations which frequently occur in animal breeding populations. In her thesis she developed a strategy to use frozen semen from earlier generations to minimize inbreeding in small populations. A simple strategy to comprise the genetic diversity for conservation is to store frozen semen of sires of two subsequent populations. The advantage of this strategy is that in the semen of the sires of the second generation also the genetic diversity in the dams of the first generation is conserved. Herwin Eding in his thesis developed a method to estimate kinship between and within breeds with molecular markers, an appropriate method when pedigree based kinships are not available. Kinship based diversity estimates based on kinship between and within breeds allow conserving the founder population allele frequencies to the maximum extent. The eradication of alleles causing scrapie sensitiveness in sheep provoked the development by Jack Windig of breeding strategies that do eliminate alleles coding for this undesirable trait while conserving genetic diversity in general as much as possible. For species where natural mating in flocks is applied rotational mating schemes were developed and introduced in populations of heath sheep. Currently, two PhD students further develop strategic knowledge in this area. Krista Engelsma is working on the use of high density markers (SNP) to improve conservation decisions.
Myrthe Maurice–van Eijndhoven studies the genetic variability in milk quality components of Dutch cattle breeds.

crucial disciplines to properly analyse the unlimited amount of data that will become available. Not only breeding strategies but also conservation strategies will benefit from the genomic revolution. One major breakthrough in the past was the development of the Optimum Contribution Theory by Theo Meuwissen, at the time associated with CGN, which made it possible to better balance genetic improvement with the maintenance of genetic variation. This theory can also be applied to create maximum diversity within genebank collections of an animal breed. With the genomic revolution that methodology can be further refined. Advances in animal genomics will result in a better understanding of genetic diversity and potential genetic erosion, and a more effective exploitation of genetic diversity.
For collections of plant genetic resources, innovations based on these principles include the shift from phenotype description to genotype identification (it is the latter that may now indicate the potential value of an accession), and even the rethinking of a collection as composed of single genotypes rather than of accessions as they appear in the field, and the use of genomics information to evaluate an accession and to guide the use of collection materials. Novel technologies may even facilitate to determine the best balance between *in situ* and *ex situ* approaches and efforts by offering new and elaborate information on the diversity maintained in *ex situ* collections as opposed to the diversity occurring in nature and farmers’ fields. These innovations have allowed and will further allow the improvement of genetic resources management.

DNA collections for research purposes

In a response to developments in biotechnology, CGN has started to build DNA collections in parallel to its crop seed collections, realizing that increasingly users of germplasm

Applications of cryobiology

One of the major challenges in animal genebank operations is the collecting and freezing of semen that remains viable and is able to produce offspring after thawing. This is not always a straightforward exercise. Challenges start with the collecting of the semen. A novel, alternative method was developed by Henri Woelders and his team to collect semen from the epididymus of young rams after they had been killed. In a trial with cryo-conserved semen collected from the epididymus very good fertility results were obtained. This method has been extended to other farm animal species and even appears very promising for the conservation of wildlife. Methods for collecting and freezing of semen were first developed in cattle driven by the wide-scale application of artificial insemination in this species. Based on theoretical predictions of optimal freezing programs and with the help of the cryo-microscope, novel freezing methods have been developed for sheep and goats, for pigs, poultry and horses. These applications of cryobiology facilitated the creation of high quality genebank operations for these species.

search for genes by analysing the DNA rather than evaluate the visible traits of an accession in order to estimate its usefulness for a breeding programme. So far, CGN requested those users likely to isolate DNA from the accessions provided to return a DNA sample to CGN. Such DNA collections facilitate CGN's own genetic studies but may also increasingly benefit its users. It can be expected that this initiative will grow out into proper DNA banks paralleling the collections of seed and sperm cells.

From conservation of part of the genome to conservation of the entire genome

Most animal genetic resources collections consist of sperm cells. For many species, it is still difficult and expensive to maintain embryos or both male and female gametes (sex cells). But as a result, part of the genetic information is missed, and rebuilding an original breed takes time and some traits may be lost. As an alternative, somatic cells of an individual may be conserved. A major added advantage is that the exact genotype of the entire accessions can be determined and used, if desirable.

Of course, conserving somatic cells requires the ability to reconstitute animals from such cells. New cloning technology will make this possible in the near future and it is likely that the costs of such cloning efforts will decrease over time. If somatic cell based collections will be built in addition to the current collections of mainly sperm cells, is a political decision rather than a technical decision. Whereas the cloning technology is available it requires an ethical decision whether such future use is not in conflict with our thinking about the integrity of the animal, be it at the individual or at the species level.

Maintenance of genetic diversity *in situ* and *ex situ*

Genetic erosion has been occurring since long. However, we do not know where genetic erosion is most dominant, we do not know how fast it takes place, and we do not know what has already been lost. This holds for *in situ* maintained diversity but also for *ex situ* collections.

In situ and *ex situ* approaches serve different goals and stakeholders. If the application of genomics leads to a far more exact definition of an *ex situ* accession in order to allow for its efficient use, more than now *ex situ* collections may represent a well-defined albeit limited sub-set of all variation present. *In situ* approaches might increasingly serve a role in maintaining a reservoir of additional and unknown diversity for further breeding, in addition to a role in keeping genetic diversity available for direct use by end-users (farmers).

Genomics provides the opportunity to compare the resources conserved *in situ* with the resources presently conserved in genebanks and used in breeding programmes at the DNA level, allowing a more effective use of collections in breeding programmes and a more rational expansion of current collections.

