BACKGROUND STUDY PAPER NO. 59

July 2011

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منظمة الأغذية والزراعة للأمم المتحدة | 联合国粮食及农业组织 | Food and Agriculture Organization of the United Nations | Organisation des Nations Unies pour l'alimentation et l'agriculture | Продовольственная и сельскохозяйственная организация Объединенных Наций | Organización de las Naciones Unidas para la Agricultura y la Alimentación

COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

ACCESS AND BENEFIT-SHARING FOR GENETIC RESOURCES FOR FOOD AND AGRICULTURE – CURRENT USE AND EXCHANGE PRACTICES, COMMONALITIES, DIFFERENCES AND USER COMMUNITY NEEDS

REPORT FROM A MULTI-STAKEHOLDER EXPERT DIALOGUE

by

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TABLE OF CONTENTS

Introduction

Over recent years, a new international legal architecture on access and benefit-sharing (ABS) for genetic resources has emerged, which may have important implications for the use and exchange of genetic resources for food and agriculture (GRFA). The recently adopted *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity* constitutes the newest element of this legal framework and adds new impetus to the discussion about how to best address ABS for GRFA.

As GRFA fall within the scope of the Convention on Biological Diversity (CBD), its Nagoya Protocol and of most regional and national biodiversity laws and arrangements, their ABS provisions have a direct impact on the practices of use and exchange of genetic resources in the food and agriculture sector. While the special nature of GRFA has been widely acknowledged – the Nagoya Protocol itself recognizes the special nature of agricultural biodiversity, its distinctive features and problems needing distinctive solutions – most existing ABS laws and arrangements do not foresee special consideration for GRFA. This implies a risk of regulating their use and exchange without paying due attention to their specific characteristics and requirements.

The adoption of the Nagoya Protocol both increases the need and opens new opportunities to identify the specific characteristics of GRFA, assess the potential impact of different ABS measures on their use and exchange, and explore existing and develop new options for implementing ABS in the food and agriculture sector.

The FAO Commission on Genetic Resources for Food and Agriculture (the Commission) started work in this field as an early task within its Multi-Year Programme of Work. It agreed on the importance of considering ABS in relation to all components for food and agriculture at its Eleventh Regular Session in June 2007[4] and considered arrangements and policies for ABS for GRFA at its Twelfth Regular Session in October 2009[5]. To facilitate discussions and debate on ABS for GRFA, several background study papers on use and exchange patterns of genetic resources in the different subsectors of food and agriculture were commissioned[6]. The studies provide an overview of past, current and possible future use and exchange patterns, as well as a description of terms and modalities for the use and exchange of GRFA, in the subsectors dealing with animal, aquatic, forest, invertebrate, microbial and plant genetic resources. Additionally, cross-sectoral studies were prepared on the role of GRFA in existing ABS policies and arrangements, on trends in intellectual property rights relating to GRFA, and on the impact of climate change on countries' interdependence in the use of GRFA. The findings of the studies were discussed in a Special Event immediately preceding the Twelfth Regular Session of the Commission.

Building upon this work, the Commission Secretariat, in cooperation with the Universitè catholique de Louvain, Belgium, and CIRAD, France, and with the support of the Government of Norway and the Agropolis Foundation (France), initiated a Multi-Stakeholder Expert Dialogue on Access and Benefit-Sharing for Genetic Resources for Food and Agriculture. The Multi-Stakeholder Expert Dialogue brought together experts from the various stakeholder groups and user communities in the different subsectors of food and agriculture. It aimed to generate knowledge and ideas that would contribute towards effective implementation of ABS for GRFA, which would both ensure the fair and equitable sharing of benefits arising from the utilization of GRFA and, at the same time, facilitate the continued exchange of genetic material according to established practices in the food and agriculture sector. In particular, it aimed to gather experience and expertise from stakeholder and user communities in the different subsectors of food and agriculture (dealing with animal, aquatic, forest, microbial and plant genetic resources, and genetic resources relevant for biological control) and provided a platform to discuss the

[4] CGRFA-11/07/Report, paragraph 71.

[5] CGRFA-12/09/Report, paragraphs 11-13.

[6] Background Study Papers No. 42, 43, 44, 45, 46 and 47.

commonalities and differences among the subsectors in their use and exchange of genetic resources, the effects and implications of ABS measures for the use and exchange of GRFA, and possible principles and approaches for addressing and accommodating the specificities of GRFA in ABS measures.

While, to date, approaches to ABS are being developed mostly within certain subsectors and user communities – plant genetic resources for food and agriculture being the most prominent example – it seemed worthwhile to analyse the extent to which GRFA display common characteristics across the various subsectors and discuss the implications of such a cross-sector analysis for the design of ABS measures for the food and agriculture sector. The exchange of experiences and sharing of views and ideas between experts from different stakeholder groups and sectors shed new light on some of the issues at stake, created a fruitful discussion, and brought-up some new ideas and approaches to addressing ABS for the food and agriculture sector as a whole.

In addition to the enhanced interaction between the different subsectors and constituencies, the Multi-Stakeholder Expert Dialogue attempted to create an interface between the GRFA and the ABS communities. It presented the concepts, ideas and values of the currently ongoing international ABS debate, assessed its implications, and integrated its perspectives into the formulation of possible solutions for the food and agriculture sector. In the same way, it provided the providers and users of GRFA with an opportunity to bring in their own perspectives and an understanding of their needs into the ABS debate.

The Multi-Stakeholder Expert Dialogue met in two workshops, which were held from 25 to 26 January 2011 in Brussels, Belgium and from 31 March to 1 April 2011 in Montpellier, France. The first workshop was mainly focused on the discussion of current practices of use and exchange of genetic resources in the different subsectors of food and agriculture and on the identification of specific features of GRFA that are common to many or most GRFA and may have an influence on the suitability of different ABS measures. The workshop also initiated the discussion on possible ABS scenarios and parameters to assess the potential impact of ABS measures on the use and exchange of GRFA. This impact assessment was then the main focus of the second workshop of the Multi-Stakeholder Expert Dialogue. Based on the conclusions of the impact assessment and the presentation of some examples of existing initiatives and innovative approaches for ABS, the second workshop also discussed possible principles and approaches for addressing ABS in the food and agriculture sector.

The Multi-Stakeholder Expert Dialogue was composed of around 40 participants from the different regions of the world. The experts represented in more or less equal numbers the six different subsectors (animal, aquatic, forest, microbial and plant genetic resources, and genetic resources relevant for biological control) of the food and agriculture sector. They work in the context of developing and developed countries, in public and private entities involved in the conservation, research and development of GRFA. In addition, some of the experts have a legal background and are involved in the international ABS debate. The list of participants can be found in the Annex to this report.

While this report attempts to reflect the discussions, findings and outcomes of the Multi-Stakeholder Expert Dialogue as accurately as possible, the responsibility for its content remains entirely with the authors of the report.

The first part of this report provides an overview on the use and exchange of genetic resources in the different subsectors of food and agriculture, including animal, aquatic, forest, plant and microbial genetic resources for food and agriculture, and genetic resources relevant for biological control. It is a brief summary of the information contained in the above-mentioned background study papers prepared for the Twelfth Regular Session of the Commission and of the presentations made by experts during the first workshop of the Multi-Stakeholder Expert Dialogue. In continuation, the second part of the report analyses the commonalities and differences of use and exchange patterns in the different subsectors, and identifies the specific features of GRFA, the degree to which these features are common to all GRFA, and possible future developments that may influence them. The third part of the report discusses the potential impact that ABS measures may have on the use and exchange of GRFA. In doing so, it also considers the influence that the identified specific features of GRFA may have on the impact of ABS measures. Finally, and based upon the impact assessment, the fourth part of the report outlines some general principles and possible approaches for addressing ABS in the food and agriculture sector.

Part 1
Summary of current practices in the use and exchange of genetic resources for food and agriculture in the main subsectors of food and agriculture

A. The use and exchange of animal genetic resources for food and agriculture (AnGR)

Animal genetic resources for food and agriculture (AnGR) have been used and exchanged by humans for the last several thousand years. Long processes of domestication and selective breeding have considerably altered the genotypic and phenotypic characteristics of the species and populations involved, and currently used AnGR are characterized by long genetic distances from their wild ancestors. In fact, for many domesticated livestock species no wild relatives exist, as they have become extinct, and for others wild relatives are very rare. Because of the relatively low reproduction rates and long generation intervals of many livestock species, animal breeding often relies on continuous genetic improvement over long timeframes, and on the inclusion of parts of the production population in the breeding process in order to achieve sufficiently large effective population sizes and obtain satisfactory selection gains. This factor limits the potential for centralizing the production of breeding stocks.

AnGR are used by a wide range of stakeholders and the level of centralization and specialization of breeding activities is quite variable within the sector. Traditionally, the management of AnGR and breeding lies in the hands of livestock keepers who combine breeding and production functions within the same populations. This can be done at a fairly local scale, selecting the animals to form the next generation from locally available herds and flocks, or at a regional or national scale by forming a common breeding population through breeding associations or herdbook societies. In recent decades, a highly specialized breeding sector has developed for some livestock species and in some regions of the world. In the poultry sector in particular, relatively high reproduction rates have enabled a large-scale breeding industry to centralize genetic improvement and the supply of improved animals to producers. Similar structures are emerging in the pig sector, although to a lesser extent [7].

The majority of AnGR are kept in the form of live animals *in situ* (in their production environments). Only a limited amount of AnGR is stored *ex situ* for conservation purposes or for breeding activities such as artificial insemination and embryo transfer. AnGR are therefore mainly held under private ownership and their exchange takes place mostly on a commercial basis. In general, the assumption when selling genetic material in the form of breeding animals, semen, embryos, etc., is that its value as a genetic resource is already reflected in its price, and that the buyer will be free to use it for further research and breeding [8]. However, in some cases restrictions on the further use of breeding material and its transfer to third parties may be agreed contractually between the parties involved, or alternatively may be based on “gentlemen’s agreements”. While livestock breeders mainly protect their investment in innovation by staying ahead of the competition and by making use of biological protection tools, the use of legal instruments such as trade secrets and patents to protect intellectual property has become more frequent lately.

Rather of holding their AnGR under straightforward private ownership, some traditional livestock-keeping communities may also practise forms of collective ownership or management of AnGR[9].

Relatively few AnGR are held in the public domain. On the one hand, public *ex situ* collections and genebanks mainly fulfil conservation purposes and are less involved in the exchange of genetic material and its provision for breeding purposes. On the other hand, public-

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[7] FAO 2009. The use and exchange of animal genetic resources for food and agriculture, CGRFA, Background Study Paper No. 43, FAO, Rome, Italy.