The challenges offered by bio-informatics

Genomics represents a set of technologies that allow the exponential growth of data generation. It is the challenge of bio-informatics to transform these data in useful information by allowing these increasingly large data sets to be effectively stored, retrieved and analysed. Such data sets may allow us to effectively identify candidate genes for certain traits, or tell us how much genetic (allelic) variation is present in the gene pool for particular genes. CGN, as a rather small institute, has not been able and will not be able to actively contribute to the development of this discipline, but as a genebank it can pose challenges and formulate questions for bio-informaticians to provide answers to. Of course, it is important to incorporate any new instruments offered by this rapidly developing discipline.

One of the limitations of *in situ* conservation so far has been that it is difficult to transform information about genetic diversity occurring in nature or farmers' fields in such a way that it allows proper use. As a result, it is often poorly known which genetic diversity is exactly maintained *in situ* and how this diversity is developing. In addition to revolutionising the documentation of *ex situ* collections, bio-informatics holds the promise to also allow a much better understanding of diversity maintained in the field, by providing us with new open text storing, searching and analysing software applications.

Knowledge base research

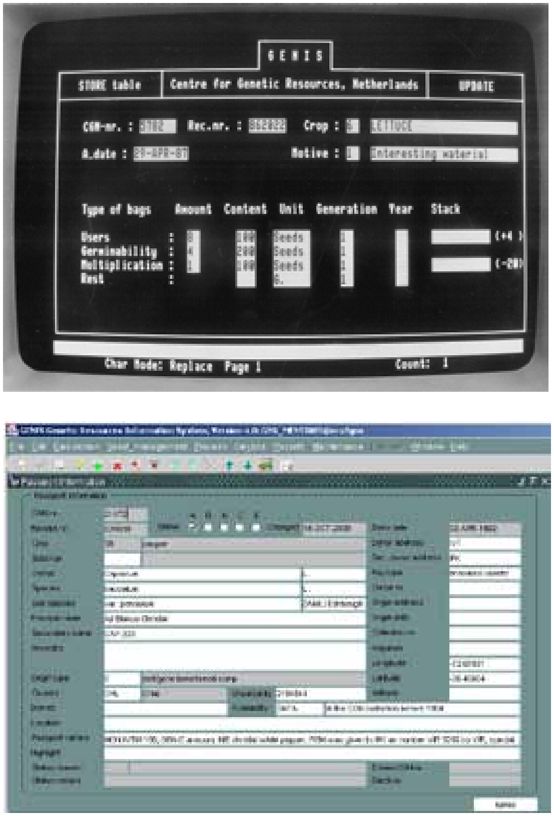
Over the years, part of CGN's budget has been available to conduct research, either by its own staff or by assignments to other researchers in Wageningen. This research has included divergent topics such as collection management, seed management, the genetic relationships between breeding animals and between animal breeds, the genetic diversity in indigenous species of trees and shrubs, genetic erosion, and indicators to measure genetic diversity. Results of this research have been published and have been used to inform the wider genetic resources community.

Sometimes, the knowledge acquired was of a purely technical nature and simply helped improve the efficiency of genebank methodology, or priority setting in CGN's own work. Early examples include the genetic analysis of *ex situ* collections and *in situ* managed varieties, breeds and populations using molecular markers (and in the early days even a now forgotten technique using isozymes). CGN has been able to acquire a much better insight in this diversity, whether occurring in its collections or in specific populations of interest. It has not only been able to improve its own collection management by determining which materials contained most additional diversity, as in the case of lettuce and potato, or which native breeds contained most unique diversity as in the case of chicken. It has also been able to advise breed organizations on how to best maintain their breeds and avoid in-breeding, to advise the State Forest Service on the development and optimal composition of the national in vivo genebank of indigenous trees and shrubs and to advice the network for traditional crop varieties Eeuwig Moes by establishing the Orange List with information on old varieties and advising them on the best maintenance practices for cross-breeding species. Jack Windig, Rob van Treuren, Theo van Hintum, and Joukje Buiteveld played a central role in developing this agenda.

Some research appeared controversial such as the work on proper seed storage indicating that not so much the level of seed humidity but the levels of oxygen to which the

Achievements in the use of information and communication technologies

To ensure storage, retrieval and analysis of data on all relevant aspects of the CGN crop genebank activities (characterization and evaluation, regeneration, storage, monitoring and distribution) a state-of-the-art genebank information system has been developed from the start of CGN's operations. The importance of such an information system was already noted in the first organizational plan of CGN of 1984 stating: 'For optimal handling of genetic resources information a computerized data based system is a necessity.' The original database in its first version was developed in 1985 in a period of four months approximately. Thanks to the efforts of Theo van Hintum, assisted by Frank Menting, CGN's documentation system on plant genetic resources gradually evolved from a simple website with downloadable files containing information on accessions in 1990 to currently a searchable on-line information system (referred to as GENIS) for ready access to conservation and evaluation data. GENIS facilitates and promotes the utilization of the CGN plant collections by domestic and foreign users. In 1989, 16,000 accessions and 105,000 evaluation data approximately had been incorporated in this system, whereas in 2011 these figures had increased to 24,000 accessions and more than 400,000 evaluation data. It is strongly believed that the digitalized web-based documentation facilities have contributed considerably to the major increase in distribution figures.



Developments in information and communication technology reflected in CGN's crop database GENIS.

seed was temporarily exposed might influence long-term seed viability. Current research even suggests that field conditions (cultivation, harvesting and processing) might form a major factor in determining long-term seed viability. Other work contained political connotations, such as CGN's research, led by Mark van de Wouw, showing that genetic erosion in the diversity of cereal crops has occurred whenever a transition happened from traditional small-scale production systems to larger-scale external input-dependent systems, but that evidence for genetic erosion was lacking whenever such small-scale systems were maintained or after the transfer to systems dependent of public and private sector breeding had been made. Such results appeared controversial to the extent that accusations about hidden CGN agendas and sponsors were made.

The result of research explained above were sometimes published in scientific journals, sometimes appeared as CGN publications, or were include in books whether edited by CGN or other organizations. Other results were mainly distributed by organizing workshops. Selected publication

channels in the first placed served to reach the stakeholders and envisaged audience.
As a bottom line, funds for supportive research were always used to improve the core mandate tasks of the centre, i.e. to best conserve and promote the utilization of genetic resources important for food and agriculture and landscape management in the Netherlands.

Reaching a wider public and engaging in education

Some years ago, CGN's advisory committee pointed out how important it was to reach a wider public in order to increase and sustain amongst the wider public interest in genetic resources for food and agriculture in the long term. From this perspective, CGN took two initiatives. In the first place it established a number of folders in Dutch language that each tell a story about the history of a certain crop or farm animal. Species covered include cabbage, potato, cattle, chicken, sheep and goats, horse. Additional folders address forgotten vegetables and indigenous trees. These folders have been used to interest a public normally not exposed to the theme of genetic resources, but with an interest to learn more about them. In addition, many efforts have been made to enrich school curriculums with information about the importance of genetic resources, both in regular and in "green" education, and from primary to higher education. Two websites, integrated in a "Green Knowledge Web" are offering news about genetic resources and attract many students and others. Kor Oldenbroek has been vital in initiating and delivering these products.
Although we still have to improve our creativeness, the lesson for CGN has been that the genetic resources community progress in reaching new audiences but that this requires continuous and sustained investments. And such efforts require not only attractive reading materials but also well considered strategies and alliances that take a specific approach for each different interest group.

Evaluation of *Poa pratensis* by Rob van Treuren (CGN).

Playing an international role

CGN's ambition has been to promote the use of its own expertise and that of Wageningen University and to maximize impact of investments in CGN by seeking and taking on assignments from international organizations such as FAO and the World Bank.
It has advised FAO through background study papers on various issues, such as the transaction costs of bilateral

Some CGN brochures on forgotten vegetables, cabbage, cattle, sheep and goats, and trees and shrubs.

exchanges of germplasm vis-à-vis exchanges in multilateral frameworks, the need for a change of the policy and regulatory framework for AnGR, the impact of Genetic Use Restriction Technologies, popularly known as 'Terminator Technology', and the functioning of plant genetic resources networks, and has also contributed chapters to the State of the Worlds on Plant and Animal Genetic Resources. CGN was heavily involved in preparing the guidelines for *in situ* and *ex situ* conservation of farm animal genetic resources. It has advised the World Bank on the impact of the introduction of plant breeder's rights and on possible improvements in the functioning of seed systems in developing countries. With Bioversity and its predecessor IPGRI, it developed a handbook on genebank management, and a website-based explanation on the use of molecular markers, and it provided a contribution to a booklet on the risks for genebanks involved with the spread of genetically modified organisms. It also participated in reviews of international programmes commissioned by CGIAR or the EU. Over the years, CGN has organized a number of activities highlighting the challenges of on-farm management of genetic resources and in particular participatory breeding approaches. In fact, CGN strived with lots of ambition to contribute to each of the major challenges confronting the genetic resources community worldwide. In these activities CGN attempted to realize its self-chosen ambition to belong to the best genebanks in the world. Such work was performed under contract and never paid much in cash. But the more it paid in substance, since through this work CGN has been able to develop an international perspective and an international profile. Similarly, CGN has invested in the functioning of the European networks in plant, animal and forest genetic resources, trying to improve the effectiveness of these network operations.
Being integrated in Wageningen University, CGN was offered one additional opportunity to increase its international influence. For many years, Wageningen University through its international departments has organized international courses for foreign participants. Since 2004, CGN has collaborated with Wageningen International and its successor the Centre for

Development Innovation, in providing short postgraduate course on genetic resources management and policies (in plants and in animals), held in Wageningen and abroad. The total number of participants over the years has surpassed the number of 300. This type of training may be considered as very effective since it is provided to professionals active in the area of genetic resources or closely related areas such as breeding.

Final remarks

Of all chapters, this chapter looks ahead rather than that it takes stock of what has been achieved so far. It shows that genebank management, the understanding of diversity occurring *in situ* and support for *in situ* management still have many profound changes, challenges and improvements ahead. CGN and the entire research and genebank community should take up this challenge in close collaboration with the relevant stakeholders and evolve into a new era that will allow much better conservation and use of genetic diversity.

5

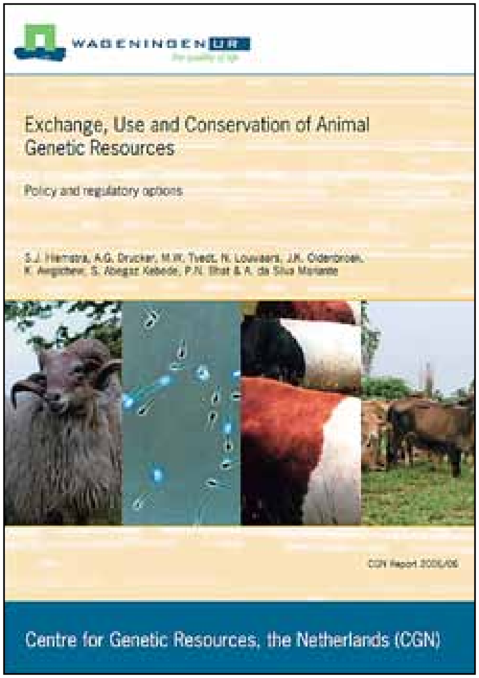
CGN’s activities in the policy arena

From heritage of mankind to national sovereignty

Policies and genetic resources: an unholy alliance or a necessity? In any case, during the past decades policy makers increasingly had to deal with genetic resources, and like it or not, the genetic resources community better deal with policies. How to best develop new policies in a way that makes them practical and effective and how to best implement policies that have been agreed? How to use policy attention for genetic resources to strengthen the profile and financial basis of genetic resources conservation and use activities? Each of these questions forms challenges that should be taken up by policy makers and the genetic resources community.