[8] Ibid.

[9] Ibid.

sector breeding programmes seldom have the resources and size to play a major role as a source of improved genetic material.

Historically, AnGR have been widely exchanged throughout the world and many of the most commonly used breeds are of mixed ancestry. Livestock keepers and breeders in many parts of the world have contributed to the development of these breeds, and today livestock production in most regions depends on AnGR that originated or were developed elsewhere. Currently, major flows of germplasm in the commercially most relevant species take place between developed countries or from developed to developing countries. Genetic material of some breeds adapted to tropical and subtropical environmental conditions is also exchanged among developing countries. In contrast to the commercially more relevant breeds that are widely exchanged, many breeds are used rather locally and are not strongly involved in international exchange. This may change in the future, as many of the traits needed to respond to the effects of climate change may be found in locally adapted breeds. Climate change is not only likely to increase the exchange of AnGR overall, but could possibly also lead to a more important flow of germplasm from developing to developed countries [10].

The need to adapt livestock production to the challenges of climate change also highlights the threat posed by the loss of genetic diversity and the importance of effectively conserving the full range of existing diversity. Genetic diversity can be lost both at the level of breeds, when local breeds fall out of use and hence risk extinction, and at the within-breed level, when the effective population size of widely used breeds becomes too small because of the use of a very limited number of parent animals.

B. The use and exchange of aquatic genetic resources for food and agriculture (AqGR)

Aquaculture is a relatively new and fast-growing activity. Aquaculture products currently account for nearly 50 percent of seafood consumed globally. The sector is characterized by a high number of stakeholders along the supply chain from breed improvement to the sale of live fish. The players range from smallholder producers to large-scale commercial companies.

Because aquaculture is a recently developed activity, two parallel approaches are taken to satisfying consumer demand and increasing food fish supply: domestication of new species and further genetic improvement of species that are already produced commercially. The domestication of new species depends on the capacity to close the whole life cycle in captive conditions. Over the last three decades, the number of taxa – families, species/species groups – being farmed has greatly increased. While in 1950, countries reported farming 72 species from 34 families, by 2004, production was reported for 336 species from 115 families[11]. Genetic improvement of domesticated species remains a nascent activity: it has been estimated that 5 to 10 percent of all aquaculture production is derived from systematic breeding programmes [12]. It is, however, expected that this percentage will increase over time as genetic improvement is facilitated by the high fecundity and relatively short life cycles of many aquatic species, which allow for intensive and rapid selection.

For many species, the source of breeding material is still significantly dependent on wild stocks. For other species, for example in the shrimp sector, which is characterized by a high level of segregation among the activities along the value chain from conservation to production, the source of breeding material is much more variable: wild-caught adults, shrimp taken from production ponds raised to maturity and bred in an ad hoc manner, and shrimp coming from long-term selective breeding programmes run by commercial breeders in centralized breeding areas,

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[10] Ibid.

[11] Bartley, D. M., J. A. H. Benzie, R. E. Brummett, F. B. Davy, S. S. De Silva, A. E. Eknath, X. Guo, M. Halwart, B. Harvey, Z. Jeney, J. Zhu, U. Na-Nakorn, T.T.T. Nguyen, and I. I. Solar 2009. The use and exchange of aquatic genetic resources for food and agriculture, CGRFA, Background Study Paper No. 45, FAO, Rome, Italy.

[12] Gjedrem, T. 2005. Selection and Breeding Programs in Aquaculture, Springer, Dordrecht, The Netherlands, 364p.

which may even be outside the species' natural ranges [13].

Aquaculture is the main reason for the deliberate movement of aquatic species to areas outside their native ranges, and farmed species have been moved extensively throughout the world. The exchange of AqGR for introduction purposes has taken place in many different directions between the northern and southern hemispheres [14]. The practices and modalities of exchange vary according to the level of domestication of the respective species and the degree of professionalization of the sector (i.e. in particular, how production is divided into broodstock development, multipliers/hatcheries, and grow-out). Generally speaking, these exchanges remain regulated by classical commercial practices, meaning that AqGR are sold without further conditions attached to them. Sometimes, they may even be freely exchanged between entrepreneurs, including across borders. Two general developments are leading to more formalized exchange practices:

- Government involvement in regulating the exchange of AqGR (e.g. through approval procedures) is becoming more frequent. In instances where the development of the aquaculture sector is primarily based on exotic species and management of the breeding populations is poor (resulting in inbreeding and loss of genetic diversity), genetic replenishment of the stocks is often required to sustain production levels. However, a general reluctance among original suppliers to provide stocks for replenishment is increasingly prevalent.
- Private law contracts between seller (breeding company) and buyer (e.g. multiplier or producer) restricting use for further breeding are becoming more frequent. Because most genetically improved aquatic species are fertile and can be reproduced easily, contractual arrangements attempt to limit the scope for unauthorized exchange of AqGR.

The importance of international exchange of AqGR is expected to increase in the future, due to a growing number of species being domesticated and taken into production, and due to the need for exotic genetic material to respond to the effects of climate change.

The risk of losing genetic diversity in the aquaculture sector is mainly related to wild stocks being threatened by environmental factors such as degradation of habitats, loss of ecosystems, overfishing or the introduction of alien species. However, genetic erosion can also be a consequence of inbreeding due to poor management of domesticated populations, which is quite frequent in farmed fish and brood stock.

C. The use and exchange of forest genetic resources for food and agriculture (FGR)

One of the main uses of forest genetic resources (FGR) is direct use as reproductive material (in the form of seeds, cuttings and other propagating parts of a tree) for the regeneration of natural forests on the one hand, and for the establishment of plantations and agroforests on the other. The extent to which FGR are used in systematic exploration and breeding programmes varies a lot among different tree species. For several fast-growing tree species used for industrial and smallholder planting, systematic exploration and improvement started some 50 years ago and has mainly focused on the most common plantation tree species such as acacias, eucalypts and pines. For various temperate and boreal tree species, exploration and assessment efforts started more than 200 years ago, although more systematic improvement programmes were initiated, for the

[13] Bartley, D. M., J. A. H. Benzie, R. E. Brummett, F. B. Davy, S. S. De Silva, A. E. Eknath, X. Guo, M. Halwart, B. Harvey, Z. Jeney, J. Zhu, U. Na-Nakorn, T.T.T. Nguyen, and I. I. Solar 2009. The use and exchange of aquatic genetic resources for food and agriculture, CGRFA, Background Study Paper No. 45, FAO, Rome, Italy.

[14] Ibid.

most part, only in the course of the twentieth century [15]. For the majority of other species, improvement efforts still remain limited and are mostly restricted to provenance trials and the selection of seed stands. In general, forest tree breeding is determined by long generation intervals and breeding cycles and most species are still within the first generations of genetic improvement. However, genetic gains per generation can be quite substantial due to the fact that many species are virtually wild and diversity and selection opportunity is very high. Additionally, some species such as tropical eucalypts, acacias and some pines are progressing relatively rapidly because of shorter generation intervals (typically less than 10 years) and early selection techniques.

In line with the situation described above, the genepools of many tree species, even in breeding programmes, are still semi-wild, and tested, selected or improved material is only available for a relatively small number of tree species. According to the level of improvement involved, reproductive material of forest tree species may be obtained from a wide variety of sources. For example, the collection of seeds from wild stands and natural populations for mass propagation of plantations or forest regeneration is still common. Additionally, seed orchards, special facilities associated with organized breeding programmes, are managed specifically for seed production. The genetic material produced in these orchards has usually been tested and selected in provenance trials across different sites and climatic conditions, and may be optimized for specific commercial traits such as wood volume, pulp yield, biomass yield or leaf oils. Large-scale nurseries producing tree seedlings and/or cuttings are often managed by large companies or state agencies, but small-scale nurseries operated by farmers and local communities are often the main source of tree seedlings in rural areas, especially in areas where no commercial forestry is practised [16]. Furthermore, some *ex situ* collections of FGR have been established for conservation and research purposes and are usually managed by public or semi-public research institutions.

While the movement of FGR around the world has a long history and the proportion of exotic forest reproductive material used for plantation and afforestation is quite high, considerable differences exist between species with regard to their involvement in international exchange of germplasm and the extent to which they have spread outside their natural distribution ranges. For example, several fast-growing plantation species, such as acacias, pines and eucalypts, have been moved extensively throughout the world and are nowadays cultivated far beyond their natural distribution ranges. Also, some tropical high-value speciality timber species such as mahogany, Spanish cedar and teak are grown as exotics [17]. Although the exchange of some species, such as agroforestry tree species, may have taken place on a smaller scale, their distribution to countries beyond their native ranges has played an important role in the development of the sector. However, for many species exchange of genetic material has been limited to date, and takes place mainly on a regional level or between countries sharing the same climatic conditions. Various species are also used largely within their natural habitats in native forests and are only exchanged very occasionally, for example for specific research purposes.

The actual flow of forest reproductive material is not determined only by the use of exotic species. For example, some countries are self-sufficient with respect to the supply of reproductive material of exotic species that have been introduced previously, because the historical movement of germplasm of the species has led to the establishment of a sufficiently broad genepool within the new country. In contrast, countries may also depend on the import of reproductive material of their own native tree species from neighbouring countries. However, the demand for seed or other reproductive material is in general higher for exotic species. For the future, it is expected that the movement of forest reproductive material will become even more important, mainly due to the challenges of climate change.

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[15] Koskela, J., B. Vinceti, B., W. Dvorak, D. Bush, I. Dawson, J. Loo, E. D. Kjaer, C. Navarro, C. Padolina, S. Bordács, R. Jamnadass, L. Graudal, and L. Ramamonjisoa 2009. The use and exchange of forest genetic resources for food and agriculture, CGRFA, Background Study Paper No. 44, FAO, Rome, Italy.

[16] Ibid.

[17] Ibid.

Forest reproductive material is mostly exchanged on a commercial basis. In some cases, the movement of genetic material is based on bilateral agreements, such as material transfer agreements (MTAs). Even though intellectual property rights are not used in the FGR sector, some restrictions on the further use of the material may still apply. For example, acacia and eucalypt clones supplied as micropropagated plantlets in tissue culture by some tree breeding agencies may be sold outright for unrestricted use by the purchaser or, in other cases, licensed for propagation with royalties payable on a permanent or per-hectare basis [18].

D. The use and exchange of plant genetic resources for food and agriculture (PGR)

Plant genetic resources or food and agriculture (PGR) have been used and exchanged since the beginnings of agriculture, some 10 000 years ago. Farmers and farming communities have planted, selected and exchanged seeds and vegetative propagating material, and a combination of natural and artificial selection has domesticated plant species and adapted them to the changing needs of farming and consumption. Migration, trade and colonization spread many species beyond their regions of origin, which spurred further selective pressures. Since the mid-nineteenth century, professional seed suppliers, followed by specialized plant breeders and biotechnologists, have developed advanced methods for selecting PGR at the phenotypic, genotypic and molecular levels to further shape crops and contribute to advanced agricultural systems and the production and supply of agricultural products with distinctive characteristics.

PGR are maintained both *in situ* and *ex situ*. A considerable amount of crop genetic diversity is held in farmers' fields and in the breeding pools of specialized plant breeders. Many wild relatives of today's crops are conserved in protected areas or within agricultural ecosystems. In addition, much of the diversity originally found *in situ* has been collected and stored in *ex situ* facilities. The constitution of these collections started many decades ago and they are mainly held by public genebanks at national level and by international research centres, with some of the most relevant collections being managed by the centres of the Consultative Group on International Agricultural Research (CGIAR). Overall, it is estimated that approximately 7 million accessions of PGR are stored *ex situ*, and it can be said that these collections play an important role in the functioning of the sector. Apart from the public genebanks, PGR are also held *ex situ* in the breeding collections of private companies. However, the extent of these private collections is mostly unknown and the stored genetic material is not publicly available.

The sector using PGR for breeding purposes is quite diverse and its organization is highly dependent on the crops bred and on the geographic area and type of user group targeted. Large private corporations increasingly dominate the commercial seed market for some of the major and high-value crops, such as maize and major vegetables. Medium- and smaller-sized breeding companies continue to operate in smaller seed markets for commercially less attractive crops, such as some self-pollinating staple crops. Public-sector institutions at national and international levels continue to play an important role in breeding and variety development both for crops not served sufficiently by the private sector and for marginal environments and resource-poor farmers who are not likely to be reached by the commercial sector. At the level of research for breeding, including rather fundamental research as well as prebreeding, both large and small biotechnology companies, sometimes integrated with plant breeding and seed production, and universities are the main players. Other users of PGR include farmer groups and civil society organizations supporting them. They may contribute to the reintroduction of PGR from genebanks into farming systems, sometimes combined with participatory plant breeding or participatory variety selection activities involving both farmers and trained breeders.

Different types of PGR may be used in plant breeding and variety development. The development of new varieties is usually based upon the use of advanced genetic material, as it is in general a costly and time-consuming process to bring less-advanced material to the same performance levels. However, old varieties, landraces and crop wild relatives may be used to introduce particular traits into breeding populations. The genetic diversity contained in landraces

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[18] Ibid.

and traditional varieties may also be used for base-broadening activities and for the development of varieties adapted to less-favourable environmental conditions and low-input production systems.

Historically, crops and PGR have been widely exchanged throughout the world, and many people in many different places have contributed in one way or another to the development of today's crop genetic diversity. As a consequence, an important part of current crop production relies on the use of exotic species, and all countries depend to some extent on genetic diversity that originated elsewhere.

The current international flow of PGR takes place in many different forms, including for example the exchange of germplasm samples from *ex situ* collections, the sale of commercial seed and vegetative propagating material, or intercompany transfers of genetic material under development. The international exchange of genebank accessions amounts to several tens of thousands of transfers annually and plays an important role in conservation, research and development both in developing and developed countries. At the same time, it has to be noted that the majority of genetic material used directly in breeding and variety development comes from the breeding pools within one region and new "exotic" material is only occasionally accessed.

The modalities for the exchange of PGR depend on the crop in question and on the type of exchange partners. Generally speaking, the trend is towards more formalized exchange practices, mainly through material transfer agreements (MTAs). Transfers of germplasm samples from genebanks are, for instance, increasingly regulated by MTAs. Contracting Parties to the International Treaty on Plant Genetic Resources for Food and Agriculture have agreed to use a standard contract, the SMTA (agreed multilaterally and non negotiable), for each transfer of material belonging to the Multilateral System of Access and Benefit Sharing under the treaty. This Multilateral System includes *"all PGRFA listed in Annex I of the Treaty* [64 crops and forages] *that are under the management and control of the Contracting Parties and in the public domain"* (Article 11.2). In an interesting development, the same standard contract (with a footnote) is used by some national and international genebanks also for the transfer of Non-Annex I material. Exchange among commercial breeders is either free (in the case of the use of commercial varieties for further breeding) or regulated by commercial material transfer agreements. Exchange among farmers is limited by distance and social factors, but is generally free.

E. The use and exchange of microbial genetic resources for food and agriculture (MiGR)

The number of MiGR currently used for food or agriculture applications is small relative to the huge number of species potentially useful, in part because of technical limitations to the culturing of many living micro-organisms. Agriculture applications of MiGR are nevertheless quite diverse: plant growth promoting agents; biological control; beneficial symbiosis in the guts of ruminant livestock; production of chemicals of direct benefit to agriculture; catalysts in agro-industrial processes; understanding and surveillance of microbial plant and animal (including fish) pathogens. Food applications are also quite varied: traditional fermentation (fermented foods); industrial fermentation of alcohol and wines; cheese production; probiotics; production of chemicals of benefit to food production (vitamins, organic acids, etc.); and understanding and surveillance of health-hazardous micro-organisms such as food toxins and food-borne pathogens.

Use of MiGR is mainly done by screening vast quantities of naturally occurring microbes or microbial resources conserved in purified form in *ex-situ* collections. Synthetic biology may involve genetic improvement, but this remains a marginal phenomenon. although it may grow in the future.

Microbial culture collections (MCC) are at the heart of the sector. All culture collections with major holdings in food and agriculture belong to the public sector or are non-profit organizations with major governmental funding. MCC fulfil several objectives: procurement of cultures and *ex situ* conservation of micro-organisms; provision of authentic microbial cultures to industries and academic and research institutes; provision of identification, freeze-drying and other microbiology-related services; depository of patent cultures; and research on microbial diversity, taxonomy and related areas. The majority of large MCC are situated in OECD countries, where the majority of deposits, distribution and exchange also occur. However, many countries are actively involved in collecting and exchanging micro-organisms internationally, and microbial collections from non-OECD countries represent an important and growing subset in the overall network of culture collections. MiGR currently used in agriculture and food systems have been collected both from tropical and subtropical species-rich agro-ecosystems and from non-tropical areas [19].

Because each MCC contains an important set of unique strains (an average of 40 percent of the strains are unique), collaboration and exchange among MCCs is common [20]. These exchanges, as well as flows from *in situ* to *ex situ*, occur in all geographical directions. Whereas historically these exchanges were quite informal, there has been a noticeable evolution towards formalization in recent decades [21]. In particular, MCC are moving increasingly towards the use of legal instruments: acquisition agreements when acquiring materials and MTA when distributing them. Some important limitations, especially on further distribution to third parties, generally apply even for non-commercial research purposes, mainly for quality management purposes and to address biosecurity issues. When commercial development is involved, additional agreements with the initial depositor are often required, with the general understanding that the depositor holds responsibility with regard to prior informed consent from the country of origin.

Exchange between qualified MCCs may involve simplified procedures. Both OECD and non-OECD collections include clauses related to legitimate/legal exchange in their MTAs, which allow public culture collections that comply with strict quality-management criteria to further distribute microbial research material that they have received from other public MCCs (so-called legitimate exchange). European Biological Resource Centres Network (EBRCN) and Asian Consortium of Microbiological Resources (ACM) are making efforts to make the cultures available within the networks with few restrictions. However, in response to growing commercial opportunities and to financial restrictions on government spending on culture collections in some countries in the 1990s, this club model is threatened. Some MCCs have departed from the sharing and collaborating practices and have introduced restrictive MTAs even for exchange between MCCs [22].

F. The use and exchange of genetic resources relevant for biological control (BC)

The biological control (BC) of pests plays an important role in integrated pest management approaches in the food and agriculture sector. It is based on the use of natural enemies of pests, often referred to as BC agents. These are predators, parasitoids and pathogens of invertebrate pests, and herbivores that attack weed pests. For the purpose of this report, only invertebrate biological control agents are included under the term genetic resources relevant for BC. Microbial BC agents are dealt with under microbial genetic resources for food and agriculture.

There are two main categories of BC. Classical BC is the introduction of one or more BC agents, usually from a pest's area of origin, to control the pest in an area it has invaded. Once introduced, the BC agent becomes established, reproduces and spreads. The BC agent then continues to have its effect on the target pest without the need for any further interventions. Augmentative BC involves the production and release of BC agents – indigenous or exotic – into specific crop situations, where they cause mortality in the target pest, but are not expected to

[19] Dedeurwaerdere, T., Iglesias, M., Weiland, S., Halewood, M. 2009. The use and exchange of microbial genetic resources for food and agriculture, CGRFA, Background Study Paper No. 46, FAO, Rome, Italy.
[20] Ibid.
[21] Dedeurwaerdere, T. 2010. Global microbial commons: institutional challenges for the global exchange and distribution of microorganisms in the life sciences. In Research in Microbiology. 161(6): 407-413.
[22] Dedeurwaerdere, T., Iglesias, M., Weiland, S., Halewood, M. 2009. The use and exchange of microbial genetic resources for food and agriculture, CGRFA, Background Study Paper No. 46, FAO, Rome, Italy.

persist from one cropping cycle to the next[23].

The research and development process leading to the use of a new BC agent involves various steps that require access to genetic resources. The largest number of exchanges of genetic material takes place in the early stages of research and development, when it is necessary to study the target pest and its natural enemies. Preliminary surveys of the target pest and its natural enemies will often need to be carried out in several countries, and specimens of pests and natural enemies normally need to be exported for identification and taxonomic studies. Detailed studies on natural enemies to assess their potential as BC agents can, in part, be carried out in the source country, while host-specificity studies involving plants or animals not naturally occurring in the source country are best carried out in quarantine in the target country or in a third country. Overall, only a small fraction of all the species found and studied will actually be recommended for use and released as BC agents. Once a specific BC agent has been identified and is being released, there is little need for further exchange of genetic material[24].

The type of genetic material used in BC consists primarily of living organisms used as BC agents. Organisms are mostly collected *in situ* and exported as live specimens. Product development does not normally include genetic improvement of the BC agent as such. At most, it sometimes entails discrimination between populations in terms of biological characteristics that affect their adaptation to the target country or target pest. While most of the genetic diversity used in BC can consequently be regarded as wild, it is at the same time closely linked to agricultural production environments.