For a long time – in ancient days – farmers exclusively managed genetic resources for food and agriculture. They exchanged genetic resources freely viewing these genetic resources as the 'common heritage of mankind'. Such a view made sense since sometimes farmers could act as 'donors' and other times they took the position of 'recipients'. In more recent days, substantial profits that were made by breeding and marketing new crop varieties and new farm animal breeds led some policy makers to believe that the genetic resources incorporated in such new varieties and breeds represented a 'Green Gold Mine'. Developing countries felt that they had to pay high prices for improved varieties and breeds that were developed using genetic resources, often originally stemming from their own countries.

Protection of new improved varieties (breeder’s rights) resulted in a trend to also protect the very genetic base on which these new varieties and breeds were developed. The concept of farmers’ rights reflecting recognition of the on-going role of farmers was coined as a complement to breeder’s rights, and Access and Benefit-Sharing conditions were to offset intellectual property rights, including patent rights and breeder’s rights. The adoption



A key publication in the area of international exchange of animal genetic resources (2006).

of the CBD in 1992 meant a paradigm shift, away from the concept of heritage of mankind to the concept of national sovereignty, which forms one of the principles of the CBD.

These developments deeply influenced the work of the genetic resources community. New germplasm could no longer be collected from farmers or from natural fields without permission. New conditions effectively hindered the access, and causing several breeding companies to start their own private genebanks. Even worse, in some cases international exchange of genetic resources became practically impossible. Intellectual property rights and new regulations on seed marketing and access and benefit-sharing also started to affect farming communities. Innovative farmers wishing to improve

Knowledge bank of rare domestic breeds on the internet (www.szh.nl).

their own germplasm with new external sources also discovered that it was sometimes difficult to obtain materials from breeding institutes, and that conditions set to access were sometimes impossible to accept.

CGN got involved in the policy aspects attached to genetic resources because policy makers realized CGN could advise them on the background of all these new developments and on the feasibility of measures discussed, and because CGN realized policies would impact on its work. CGN got pro-actively involved because it hoped it could influence policy making for the better. Its agenda has included work on access and benefit-sharing, on intellectual property rights systems and their impacts on agriculture, on seed systems in which genetic resources were managed, and on farmers' rights that are to protect the traditional role of farmers in managing genetic resources.

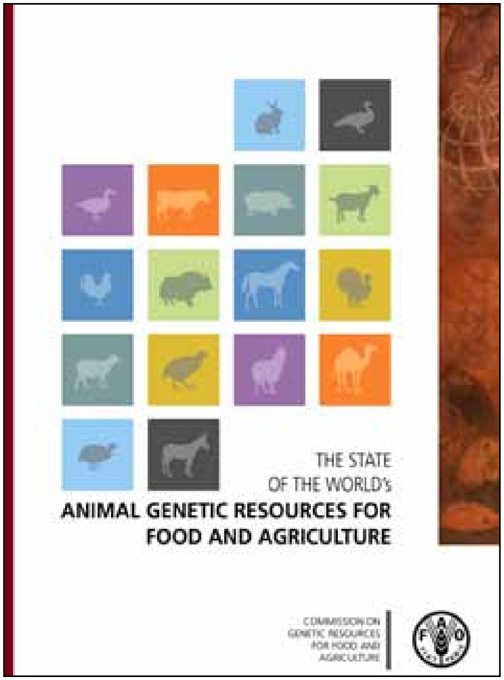
Genetic resources and farm animal diseases

CGN also advises the Netherlands' government on policies regarding the management of rare breeds during infectious disease outbreaks, in order to avoid the culling of rare populations.

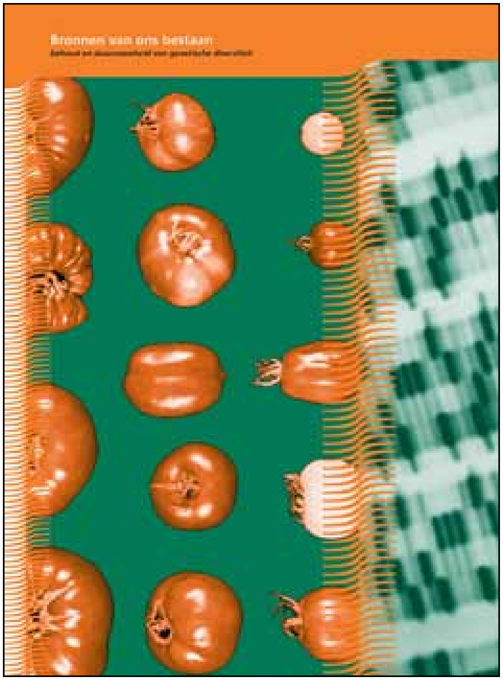
How to best secure animal genetic diversity at the occasion of outbreaks of contagious animal diseases including zoonoses (diseases that can also spread to humans such as scrapie and bird flu) has been an area in which CGN advises the government. Major efforts are underway to provide an-up-to-date overview of the exact location of populations of rare and threatened breeds so that these can be rescued in times of disease outbreaks.