A particular attribute of classical BC is the public good nature of its activities. As classical BC agents establish and reproduce themselves in the target environment and from that point on are freely available, it is not possible to make any profit from their production and release. Consequently, classical BC is exclusively run by the public sector, mainly through national and international research institutions paid by governments or development agencies. Augmentative BC, in turn, is a relatively recently developed activity. The history of commercial mass production and sale of natural enemies spans less than 50 years. It is carried out by a relatively small number of companies worldwide, of which most are located in developed countries and the majority are medium or small-sized. Even though augmentative BC agents are mainly produced for high-value crops such as greenhouse vegetables and ornamentals, the average profit margin is usually quite low. While the development of rearing, distribution and release methods is mainly carried out by commercial producers, public research institutions and universities sometimes play an important role in the early stages of research and development.

The international exchange of genetic resources relevant for BC plays a critical role in the functioning of the sector. The importance of exchange can easily be understood by looking at the case of classical BC. The introduction of a new classical BC agent is always linked to the use of exotic genetic material, as it follows the movement of target crops and pests around the world. In fact, the great majority of classical BC transfers are intercontinental, which is to be expected as the target pests are themselves introduced species, often of intercontinental origin. Once a BC agent has been used successfully in one country, the opportunity is often taken to repeat the success in other countries through redistribution of the agent. Consequently, the international flow of genetic resources related to BC has been quite significant, involving several thousand BC agent species from more than a hundred countries, and introductions into an even higher number of countries[25].

As the BC sector is composed of a small number of actors, exchanges of genetic material have essentially been regulated through informal means, mainly by professional networks, which

[23] Cock, M. J.W., J.C. van Lenteren, J. Brodeur, B.I.P. Barratt, F. Bigler, K. Bolckmans, F. L. Cônsoli, F. Haas, P. G. Mason, J. R. P. Parra 2009. The use and exchange of biological control agents for food and agriculture, CGRFA, Background Study Paper No. 47, FAO, Rome, Italy.

[24] Ibid.

[25] Ibid.

may be institutionalized or simply operate at a personal level. However, the informal character of exchange practices does not necessarily mean that no terms and conditions apply. Established "customary" practices for use and exchange may, for example, foresee the sharing of results obtained from the use of the material or, in the case of research, the joint publication of results. In addition, in the augmentative BC sector, exchange practices are also regulated through classical commercial practices such as licensing production (i.e. larger augmentative BC companies license production to smaller companies as a way of facilitating the establishment of new companies in new countries to supply new markets) and intercompany supply (i.e. commercial augmentative BC companies sometimes buy BC agents from each other) [26].

[26] Ibid.

Part 2
Commonalities and differences of the main subsectors of food and agriculture in their use and exchange of genetic resources

A. Introduction

As described in Part 1, genetic resources for food and agriculture (GRFA) are exchanged in many different ways, by a wide range of stakeholders, for various purposes, and under a wide variety of conditions. The patterns of use and exchange of genetic resources vary not only between the subsectors of food and agriculture, but also within the subsectors according to the type of use and depending on the type of genetic material and taxonomic group involved. Despite such variations, there has been wide recognition of the special nature of GRFA, their distinctive features and problems needing distinctive solutions, and there seem to be some common characteristics shaping the patterns of use and exchange of genetic resources in the food and agriculture sector as a whole.

Therefore, rather than describing in detail all the commonalities and differences that can be observed in the use and exchange of different types of GRFA, the present chapter aims to identify the features that, on the one hand, may be common to many or most GRFA, and, on the other, may affect the suitability of particular ABS measures.

The questions underlying the present chapter can be spelled out as follows:

- What are the specific features of GRFA?
- To what degree are they common to all GRFA?
- Are there relevant differences between the subsectors with respect to these features?
- Are there any current or future developments that will affect these features?

B. Human management, genetic improvement and incremental innovation

One of the most prominent features of the use and exchange of genetic resources in the food and agriculture sector lies in the fact that many of the genetic resources used are human-modified forms of biodiversity and their existence is closely linked to human activity. They are at the basis of agricultural production systems and have long been at the centre of human attention. Humans have not only accumulated vast amounts of knowledge about them and made them integral parts of their cultures and traditions, but have also shaped the evolutionary processes by which they have developed. To start with, humans have influenced the evolution of many GRFA by changing the conditions in which they live through the modification of ecosystems and the provision of artificial habitats in agricultural production systems. Furthermore, GRFA are often the result of long and complex processes of domestication and selective breeding that have considerably altered the genotypic and phenotypic characteristics of the original wild species and populations, and adapted them to the changing needs of production and consumption.

The degree to which humans have influenced the evolutionary process and altered the genetic set-up of populations, varies between the different subsectors of food and agriculture and from one species to another. It depends both on the intensity and the type of genetic improvement applied, and on the amount of time that has passed since domestication and the initiation of selection. In comparing the different subsectors of food and agriculture, a gradient can be observed in the use of improved versus wild genetic material.

At one end of the gradient lie AnGR and PGR, which have been under human management and subject to domestication and selective breeding for about 10 000 years. As a consequence, the vast majority of genetic resources used in these two sectors are improved. The genetic distance between modern crop varieties and animal breeds and their wild relatives or ancestors is usually very large. For PGR, wild material is occasionally used to introduce particular traits of interest into advanced breeding material. For AnGR, the sourcing of genetic material from wild populations can probably be regarded as negligible, as many wild ancestors of domesticated livestock species have become extinct.

At the centre of the gradient are FGR and AqGR , whose sectors rely on a mixture of wild and improved genetic material. Apart from a few exceptions, farming of most aquatic species is a relatively recent activity and major domestication and genetic improvement efforts have only been undertaken during the last 40 to 50 years. As a consequence, a significant part of aquaculture still depends on wild genetic resources, and many farmed populations are similar to their wild relatives. Nevertheless, due to their high fecundity many aquatic species are amenable to systematic genetic improvement, and once their life-cycles have been closed in captivity, rapid selection gains can be achieved. Thus, for some of the commercially most relevant species, improved varieties have been developed and their production relies mainly on domesticated stocks.

A similar situation holds true for FGR. For several fast-growing tree species (such as acacias, eucalypts and pines) and for various temperate and boreal tree species, systematic exploration and improvement programmes have been initiated in the course of the twentieth century, and nowadays their production relies mainly on improved genetic material. However, because of long generation intervals and breeding cycles, most species are still within the first generations of genetic improvement. For the majority of other species, no major improvement efforts have been undertaken or they remain limited to provenance trials and the selection of seed stands. The gene pools of such species still remain wild or semi-wild, and reproductive material is usually collected from the wild.

Particularly in the context of aquaculture, but also in the case of forestry, there is a consistent increase in the number of species being domesticated and for which improvement programmes are being conducted. It is, therefore, expected that in both sectors the importance of improved genetic material will increase in the future. Nevertheless, the use of wild or semi-wild genetic resources will continue to play a very important role.

At the other end of the gradient lie MiGR and genetic resources relevant for BC, which have rarely gone through an improvement process and are mainly of wild origin. For MiGR there are some exceptions, for example in the area of food processing where microbes have long been under human management and selected for specific purposes. Other than that, microbial genetic resources for use in food and agriculture are usually obtained by collecting and screening vast amounts of naturally occurring microbes. BC makes use of genetic resources by searching among the natural enemies of a target pest for a suitable BC agent. The research, development and production of a BC agent do not normally entail any genetic improvement. At most, in some cases value may be added by discriminating between different populations with different biological characteristics. With the expansion of commercial activities making use of MiGR and BC agents and the advance of technology, there may in the future be more potential for the improvement of genetic material in both sectors.

While genetic improvement has clearly been one of the strongest forms of influence that humans have had on the evolution of GRFA, it has to be noted that the wild genetic diversity used in the food and agriculture sector has also been shaped by humans. Through the modification of living conditions in ecosystems and agricultural production environments, humans have at least indirectly influenced the development of many wild GRFA. This can easily be illustrated in the case of biological control, where natural enemies of crop pests have evolved in parallel with the pests and depending on the relevant production system. The same can, for example, be said for nitrogen-fixing microbes associated with the cultivation of particular crops and influenced in their living conditions by agricultural practices.

Where domestication and selective breeding have occurred in the food and agriculture sector, the process of genetic improvement has usually been incremental in the sense that the genetic material has been improved continuously over many successive generations and the gains are cumulative. In other words, the improvement of genetic material is a process of incremental innovation, in which one innovative step is added on to another, and where a product is not the end point of a development process, but rather an intermediate step in an ongoing chain of improvement. In the course of this continuous improvement process, genetic material is frequently exchanged across communities, countries and regions, and different people in different places contribute their share to the incremental innovation being achieved. Consequently, a particular GRFA developed through such a process has normally come into being thanks to "dispersed" contributions made by various actors in different locations at different points of time.

The degree to which contributions to the development of GRFA are dispersed, depends on the intensity and length of the incremental improvement processes to which they have been subject. Thus, the gradient described above for the use of improved versus wild genetic material can also be observed when comparing the different subsectors of food and agriculture. For most AnGR and PGR, the history of incremental improvement goes back several thousand years, and it can be concluded that they are the products of the efforts of many people in places that are sometimes geographically very distant from each other. In the aquaculture and forestry sectors, domestication and genetic improvement activities are often so recent that only a moderate number of innovative steps have accrued so far, and contributions to the development of a specific genetic resource can more easily be attributed to individual people, communities or countries. However, it can be expected that as the improvement process progresses, contributions will be increasingly dispersed and difficult to attribute. As genetic improvement does not normally play a role in the use of MiGR and BC agents, the present considerations are mostly irrelevant to them.

The fact that many GRFA owe their development to a range of actors and environments, also poses a difficulty in determining their countries of origin according to the definitions of the Convention of Biological Diversity (CBD). The CBD stipulates that the country of origin of a genetic resource is the country "which possesses those genetic resources in in-situ conditions", which, in the case of domesticated or cultivated species, are "the surroundings where they have developed their distinctive properties". In the course of many years of incremental improvement under frequent exchange, GRFA have often acquired their distinctive properties in several different surroundings, not just in the one where they are currently found.

The incremental nature of the innovation process also means that products are usually not developed from an individual genetic resource. On the contrary, a broad range of genetic diversity has been included in the improvement process at some point. In other words, many genetic resources have contributed in one way or another to the creation of a specific genepool and the products developed from it. This implies, on the one hand, that an individual genetic resource is only responsible for certain part of the genetic set-up of a specific product. Depending on the number of contributing genetic resources, the extent of this contribution is often unknown or at least difficult to assess, and rather small. On the other hand, it also means that a specific genetic resource may have contributed to the genetic set-up of several products. These considerations hold true for the sectors that make use of genetic improvement in product development (AnGR and PGR; certain species of AqGR and FGR; exceptional cases of MiGR). If product development does not involve improvement of the genetic material, as in the case of biological control, it becomes much easier to attribute the creation of a particular product to the use of a specific genetic resource.