The FAO Commission of Genetic Resources and the development of the International Treaty

The UN Food and Agriculture Organization FAO attaches great importance to genetic resources and in that context has established the Commission of Genetic Resources for Food and Agriculture. This Commission has overseen the development of a series of documents describing developments in genetic diversity world-wide. This information is contained in the State of the Worlds and Global Plans of Action on Plant Genetic Resources for Food and Agriculture (first and second) and on Animal Genetic Resources for Food and Agriculture. A similar State of the World on Forest Genetic Resources is now in preparation. For the development of these key documents FAO depended on country reports. CGN has prepared these country reports for the Dutch government. In addition it contributed chapters of the State of the Worlds and provided some of its background documents.
In the late 1980s and early 1990s CGN's director often represented the Netherlands' government in the FAO Commission on Genetic Resources for Food and Agriculture. This body was tasked with the negotiations of what became the International Treaty on Plant Genetic Resources for Food and Agriculture in 2001. CGN contributed to these negotiations by a background study paper on the transaction costs involved in international



Front cover of 'State of the world of animal genetic resources for food and agriculture', FAO (2007), with contributions by CGN.



Front cover of the government policy document 'Sources of Existence' ('Bronnen van ons bestaan').

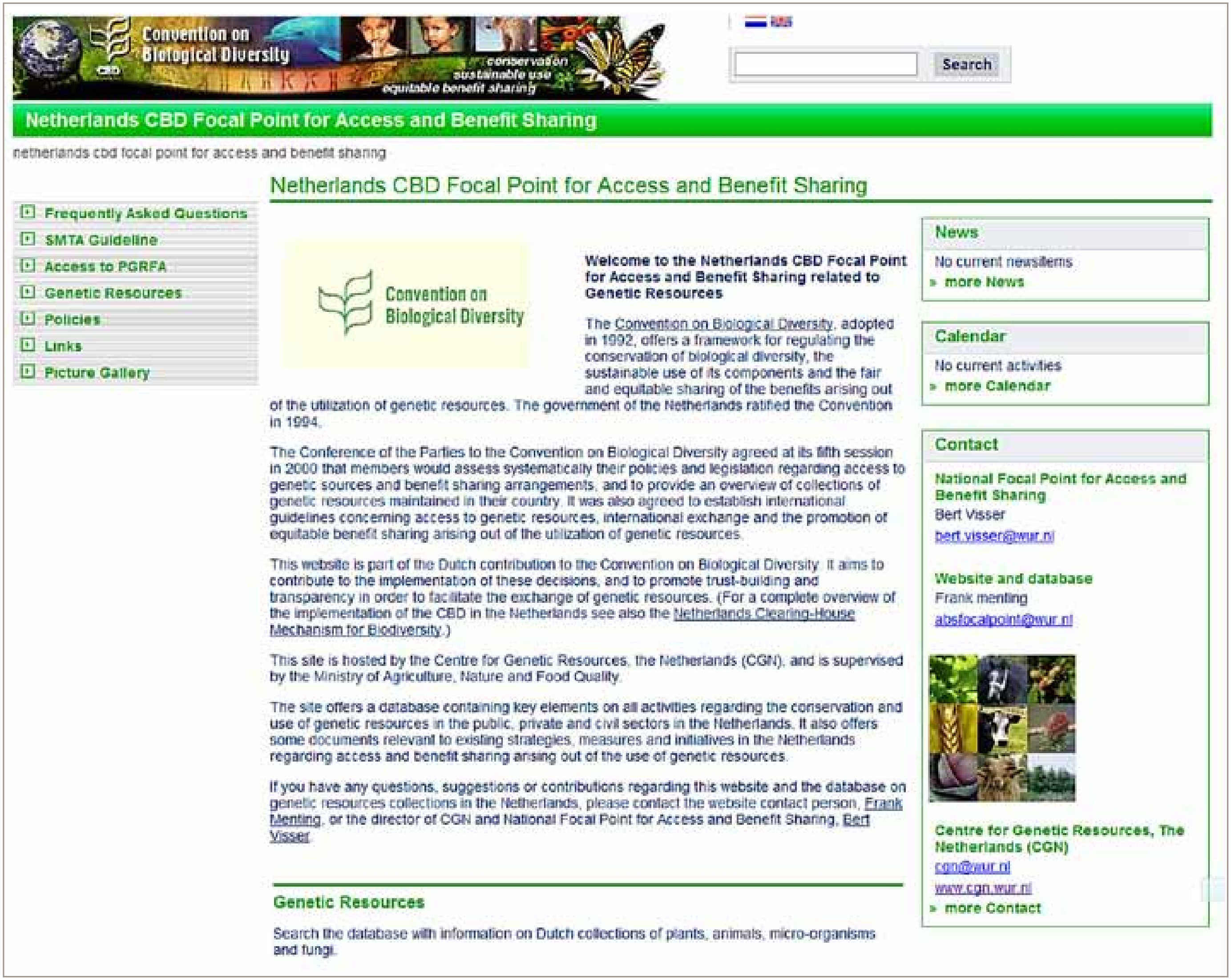
exchange if based on either bilateral or multilateral agreements.

It contributed to its implementation by participating in the negotiations of the Standard Material Transfer Agreement, and by being involved in the development of a Strategic Plan for the implementation of the funding strategy of the Treaty, and in the elaboration of the Farmers' Rights article of the Treaty. It contributed to the work of the FAO Commission by advising on the impact of genetic use restriction technology or GURT, popularly known as Terminator Technology, on the functioning of genetic resources networks that provided support for the functioning of the Treaty, and on the functioning of seed systems and the impact that seed laws may have on genetic resources maintenance and marketing.

The Global Plan of Action for Animal Genetic Resources

CGN made a substantial contribution to the development of the first the State of the World on Animal Genetic Resources for Food and Agriculture by providing the national report and by joining in the writing of some of the chapters, followed by the adoption of the Global Plan of Action for Animal Genetic Resources. These two documents form major milestones in the work on farm animal genetic resources. The documents provide a state-of-the-art overview of trends in genetic resources, and a reference point for all future strategy and project development in the area of genetic resources.

In the process CGN got intimately involved in the work of the Commission realizing how important its successful functioning was for global efforts to maintain and use



Homepage of Netherlands CBD Focal Point for Access and Benefit Sharing related to Genetic Resources (www.absfocalpoint.wur.nl/UK/).

genetic diversity. Likewise, CGN invested in the Treaty to sustain international exchange of plant genetic resources for the benefit of global food security.

EU requirements on forest species diversity

EU regulations require the production of the National Variety List for Trees, providing an overview of varieties and provenances of trees and shrubs important for the

Netherlands. This list also contains information on the genetic diversity maintained in these varieties and provenances. All technical preparations for the five-yearly production of this list are undertaken by CGN. Whereas so far the Lists were printed, the next List will be published on-line.

The impact of Intellectual Property Rights

A recent advice provided by CGN to the government concerned the impact of intellectual property rights in the organization of plant breeding. An expert group co-ordinated by one of CGN's staff, Niels Louwaars, analysed the impact of both plant breeder's rights and patent rights on the organization of plant breeding and advised the government in the report 'Breeding Business' to reconsider current policies and regulations in order to maintain a fair competition in the plant breeding sector. A wider number of companies active in plant breeding may also imply a wider diversity used in breeding programmes and offered on the markets. The role of patent rights in plant breeding is now heavily debated.

A major national advisory role

Based on the government policy document Sources of Existence CGN assumed the role of National Focal Point on Access and Benefit-Sharing. It provides advice on access to genetic resources held in the Netherlands but also for domestic parties on measures and practices implemented in other countries, through a website and by personal contacts and in meetings. It also advised the government on the implementation of protocols that single out rare breed populations if veterinary rules require the culling of certain animals because of veterinary risks. Another major topic addressed by CGN at the request of the government regarded the impact of intellectual property rights on the organization of the plant breeding industry. All of these issues are highly political and often sensitive topics. CGN's own strategy is based on the conviction that in its policy work it should only be led by the principle question how certain policies and practices impact on the (long-term) conservation and use of genetic resources, and how these policies can be influenced in such a way that options for conservation and use become optimal.

Experiences from involvement in on-farm management of genetic resources

Whereas CGN's involvement in national and international projects and initiatives to better manage and use genetic resources on-farm often involved technical advice, CGN was invariably confronted with some negative impacts of various policies on the roles that farmers and hobbyists could play. In particular, rights of access to genetic resources, protection of local genetic resources from misappropriation, and the right to market farmers' varieties and traditional varieties were at stake. Seeking ways to counter these unintended negative effects of policy or practice helped CGN to thoroughly understand the position of local farming communities in developing countries and hobby holders of crop's varieties and rare breeds alike.

The result

Since long CGN is no longer just a genebank, but a genetic resources centre in a much wider sense, by not only managing and providing germplasm, but also advising others how to do so optimally, and advising governments how to make policies conducive to the conservation of use of genetic resources. On CGN's agenda, attention for and work on policies have come to stay. And with it, CGN has got used to work with economists and social scientists in order to achieve its goals and to serve its governments and its stakeholders. To answer the question at the beginning of this chapter: yes, involvement in policies nowadays forms an unholy necessity for the genetic resources community.

Expectations about the future

6

This last, short chapter ends with some words about CGN's future in *ex situ* and *in situ* conservation and use. Some drivers will heavily influence this future. One of these is ensuing climate change, another one globalization. Both genomics and bio-informatics have come to stay and form technologies that will further influence conservation and utilization strategies. And last but not least, policies and politics will decide where CGN will stand in 10 years from now.
CGN was shaped by its environment and a new environment will continue to do so. Since predicting the future is difficult and full with uncertainties, the chapter is short.

Climate change and globalization as drivers of change

First some words about climate change. It has often been argued that climate change will affect all of us, albeit in different ways. Some parts of the world will become drier and hotter, and will experience a loss of productivity in the food crops currently supplying staple diets. New varieties and crops will have to be adopted to create lasting food security. Temperate climates may see a lengthening of the growing season, allowing the cultivation of crops not suitable until now, but also introducing new pests and diseases in the process. New climate types may emerge, other might disappear or shift to new geographic locations. All climates may experience a larger unpredictability of weather patterns, asking new and more robust and versatile crops and varieties. In sum, new traits and trait combinations in our crops will be badly needed. Similarly, farm animal breeds will have to adjust to new circumstances, in particular for species kept in the open and new animal diseases may show up in certain regions because of climate change. Forest trees will have to change or move, and effects of climate change on forest genetic diversity might play out over much longer time frames than for crops and animals, whereas for that reason the effects will be more difficult to avoid or correct.

The Svalbard Global Seed Vault officially opened in February 2008, when it received its first shipment of seeds. Most of CGN's collections have been duplicated in Svalbard.

New environments will ask for another genetic diversity, and this will make countries and regions even more interdependent than they are currently already. Genetic diversity stored *ex situ* in genebank collections will have to be evaluated for traits needed de novo and the importance of genebank collections as a safety strategy for what is maintained in farmers' fields will grow.
On-farm and *in situ* conservation will pose many new challenges and see more failures, and *ex situ* conservation will form an even more important complementary conservation strategy than it is already.