C. Exchange of germplasm and the addition of value

Another outstanding feature of GRFA is the crucial role that their exchange plays in research and development in the sector. Normal business practices in the food and agriculture sector are characterized by an extensive transfer of genetic resources between different stakeholders along the value chain, and imply a continuous demand for access to germplasm. The type of genetic diversity needed may be both wild or improved, interspecific or intraspecific. Animal and plant breeding mainly make use of intra-specific diversity. The number of species used in the animal sector is much more restricted and genetic improvement takes often place at intra-breed level. Forestry and aquaculture rely both on intra- and interspecific diversity, depending on the level of domestication achieved in the respective species. For example, for some domesticated and genetically improved aquatic species, breeding practices are similar to those of terrestrial animals. The development of BC agents is mainly based upon interspecific diversity. The microbial sector is a specific case in the sense that both intra- and interspecific diversity can be used independently of whether or not genetic improvement is applied.

Several stages in the research and development process require extensive exchange of germplasm. At the beginning of a product-development process, often large amounts of samples of genetic material are accessed to screen the existing genetic diversity for interesting traits and genetic combinations and to identify the most suitable genetic material for the desired purpose. At later stages in the process, and if product development is based on genetic improvement, genetic variation is required to generate new genetic combinations. Because of the incremental character of genetic improvement, there is a recurrent need for adding genetic diversity to the research and development cycle.

Thus, the overall quantity and frequency of exchange of germplasm in the food and agriculture sector are relatively high. However, the actual amount of genetic material exchanged varies considerably between the different subsectors and species according to:

- the overall volume of research and development activities in the subsector (exchange rates increase as the subsector becomes more established and professionalized);
- the importance and the level of species domestication (exchange increases with progress in domestication);
- the different phases of research and development (often high rates of exchange in the early phases and, depending on the type of R&D activities, recurrent exchanges in later phases); and
- the importance and the level of genetic improvement applied in the sector (increased exchange rates with increased intensity and length of the improvement process).

In addition to factors linked to the nature of the research and development process, factors related to the broader regulative framework may also influence the level of exchange of GRFA. These include:

- sanitary and phytosanitary considerations and regulations;
- environmental impact considerations and regulations related to the introduction of exotic genetic diversity; and
- intellectual property tools and regulations, which may, depending on their type and level of use, both enable or restrict the exchange of protected material.

Despite the crucial role that the exchange of genetic resources plays in research and development in the food and agriculture sector, the monetary and non-monetary value of an individual sample of germplasm is in most cases uncertain and on average relatively low at the time of transaction. This is, for example, the case when vast amounts of genetic resources are exchanged for screening purposes, but only a very small fraction of the exchanged samples is eventually included in product development. It is also more notably the case when genetic resources are exchanged in the course of incremental genetic improvement and incorporated as one of many genetic components in potential products, and thereby only contribute a tiny part to the genetic set-up of the products.

Nevertheless, there are important exceptions in which the value of an individual genetic resource can be known at the time of transaction and quite relevant in its amount. Such cases include for example genetic resources carrying identified resistance to a relevant pest or disease. Indeed, the value of an individual sample of germplasm strongly depends upon the degree to which it has been characterized and the amount and type of related information available. The more the material has been characterized, the more its potential value in product development can be assessed at the point of transaction, and the more targeted can be its use in the development process. For the same reasons, the average value of an individual germplasm sample, and the degree of certainty regarding this value, changes according to the stage reached in the research and development process. As the development process proceeds, the genetic material usually becomes better characterized and is evaluated and selected accordingly. Hence, its monetary and non-monetary value is in general more certain and on average higher. The direct relationship between the available information and knowledge about a genetic resource and the potential use that can be made of it highlights the crucial role played by both traditional and scientific knowledge in the use and exchange of GRFA.

Another characteristic of the food and agriculture sector is that the use of genetic resources generally leads to the development and release of a relatively high number of products with a relatively low profit margin per product. This statement is only true in very general terms and there may be important exceptions to this pattern, with individual products arising from the use of genetic resources achieving high market values and generating considerable profits.

Thus, while the relatively large number of products developed using genetic resources leads to a large number of potential benefit-sharing events, the low average profit margin per product means that the average monetary benefit to be shared will often be quite moderate. On the other hand, the use of GRFA usually generates important non-monetary benefits, sometimes even independently of whether or not the product reaches the market place. This creates enormous potential for non-monetary benefit-sharing mechanisms such as technology transfer, capacity building and the sharing of information. Furthermore, product development and release involving the use of GRFA frequently leads to external effects that go far beyond the individual provider and recipient of the respective genetic material. These external effects may, for example, contribute to the creation of important public goods such as rural development and poverty alleviation, environmental protection, food security and cultural diversity. In some cases the external effects of product development and release are much more important than the profit that can be made.

D. The nature of products derived from GRFA

Another feature of GRFA is that most of the products derived from their use can themselves be used as genetic resources. They mostly comprise genetic material containing functional units of heredity and are, at least theoretically, ready to be reproduced and used for further research and development based on their genetic set-up. Furthermore, if product development is based on genetic improvement, it lays in its incremental nature that products are not the end-point of a development process, but are themselves inputs to further innovation. Exceptions to this occur when the reproduction line is stopped intentionally at the product level and the biological characteristics of the product prevent further reproduction, (e.g. through the creation of sterile individuals).

The fact that products developed with the use of genetic resources can in turn be used as genetic resources for further research and development, makes it impossible to draw a clear line between providers and recipients of genetic resources in the food and agriculture sector. At least potentially, every recipient of genetic material can also become a provider of genetic resources, if his or her products are used by others.

It also means that many agricultural products reach the market place in a form in which they may be used both as biological resources (i.e. for production and consumption) or as genetic resources (i.e. for reproduction and further development). The ultimate purpose for which they will be used is often unclear and unpredictable at the time of transaction. While this is in principle true for all subsectors of food and agriculture, the degree to which the purpose of use is predictable depends on the level of differentiation and specialization in breeding/reproduction on the one hand and production on the other.

If reproduction and breeding have been centralized in the hands of specialized actors and separated from production and grow-out, this often also implies that genetic material with different characteristics is developed for the different purposes, and it usually becomes easier to determine which genetic material is going to be used for which purpose. For example, forest reproductive material of mixed progeny might be sold for plantation purposes, while genetic material of single progeny would be supplied if the intention is further breeding. The more specialized, differentiated and developed a sector is with regard to breeding and production, the more specialized and advanced becomes also the knowledge and technology required for further improvements. In such circumstances, even though most products might in theory still be used as genetic resources, in practice this rarely happens due to a lack of knowledge and capacity among actors other than those specialized in the task.

Another factor that makes the use of genetic material as a genetic resource more predictable, is the existence of specialized conservation activities. For example, it can be assumed that the majority of germplasm accessed from a genebank will be used for further research and breeding and not for direct production.

Thus, from a biological point of view, the innovation contained in many products developed from GRFA is freely available to others for further use in research and development. This means that the realization of individual benefits from the use of genetic resources requires biological, contractual or legal mechanisms to protect innovation. However, measures taken to protect innovation often imply the risk of restricting access to products in their function as genetic resources for further research and breeding. Establishing an adequate balance between rewarding innovation and not restricting access to genetic resources is consequently a major challenge in the food and agriculture sector. The degree to which this balance is achieved in the various subsectors depends on the different levels and types of measures and instruments used to reward investment in innovation.

E. Holders and users of genetic resources

GRFA are held and used by a broad range of stakeholders, under different types of ownership. The different actors involved in the use of GRFA all play an important role in conserving, developing and making them available for further utilization. Stakeholder groups holding and using GRFA include, *inter alia*, farmers, communities and producers at the local level; public institutions at national and international levels; and private enterprises and farmers' and breeders' cooperatives at national and international levels. They all fulfil different tasks in a complex network of actors, and are to various degrees involved in the maintenance and conservation of genetic diversity, the exchange and direct use of genetic material, and research and product development based upon genetic resources.

A special feature of GRFA is that an important part of them are kept and can be accessed *ex situ*. With the exceptions of AqGR and BC agents, genetic resources in all the other subsectors are held in *ex situ* collections, which are mainly, but not only, maintained by public institutions. This is particularly true for PGR and MIGR, where national and international collections play a crucial role in the overall functioning of the respective sectors. To a lesser extend it is also the case for FGR and AnGR. Although *ex situ* collections do not play a role in the AqGR sector at the moment, it can be expected that they will become more important for some species in the future.

Another feature of GRFA is that some of them are privately held. The proportion of GRFA that are under private ownership varies considerably between subsectors. While privately owned material accounts for the majority of genetic resources held and exchanged in the AnGR sector, the situation in the MiGR, PGR and AqGR sectors is much more balanced between privately and publicly held material. In the FGR and BC sectors, privately held material only plays a minor role.

In addition to the differences between the subsectors, it is important to note that no single set of actors in any subsector is entirely self-sufficient with regard to their need for GRFA. Even in cases where a substantial part of the exchange of genetic resources takes place within a particular group or category of stakeholders, interdependence between different stakeholder groups still exists. This interdependence is a consequence of the diversity of activities undertaken and objectives pursued by the range of actors using and managing genetic diversity at local, national, regional and international levels. Overall, and as a consequence of the broad range of very diverse stakeholders involved in the management of GRFA, any administrative or legal framework regulating their exchange and use has to cope with diverse realities, needs and practices, while taking into account the interdependencies that exist among the various actors.

F. International exchange and interdependence

One of the special features of GRFA lies in the fact that many of them have been widely exchanged across communities, countries and regions, often over long periods of time. As they are inherently linked to human livelihoods and food security, they have historically moved together with people throughout the world. Furthermore, it has been common practice in the food and agriculture sector to exchange genetic material among local communities, farmers and breeders, as part of the normal improvement and production process. Successful production systems and technologies , including the associated genetic diversity, have also frequently been transferred to other countries and regions. This has led to a situation in which a significant part of the genetic diversity used in food and agriculture today is of exotic origin.