Continuing globalization will equally pose new challenges. The private breeding sector has become fully international. Its markets can be almost anywhere, breeding can take place in locations in different countries and even regions, and the local genebank around the corner will become meaningless. Globalization means that any genebank can be situated around the corner, and that increasingly quality and not location will determine its role

From phenotype to genotype

Many plant and all animal collections harbour several genotypes potentially containing divergent genes and traits. Furthermore, a substantial number of genes present in a single genome might not be expressed in a way that allows their easy registration in phenotypic evaluations. Genes might be silent (for example genes related to disease resistance or potentially useful (for example higher temperature tolerance). Traits may be covered by other traits preventing the observation of such useful traits (for example yield potential in crop wild relatives).

The concept of single genotype-based plant accessions means that entire crop genebank collections will need to be rebuilt. CGN is currently considering a first step on this new road by building an additional sub-collection of tomato based on a careful analysis of existing material.

and usefulness. As a consequence, genetic diversity is no longer only used for local or regional climates and production systems but also for production systems behind distant markets. A countermovement preferring locally grown and traditional food can also be distinguished, simply meaning that requests for diversity will tend to become more diverse if not disparate. So, globalization will result in requests for a much wider diversity. And so, these two drivers of climate change and globalization lead to the same needs and pose the same challenge to genebanks: the challenge of diversification of what is conserved and offered for utilization.

For CGN it means that it will have to collaborate with the private breeding sector even more, and that the importance of public-private partnerships will further increase in the near future.

Technologies as drivers of change

Recently, technical progress in genomics has been mind-boggling. Whole genomes can be sequenced in a number of days or less against prices that become more and more affordable. But new technological challenges have appeared already. Understanding the primary DNA code does not mean that from now on breeding has become a cut-and paste affair. Phenotype evaluation will still be necessary, since it forms the proof of the pudding, but now on high numbers. High-throughput phenotyping and more detailed phenotypic measurements will have to co-evolve with the increasing power of genomics. Other 'omics' will need to be more developed as well, in order to fully exploit the knowledge of the genome and the interactions within the genome, and data on GxE (genotype/environment) interactions for the purpose of optimal use. For genebanks it means that they will need access to these new technologies in order to add value to their collection. And in turn, this means that genebanks either need strong connections with academia or service providers, or need to be embedded in a wider scientific infrastructure to remain useful players.

Bio-informatics will follow suit. The increasing numbers of data produced by the use of genomics technology poses challenges of a new order of magnitude to informaticians, whether dealing with questions of efficient storage, retrieval or analysis of data. Again, in order to play a meaningful role in the not-too-distant future, genebanks will need access to bio-informatics capacity, will need to have their own specific questions addressed, and will have to adapt to the new opportunities that bio-informatics will offer for the better understanding of the materials in their collections and hence for a better utilization of these materials. Again, an isolated position is likely to make genebanks useless, and an embedding in a scientific environment will be increasingly important. For CGN it means that it will have to integrate even more in Wageningen UR in order to make full use of all new scientific and technological developments and to play a role that can meet with the standards and expectations of its users.

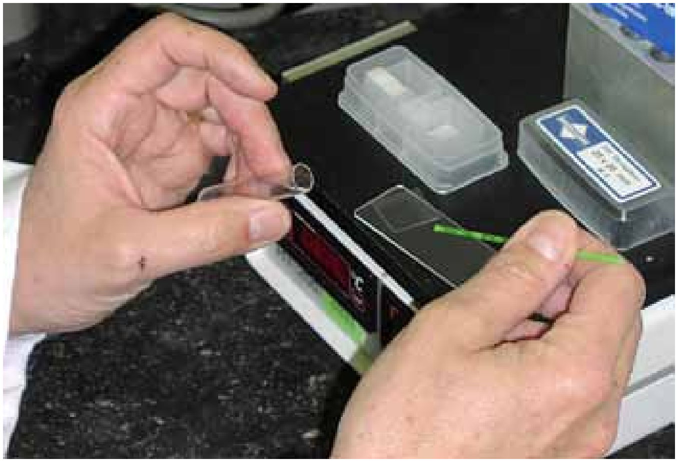
Policies and politics as drivers of change

Will future policies on access and benefit-sharing facilitate or hamper the exchange and wide use of genetic resources? This question seems more difficult to answer than the questions associated with climate change, globalization and technologies. Pessimists may argue that things have turned for the worse since the adoption of the Convention on Biological Diversity in 1992. Have major genetic resources not become locked up due to rigid legislation, lack of legislation and fear for 'misuse' of genetic resources in general? But past trends do not necessarily predict future developments. Most stakeholders in the agricultural domain are conscious of the heavy and increasing interdependence between different players, countries, and regions. The International Treaty on Plant Genetic Resources by creating a Multilateral System was an adequate response to the negative effects of the Convention on Biological Diversity. The Nagoya Protocol of the CBD does recognize the importance of the Treaty. So, all is not lost. But implementation of the Treaty is slow, incomplete or even absent in some countries and regions, as a result of poor recognition of the absolute need of the Treaty and its Multilateral System and ill-understood self-interests. Much will also depend on developments in the interpretation of patent rights and plant breeder's rights and their effect on the accessibility of breeding products in all parts of the world. If intellectual property rights tend to limit access of users to new breeds and varieties, the willingness to provide open access to the germplasm will be lacking. The various stakeholders in this policy arena tend to keep each other in a deadly

Cleaning of pepper seeds at CGN.

gridlock and the resulting enclosure of the minds needs to be challenged and dissolved.
The effective operation of genebanks depends fully on developments in access and benefit-sharing policies that do recognize the roles and interests of all stakeholders and the need for free access at the same time.