The degree to which genetic resources have been exchanged varies (in terms of the geographic distances and timeframes involved) between the subsectors of food and agriculture and from one species to another. It depends on various factors, such as the age and level of development of the sector, the extent to which species have entered into production and the volume of commercial activities, and the degree of domestication and genetic improvement applied. While AnGR and PGR have been extensively exchanged over the last 10 000 years, and livestock and crop production in most regions of the world today utilizes genetic resources that originated or were developed elsewhere, the situation in the forestry and aquaculture sectors, which are in much earlier stages of development, is mixed. On the one hand, some of the commercially most relevant species (e.g. farmed aquatic species and fast-growing forest plantation species) have been moved extensively throughout the world and are now cultivated far beyond their natural distribution ranges. On the other hand, there are several species that are just starting to be farmed in aquaculture, that are only used within their natural habitat in native forests, or that are only being produced on a rather local scale for limited markets. For such species, exchange of genetic resources has been limited and their production still relies mainly on native genetic diversity. However, to the extent that new species are taken into production and related commercial activities grow, it can in general be expected that they will come to be exchanged more widely, both on a regional and a global scale.

The fact that an important part of agricultural and food production relies on the use of species of exotic origin also means that countries are usually not self-sufficient with regard to GRFA. Most countries need to access genetic resources from elsewhere for their agricultural production and food security, and can consequently be regarded as interdependent. This makes it very difficult to draw a clear line between provider and recipient countries, as most countries may, at least potentially, be providers of some types of genetic diversity and recipients of others. It also means that cross-border exchange of GRFA plays an important role in the normal functioning of the sector. Even though this is true in general terms, the actual quantities of GRFA exchanged internationally are difficult to assess for most sectors and species, as available data are limited and do not normally differentiate between genetic material transferred as a genetic resource (e.g. to be bred or improved) and that exchanged as a biological resource or commodity (e.g. to be grown-out and consumed). The amount of material exchanged across borders varies considerably among different sectors, species and countries, and over time. There may for example be situations in which countries are self-sufficient even with respect to reproductive material of species that originated elsewhere, because the historical movement of germplasm has lead to the establishment of a sufficiently broad genepool of the introduced species in the recipient country. It may also be that the exotic origins of a species lie quite far back in time, and that the introduced material has in the meanwhile become adapted to the new environment and local needs, making it more attractive for further use than genetic material from the centre of origin. The same applies, if sanitary or environmental considerations create an incentive for using local instead of foreign genetic material. Conversely, there may be cases in which countries rely on the supply of reproductive material from foreign sources even for native species, because of increasing specialization and division of labour among actors across national borders. There may also be cases in which little attention is paid to genetic factors in the initial exchange and introduction of new exotic species, and where the production of the species in the receiving country is actually based upon regular replenishment of genetic diversity from the centre of origin.

For the future, it can be expected that there will be a trend towards more international exchange of GRFA due to the challenges posed by climate change. Also, globalization and a growing number of transnational companies, as well as international trade and travel may lead to an increase in the transfer of germplasm across borders. However, concerns about the environmental effects of the movement of genetic diversity and the introduction of exotic diversity, may in some cases lead to increasing reliance on native diversity.

G. Conservation of genetic resources

As GRFA play an integral part in agricultural and food production systems, they are to a large extent the result of human activity and their maintenance and evolution depend on continued human intervention. In other words, and contrary to many other genetic resources, they cannot be adequately maintained simply by protecting them from human access, and their sustainable utilization in research, development and production is an important means to ensure their conservation.

At the same time, many GRFA are at risk of being lost and the erosion of genetic diversity poses a threat to future research, development and production options in all of the subsectors of food and agriculture. The intensity of the risks of loss of diversity and the driving factors behind them may vary from sector to sector and from one species to another. Among domesticated and improved genetic resources, the main reason for loss is when particular genetic resources drop out of utilization, because of changing agricultural practices and production systems. This is particularly relevant in the livestock and crop sectors. For those sectors that also rely on the use of wild genetic resources, environmental factors such as the degradation of habitats, the loss of ecosystems, overexploitation and the introduction of alien species play key roles. Such effects can, for example, be observed to different degrees in the aquaculture, microbial and forestry sectors.

As genetic diversity represents a unique source of traits for agricultural development in response to changing environmental conditions and evolving human needs, conservation activities need to be enhanced. The effective conservation of GRFA plays an important role both for the maintenance of livelihood options for farmers and local communities and overall in enhancing agricultural production and ensuring food security. The utilization and management of GRFA, whether through conservation efforts (*in situ* and *ex situ*), research (e.g. characterization and evaluation), reproduction (e.g. selection and breeding) or production (direct use), is an important element of effective conservation strategies.

Part 3
Potential impact of ABS measures on the use and exchange of genetic resources for food and agriculture

A. Introduction

Over recent years, a new international legal architecture on access and benefit sharing (ABS) for genetic resources has emerged, which may have important implications for the use and exchange of GRFA. The fair and equitable sharing of benefits arising from the utilization of genetic resources is one of the three objectives of the CBD, which came into force in 1993. The CBD recognizes the sovereign rights of states over their natural resources and lays down the principle that the authority to determine access to genetic resources rests with the national government concerned, and is subject to national legislation. While the development of concrete arrangements and mechanisms for granting access to genetic resources and ensuring the sharing of benefits arising from their use is left to national governments, the CBD introduces two concepts of a more general nature that should govern access to genetic resources. It establishes that access to genetic resources shall be subject to the prior informed consent (PIC) of the Contracting Party providing the resources, and that it is to be granted based on terms agreed mutually between the provider and the recipient of the resource (mutually agreed terms – MAT). Even though nothing would prevent Contracting Parties from implementing the ABS provisions of the CBD through a multilateral approach, to date most ABS regulatory frameworks take a bilateral approach. With the prominent exception of the International Treaty on Plant Genetic Resources for Food and Agriculture, the use and exchange of GRFA is therefore mainly determined by ABS measures at national level.

To help assess the potential impact that these developments may have on the use and exchange of GRFA, three ABS scenarios have been developed and are described in the following section. They aim to reflect the main features of typical approaches to ABS at national level and serve to highlight some critical aspects of commonly used ABS measures. An attempt is made to analyse the implications and effects of introducing ABS regulatory frameworks as such, and to identify the advantages and disadvantages of some key elements of potential frameworks. The scenarios should not be understood as providing a comprehensive description of all possible ABS measures, and the impact assessment does not serve the purpose of a detailed evaluation of all possible ABS solutions. For example, the scenarios do not take into account options for addressing ABS beyond the national level. However, it is hoped that by assessing the impact of bilateral approaches to ABS, some lessons may also be learned for possible solutions at the international level.

B. Methodology

The first ABS scenario reflects one of the most common approaches to addressing ABS at the national level, which is in a purely bilateral and case-by-case manner ("bilateral case-by-case scenario"). The scenario consists of a national regulatory framework for ABS that provides for ABS conditions to be established bilaterally between provider and recipient on a case-by-case basis for each individual transaction of a genetic resource. It requires access seekers to request and obtain consent and approval for access on a case-by-case basis from the relevant competent national authorities. There may be different competent national authorities involved, depending on the type of genetic resources sought, their location, the intended use and other factors. For each transaction of a genetic resource, the terms and conditions for ABS have to be negotiated and mutually agreed with all concerned parties, including the competent national authorities, the actual provider of the genetic material and in some cases local or indigenous communities. The terms and conditions agreed upon with the provider of the genetic resource have to be set down in an MTA governing the actual transfer of the material. The MTA may also include some obligations *vis-à-vis* third parties, reflecting the terms and conditions agreed upon with the competent national authorities and local or indigenous communities. Otherwise, such terms and conditions may also be set down in a separate contract between the recipient of the genetic resource and the national authorities or concerned communities. Hence, the transfer of a genetic resource may be accompanied by one or several bilateral contracts. According to the mutually agreed terms, monetary and non-monetary benefits arising from the utilization of the exchanged genetic resource are shared on a bilateral basis with the provider of the genetic material, and possibly also with the providing country and concerned communities. Finally, monitoring and reporting requirements for the use of the transferred material are also agreed upon on a bilateral and case-by-case basis, and have to be implemented both by the provider and the recipient for each individual genetic resource that has been exchanged.

The impact that such an ABS scenario has on the use and exchange of GRFA is highly dependent upon the type of material covered by it, in particular with regard to whether only publicly held material is covered or whether privately held material is also included. As described in Part 2 of the present report, a significant amount of GRFA are held under private ownership and many agricultural products reach the market place in a form in which they can be used not only as biological resources (for production and consumption), but also as genetic resources (for reproduction and further development). The question that arises here is whether ABS measures would also apply to genetic resources kept, for example, in the form of live animals, commercial seed, brood stock, seedlings, genetic material in private biobanks, breeding pools of private companies, etc. Depending on the subsector and the proportion of genetic resources held privately, this would make a big difference to the number of transactions falling under a given ABS regulatory framework and the extent to which use and exchange practices would be affected by it.

As many existing national ABS laws do not clearly define whether and to which extent they cover privately held genetic resources, and as it seems to be an issue of major relevance to the impact that ABS measures may have on the use and exchange of GRFA, these considerations were included in the presented ABS scenarios. Thus the first scenario is split in two subscenarios, one applying only to publicly held material and the other to both publicly and privately held material.

In the subscenario in which also privately held material is covered by the national ABS regulatory framework, in addition to the agreement on transfer conditions between the private provider and the recipient of the genetic material, consent and approval of the competent national authorities is also required. Such a scenario also means that, depending on the requirements for access approval, some specific terms and conditions for ABS may be imposed by the state, in addition to those agreed upon by the provider and the recipient. In other words, while such ABS measures obviously do not remove private ownership of the exchanged genetic resources, they add an additional layer of regulation to transactions of private property, by requiring a state permit and setting certain conditions.

In the subscenario covering only publicly held material, transfers of privately held material are not subject to access approval by the national competent authorities, and the terms and conditions for access, and eventually benefit-sharing, can directly be agreed upon between the private provider and the recipient of the material.

The second ABS scenario departs from the purely bilateral and case-by-base approach of the first scenario in the sense that ABS operations are aggregated and standardized at national level. The scenario consists of a national regulatory framework for ABS that foresees a centralized national authority (CNA) responsible for managing ABS-related procedures and mechanisms and for setting the terms and conditions for ABS for all publicly held GRFA. The CNA acts as the single interlocutor for ABS-related issues and is responsible for examining and responding to requests for access approval according to a standardized approval procedure. The CNA also provides a set of standard terms and conditions for ABS for the exchange of all publicly held GRFA in the form of standard clauses that are to be included in any MTA concluded by the actual provider and recipient of the material. Including the standard clauses means that there is no need to negotiate ABS terms and conditions with any other concerned parties, such as national authorities or local or indigenous communities, as the rights and interests of such parties would already be served through the standard clauses. There is, nevertheless, still some scope for the actual provider and recipient of the material to agree upon specific terms and conditions governing the transfer of the material. The sharing of benefits is organized centrally by the CNA, and not on an individual basis between the recipient and each of the concerned parties (i.e. provider, state, local or indigenous communities). Both monetary and non-monetary benefits are to be provided by the recipient to the CNA, which will then be in charge of channelling them to the relevant parties (in the case of monetary benefits) or of managing their sharing on a collective basis (in the case of non-monetary benefits). Hence, non-monetary benefits are made available at a collective level, and not related to the individual genetic resource that generated them and the individual provider of the resource. This could, for example, be achieved by compiling the information derived from the use of genetic resources and making it publicly available through a centralized information system. Finally, the CNA also organizes monitoring of the use of GRFA at an aggregated level. To this end, it manages a centralized monitoring system to which recipients are to provide periodic status reports on the use of all GRFA they have received from the country.

The scenarios are compared to two situations that might be referred to as the “status quo”. The first represents a hypothetical “ABS-free” environment and serves to assess the impact of the ABS scenarios compared to no ABS at all. It assumes that there are no legislative, administrative or policy measures related to ABS in place. But it also assumes the absence of any ABS discourse or debate that would shape the perceptions, beliefs and behaviour of stakeholders. Consequently, ABS considerations do not play a role in the exchange of genetic resources, which is entirely framed by other issues such as sanitary or environmental concerns. This might to a certain extent resemble the status quo in some subsectors and user communities of the food and agriculture sector, in which the awareness of ABS is still very limited and that have not so far been directly affected by ABS measures.

The second situation resembles the status quo as felt by most stakeholders in the food and agriculture sector, in which actors’ behaviour is already heavily influenced by the ABS discourse, but no fully functional ABS regulatory framework has been established. On the one hand, the exchange of genetic resources is dominated by high levels of politicization around questions related to access to genetic resources and terms and conditions for benefit-sharing. On the other hand, the situation is characterized by a lack of clear and transparent rules and procedures, unresolved competencies and responsibilities, and uncertainty on the part of most stakeholders regarding their rights and obligations. This creates an atmosphere of confusion and insecurity in which both potential providers and recipients of genetic resources fear being held responsible for unintentionally breaking the rules, and are not confident that the system will safeguard their interests.

The impact of ABS measures in general, and of the described scenarios in particular, will be felt both by the providers of GRFA and by the users of GRFA. While the effects and implications will undoubtedly be different for the two groups and will be described as such in the following sections of this report, it is important to keep in mind that in the food and agriculture sector many stakeholders can act both as providers and as users of genetic resources and no clear-cut line can be drawn between them (see Part 2 of this report).

The establishment and maintenance of a regulatory framework for ABS and of the related administrative procedures, also has a considerable impact on the type and level of resources and capacities that need to be provided by the state, both for the set-up and for the operation of such a system. These costs and requirements may vary between different ABS systems depending on their design and the distribution of tasks between the state and other stakeholders. For example, the CNA in the second scenario might require more resources than a competent national authority in the first scenario, because it takes over certain tasks that would otherwise need to be fulfilled by individual providers and users of genetic material. On the other hand, the standardized approach taken in the second scenario could reduce costs for the CNA in the long term, because it would allow economies of scale in redundant exchange events, and would not require the CNA to negotiate terms and conditions of ABS for every transaction. Even though the present impact assessment does not aim to evaluate the implications of different ABS scenarios for the state, but rather focuses on stakeholder perspectives, the former is an important consideration to take into account when choosing an ABS system at national level. If the implementation costs and requirements of a given ABS system cannot be met, the impact of any ABS measure or regulatory framework will be detrimental for the use and exchange of GRFA, regardless its specific features and nature. It can actually be said, that the proper implementation of any ABS system is at least as important as choosing the right measures. The present impact assessment is therefore conducted under the assumption that the ABS measures contained in each of the scenarios are fully implemented and not jeopardized by a lack of implementation capacity. If the latter is the case, and the state does not have the means to implement its ABS system properly, the situation becomes similar to the one described above as the second “status quo”.

In the following sections of this report, the potential impact of ABS measures on the various aspects of use and exchange of GRFA will be described according to a set of parameters. Some parameters reflect the direct impact that ABS measures may have on access to genetic resources and the sharing of benefits. These parameters include transaction costs, time requirements and capacities needed to cope with certain procedures, and the level of legal clarity and certainty provided by a given ABS system. Other parameters are used to assess the indirect impact that ABS measures may have on the use and exchange of GRFA, mainly due to changes in the incentive structures for exchanging GRFA and for investing in their utilization. These parameters, for example, reflect potential effects on the number and frequency of exchanges of GRFA, the volume of benefits shared, and the amount and type of activities carried out that involve the use of GRFA. They also take into account the implications that ABS measures may have for the different holder and user groups and for different types of genetic material.

In analysing the potential effects of ABS measures on the use and exchange of GRFA, the specific features of GRFA identified in Part 2 of this report and their influence on the expected impact were taken into consideration.

C. Direct impact on access and benefit-sharing for GRFA

The direct impact of ABS measures can be felt on two sides. On the one side, they have an effect on the transaction costs and time requirements for exchanging genetic resources and on the capacities needed by stakeholders to comply with the established measures and procedures. On the other side, they have an influence on the level of legal clarity and certainty governing the exchange of genetic resources, and on the degree of trust and confidence that different stakeholders have in the system.

a. Transaction costs, time requirements and capacity needs

In general terms, it can be said that the introduction of any ABS measure or regulatory framework means the addition of a new layer of regulation on the use and exchange of GRFA, and in many cases will lead to a formalization of previously informal exchange practices. As such, it is likely to provoke additional administrative burden associated to the different steps in the exchange and use process, but could also provide new tools and mechanisms to facilitate interactions between different actors in the process and to overcome conflictual situations.

The direction of the overall impact of ABS measures therefore depends on the status quo before their introduction. If the status quo is similar to the first one described above and ABS considerations have not played a role in the exchange of genetic resources so far, then the establishment of an ABS regulatory framework would most probably mean an increase in transaction costs, time requirements and capacity needs for using and exchanging GRFA.

This increase in transaction costs, time requirements and capacity needs is generated at the different stages of an ABS process, and can be illustrated by looking at the consequences of the first ABS scenario described above. The purely bilateral and case-by-case approach to ABS first of all requires potential users of GRFA to become familiar with and understand the national regulatory framework for ABS of every country they want to access genetic resources from. For every single transaction of a genetic resource they would then need to identify and enter in contact with the relevant competent national authorities and other concerned parties, like local or indigenous communities, to seek their prior informed consent or access approval. Therefore they would need to identify and follow the relevant rules and administrative procedures. In some cases several national authorities might be involved in the approval process and the procedures to be followed may differ between one case and another. If consent from third parties is required, it might be necessary to go through public information or consultation processes. To establish mutually agreed terms for access and benefit-sharing, the potential users would then again need to identify all concerned parties, this time including the actual provider of the genetic material, and enter in negotiations with each of them. Some of the concerned parties might be located in remote areas and there may also be some idiomatic and cultural barriers to be overcome by the user. The exact terms and conditions for access and benefit-sharing would be negotiated individually and could be different for every single genetic resource that is exchanged. In case negotiations are successful, the mutually agreed terms would then need to be reflected in contractual agreements with the concerned parties. In some instances, the exchange of a genetic resource might be accompanied by several contracts with different parties. After exchange, users would need to monitor separately the use of every single genetic resource received, and would have to track its way through the research and development process. As mutually agreed terms were established for every exchanged genetic resource individually, users would have to manage genetic material under a range of different legal conditions. Finally, users would have to determine which benefits were generated from the use of which genetic resource, which part of them are to be shared and who are to be the beneficiaries according to the benefit-sharing conditions attached to the specific genetic resource. They would then need to enter in contact with each of the beneficiaries and organize the transfer of benefits with them individually.

To go through all these steps is not only very complex, time-consuming and cost-intensive, it also requires substantial human, technical, and legal resources on the side of the user. They need to be prepared to interact with a whole range of different parties, they have to be able to comply with different legal systems and administrative procedures, they need to have the skills to conduct negotiations, and they have to set-up the necessary information systems and management tools for monitoring the use of genetic resources and complying with contractual obligations.

The requirements for potential providers of genetic resources mirror the ones just described for potential users. First of all, every single provider would have to understand and comply with the respective national regulatory framework for ABS. Each of them would have to establish their own internal policies and administrative procedures to conduct ABS processes, and would have to raise awareness and build capacities related to ABS specific tasks among their staff. Negotiations on the terms and conditions for access and benefit sharing would have to be conducted with every potential user for every single transaction of a genetic resource individually. Every single transaction would then require the establishment of a specific contract reflecting the respective mutually agreed terms. As the specific terms and conditions for ABS may differ from one case to another, providers would have to monitor and enforce compliance with a range of different contractual obligations by different users of different genetic resources.

Apart from affording the time and costs associated to these steps, each provider needs to dispose of the human, technical and legal capacities to manage the necessary administrative procedures and internal decision making processes and to monitor and enforce concluded ABS agreements. Furthermore, they need to have the technical information and knowledge required to identify and articulate their interests in terms of benefit-sharing, and the negotiation skills needed to establish mutually agreed terms with the users.

As normal business practices in the food and agriculture sector are characterized by an extensive transfer of genetic resources between different stakeholders along the value chain and imply a recurrent demand for access to germplasm, the described steps of the ABS process would not just have to be made once at the beginning of a research and product development process, but would need to be repeated many times during its course. GRFA are exchanged in often large numbers of samples of genetic material at different stages in the research and innovation process.

As different stakeholders fulfil different functions in the value chain, GRFA are frequently passed on from one to another before reaching the stage of product development. Some of the stakeholders act more as a type of intermediaries in the process providing certain services like characterisation, authentication or multiplication. All this leads to a high number of redundant exchange events and a broad range of involved providers and recipients. Consequently, the costs, time requirements and capacity needs associated to every single transaction would add up to a very high burden for a research and development process as a whole.

Another aspect adding to the complexity of applying a bilateral approach to ABS for GRFA, lies in the fact that for many GRFA it can be quite complicated to identify the country of origin, according to the CBD definition, and the rightful holder of the genetic material. This may have different reasons. For example, some GRFA move undetected across national borders by their own force (e.g. fish stocks moving freely across different jurisdictions), or by external forces (e.g. microbes being unintentionally moved with commodities, humans etc.). Other GRFA are home to specific ecological niches that occur in many geographical locations all over the world (e.g. ubiquitous microbes). For domesticated and genetically improved GRFA, the difficulty is that they may have acquired their distinctive properties in many different surroundings and not just the one in which they are currently found.