For CGN, it legitimizes on-going investments in policy development and implementation. It is the shop floor that needs to inform policy makers about the consequences of their decisions or lack of decision-making, even if the outcome of policy making is unpredictable.
In an economic crisis, politics will also question the need for genebanks and the effectiveness and efficiency of genebanks and the genetic resources community as a whole. We do not need genebanks that are merely museums and a waste of money. Genebanks need to economize on their operations and genebanks need to cooperate in order to increase efficiency by sharing tasks and reduce overlap in activities. A European system of crop collections and task sharing in the management of farm animal breeds is a logical goal. But politicians will determine if conditions will allow international task-sharing



Improvement of cryopreservation methods in the Lelystad Laboratory.

and determine – by making decisions about genebank budgets – if individual countries can contribute in a meaningful way.
For CGN it means, we shall have to stay lean and mean. But in the past this situation has forced us to innovate continuously. In future it might mean that CGN's operations will turn international as well. Why carry out here, what can be done more efficiently or cheaper elsewhere? Why not regenerate seeds in other genebanks and provide information services for these genebanks from Wageningen? If that is what globalization means, CGN will have to globalise as well.

A few words about food security are warranted when looking at the future position of genebanks in general and CGN in particular. The goal of global food security should not be a token justification for the maintenance of a genebank, but a real driver of conservation and utilization efforts. It should inform investments of CGN in collaboration with stakeholders in the developing regions in this world, in order to fully conserve and utilize genetic diversity in those parts of the world for the benefit of food security, realizing that this is only partially a technical question but to a large extent a development question. Will CGN keep the opportunities to remain active in such collaborations?

One or more likely scenarios?

Climate change and globalization will each influence the relevance of genebanks and guide their operations. Conservation strategies opting for a wide genetic diversity in the collections will constitute added value. This points towards essentially one scenario. CGN will have to consider at regular intervals whether its collection strategies live up to the increasing needs for diversity in the collections.

Technological developments will further drive genebanks towards operating in a scientific and technological environment in which new developments can be absorbed in and adapted to genebank operations. Again, this represents essentially one scenario. CGN will have to foster its embeddedness in Wageningen University and Research Centre and strengthen its links within Wageningen.

Future policies can facilitate the full use of global networks of genebanks under efficient task-sharing agreements or limit genebank roles to regional or even national interests. Here more scenarios are open. Given the international orientation of Dutch plant and animal breeding and as a consequence the importance of international exchange of germplasm for the Dutch economy, CGN should continue to develop new forms of international collaboration and set examples showing the added value for all stakeholders of an open exchange policy. But much will depend on the further implementation of the International Treaty and the Nagoya Protocol at the regional and national levels.

Finally, available funding levels will determine CGN's future to a large extent. The Dutch plant and animal breeding industry has repeatedly emphasized the importance of national collections of genetic resources as a source and back-up for breeding programmes and as a Dutch contribution to international efforts to secure genetic diversity for food and agriculture. It is up to the Dutch government to provide sufficient funding to CGN to live up to the role of a genebank in a country with one of the world's leading breeding industries. It is up to CGN to complement the government programme by securing additional funding for activities contributing to the conservation and utilization of genetic diversity for global food security, a more sustainable agriculture and diversity-rich rural development.

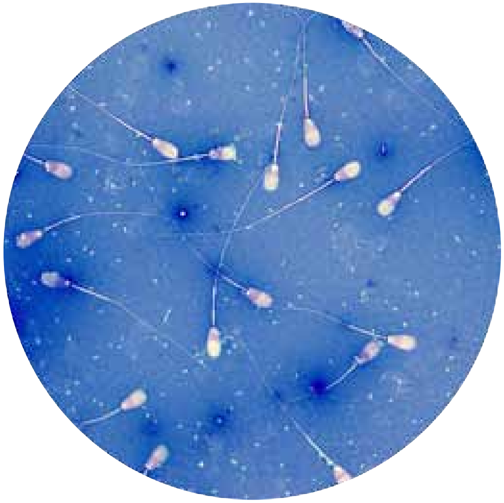


Photo gallery of current CGN staff at the occasion of CGN's 25th anniversary

Noortje Bas	Jan Bovenschen	Joukje Buiteveld	Willem van Dooijeweert	Krista Engelsma	Liesbeth de Groot
Yvette de Haas	Toon Helmink	Sipke Joost Hiemstra	Theo van Hintum	Roel Hoekstra	Rita Hoving-Bolink
Ina Hulsegge	Chris Kik	Jitze Kopinga	Ivo Laros	Niels Louwaars	Woukje Maigret
Myrthe Maurice-Van Eijndhoven	Frank Menting	Kor Oldenbroek	Henk Sulkers	Rob van Treuren	Bert Visser
Sven de Vries	Jack Windig	Debby de Wit	Henri Woelders	Mark van de Wouw	Kees Zuidberg

Colophon

This booklet has been produced by the Centre for Genetic Resources, the Netherlands at the occasion of its 25th anniversary. Robin Pistorius did essential groundwork with the support from Kor Oldenbroek.
All CGN staff contributed to the book's content. Ruud Verkerke and Communication Services, Wageningen UR were responsible for the design. Bert Visser was the responsible editor. Photographs were provided by CGN, Wageningen UR, Fokkersvereniging Het Drentse Heideschaap, IISD Reporting Services, Nijhuis + van de Broek, Svalbard Global Seed Vault, Guy Ackermans, Jon Bakker, Leonie Linotte and Robin Pistorius.

December, 2011.