One of the most complicated and burdensome steps in the ABS process is the one of monitoring and tracking the use of exchanged GRFA. On the one side, this is due to the sheer number of samples of genetic material that are being transferred in the course of the time and whose destiny needs to be followed. On the other side, it is because users are required to track the many different genetic resources that may have been included into the innovation process at different instances and that have been received from a wide range of providers under varying terms and conditions. Tracking of GRFA becomes even more complicated in the case of incremental innovation based on genetic improvement. In that case, a genetic resource does not preserve its genetic identity throughout the research and development process. In the contrary, its genetic components get mixed with others and appear in always new combinations and genetic set-ups. They could be described as a moving target for tracking in the sense that their genetic identity is under constant reconfiguration. Another difficulty in monitoring the use of GRFA arises from the fact that for some groups of GRFA there are no or only very initial monitoring systems in place and there is very little information available about their characteristics, properties and even taxonomic classification (e.g. for many aquatic genetic resources). The utilization of GRFA can also mean that they are released to the environment and that some of them will move on freely and independent from human action (e.g. biological control agents).

For the same reasons mentioned above, also the costs for managing the sharing of benefits arising from the use of GRFA are likely to be quite high on a bilateral basis. The use of GRFA leads to relatively high numbers of released products, of which many have been developed with the contribution of several genetic resources. The individual genetic resources may have contributed to varying degrees and at different instances in the innovation process. It would be quite burdensome to trace back the contribution of each individual genetic resource to every product, and to determine the respective beneficiaries and benefits to be shared, based on the specific terms and conditions agreed upon for every specific genetic resource.

If ABS measures would also be applied to privately held genetic resources, such as life animals, commercial seed, brood stock, seedlings, etc., this would greatly increase the number of transactions covered, and the range of potential providers and recipients affected. As such, it would add a considerable burden in terms of transaction costs and time requirements to established practices of use and exchange of GRFA, and would require a multitude of very diverse stakeholders to come up with the necessary capacities to comply with ABS procedures. As many agricultural products can also be used as a genetic resource, meaning as an input to further research and development, it could further mean to interfere with normal market transactions and commodity trade.

The somewhat aggregated and standardized approach taken under the second ABS scenario, would potentially lead to a decrease in the transaction costs, time requirements and capacity needs provoked by the introduction of ABS measures. By centralizing competencies and procedures in the CNA it reduces the number of bilateral interactions needed between different parties throughout the ABS process, and by harmonizing administrative procedures and standardizing the terms and conditions for ABS it reduces the workload and costs associated to every individual transaction. Compared to the first scenario, the advantages would for example be the following: Users would no longer have to identify and enter in contact with a range of different parties and authorities to obtain access approval and establish mutually agreed terms. Instead they could direct themselves immediately to the CNA, where they would receive all necessary information about the applicable rules and procedural requirements, and where they could request approval for access following a routine procedure. They would need to establish mutually agreed terms and sign a contractual agreement only with the actual provider of the genetic material, and the negotiation process should be facilitated by the existence of standard clauses. This would also reduce the number of case specific contracts to be established and managed by providers and users, and the variation of specific legal conditions attached to different genetic resources. Monitoring the use of genetic resources would be facilitated in so far, as users would only have to report to the CNA in an aggregated way on all genetic resources received from the country, instead of having to report to every concerned provider individually. For individual providers the burden associated to monitoring and enforcing compliance with concluded contracts would be greatly relieved, as this function would be provided centrally by the CNA. In the same way, managing the sharing of benefits would be less complicated, as they would all be provided to the CNA and would not need to be organized with every beneficiary individually.

In summary, it can be said that the aggregated and standardized approach towards ABS under the second scenario makes use of the economies of scale offered by redundant exchange events in the food and agriculture sector. It thereby has the potential to increase the overall efficiency of the ABS process, speed up administrative procedures and approval and negotiation processes, and reduce the capacities required by individual providers and recipients. The aggregated or centralized approach under the second ABS scenario basically means that the state takes over certain tasks in the ABS process that would otherwise have to be fulfilled by individual providers and recipients of genetic resources. This has the advantage of reducing the amount of capacities needed by individual stakeholders, and of reducing potential inequalities in terms of capacities between different providers and users, giving a better chance to the less well equipped. However, it should be noted that while the second scenario might ease the burden compared to the first scenario, it still requires substantial resources and capacities to be made available by both providers and users of genetic resources.

Possible downsides of a centralized and standardized approach could be a lack of flexibility and responsiveness to address case-specific circumstances and diverse stakeholder needs, and an overly rigid implementation by a central authority taking the process out of the hands of those directly involved in the transaction. Hence, a balance should be struck between the use of standardization to realize economies of scale and the provision of sufficient flexibility to accommodate the needs of different stakeholders and types of transaction. It would also be important to ensure sufficient stakeholder involvement in the design and oversight of the system, and to build upon existing capacities of stakeholders related to the exchange of genetic resources.

Finally, it should be noted that in order to bring about the described advantages compared to a purely bilateral and case-by-case approach, the centralized national authority would have to be adequately equipped and fully functional. It would need considerable additional capacities to be able to fulfil its coordination function and establish and maintain the centralized procedures and mechanisms. This may lead to a lack of operational efficiency in the start-up phase, which should be overcome once the system is fully established.

At the beginning of this section it was noted that the potential impact of introducing an ABS regulatory framework would depend on the status quo before its introduction. It was also mentioned that ABS measures could not only lead to additional administrative burden, but could also provide new tools and mechanisms to facilitate interaction between different actors and to overcome conflictual situations. Until now, the three ABS scenarios have been compared to the first status quo described above, characterized by a situation in which ABS considerations have not played a role in the exchange of genetic resources so far. But the status quo could instead be similar to the second one described above, in which the “rules of the game” for exchanging GRFA are missing or uncertain, and where there is no established “playing field” for stakeholders to interact on a reliable basis. In that case, an ABS regulatory framework addressing those gaps could actually also contribute to the reduction of transaction costs, time requirements and capacity needs associated to the use and exchange of GRFA. But its impact would be felt even more on a set of different parameters described in the following section.

b. Trust, legal certainty and clarity

The introduction of any ABS measure or regulatory framework has a direct impact on the level of legal clarity and certainty governing the exchange of GRFA, and on the degree of trust and confidence that different stakeholders have in the system.

If the status quo is similar to the second one described above, than the introduction of any fully functional and well-managed regulatory framework for ABS has the potential to increase legal certainty and clarity of the system. ABS measures could for example achieve this by providing for clear and reliable rules of the game and making them accessible to everybody. This would, *inter alia*, mean to clearly define and spell out the rights and obligations of all concerned parties; to clearly assign responsibilities, competencies and authorities; to establish transparent and simple administrative procedures; to make all relevant information easily available; and to ensure compliance with and guarantee persistence of established rules and regulations. For both users and providers of GRFA this would facilitate the understanding of the steps to be followed in the process of exchanging and using genetic resources, it would make the consequences of their own actions more predictable, reduce the risks associated to them, and make the behaviour of their counterparts more reliable. All together this could contribute to an atmosphere of confidence and security and thereby favour interaction of stakeholders and engagement in the system.

ABS measures could also have a positive impact on the trust and confidence that stakeholders have in a given use and exchange system for GRFA. The trust that stakeholders have in a system does not only depend on the legal clarity and certainty it provides, but also on the perceived fairness and appropriateness of the rules it is governed by, and the degree to which different stakeholders agree with those rules and believe that they adequately reflect their interests. In this sense, ABS measures could for example enhance the trust of providers of GRFA in the system by ensuring that they would get adequately rewarded for their efforts in developing, maintaining and providing genetic resources, and that their resources would not be misappropriated by others. Another gain in fairness could be reached if ABS measures would strengthen the rights of formerly marginalized or excluded stakeholder groups. This could for example be achieved by making sure that less sophisticated providers of GRFA receive a fair return for the genetic material they provide, or by making genetic resources accessible to user groups with limited resources and capacities. In more general terms, stakeholder trust and confidence in any ABS system could be enhanced by involving them in its design and oversight, and by providing for them to be heard in related decision making processes. All of those examples would probably lead to an increased inclination of the concerned stakeholder groups to participate in the use and exchange of GRFA.

As mentioned above, the potential positive impact that the introduction of ABS measures can have on legal clarity and certainty and stakeholder trust, is dependent on the fact that the introduced ABS system is fully functional and well managed. If the required human, financial and technical capacities to fully implement an ABS system are not available, and its implementation remains half-done, the effect is likely to be the opposite and will lead to an increase in uncertainty, confusion and insecurity.

In the same way, if the status quo is characterized by long established and smoothly running exchange practices that are acceptable to all concerned stakeholders, the change of the rules of the game through the introduction of new ABS measures could disrupt the existing equilibrium and reduce the level of clarity and certainty.

D. Indirect impact on the use and exchange of GRFA

The potential indirect impact of ABS measures on the use and exchange of GRFA is mainly associated with the changes they may provoke in the incentive structure for providing, accessing and using genetic resources. In the first place, this will have an influence on the overall number, frequency and type of exchanges of GRFA and on the volume of benefits that are shared. Secondly, it will affect the amount and type of activities that take place involving the use of GRFA, the extent to which different stakeholder groups hold and use GRFA, and the degree to which different types of genetic material are used.

a. Exchange of GRFA and benefits shared

i. Number, frequency and type of exchanges of GRFA

The indirect impact that ABS measures may have on the number, frequency and type of exchanges of GRFA is caused by their influence on various aspects of the incentive structures for both providers and users of GRFA.

For the providers of GRFA, ABS measures may create incentives for making their genetic material available, by ensuring that the providers will be adequately rewarded for doing so. Conversely, ABS measures may increase the administrative burden of providing genetic resources, and thereby discourage providers from doing so. For the users of GRFA, the increased transaction costs, time requirements and capacity needs for complying with ABS procedures will usually be disincentives to accessing genetic resources. One risk in this sense is that stakeholders (both providers and recipients) who do not have the required human, financial, technical or legal capacities to go through all the steps of an ABS process may be excluded from the exchange of GRFA.

Regarding the effect of transaction costs on the incentives for exchanging GRFA, it can be said that for both users and providers the transaction costs have to be justified by the benefits derived from the exchange of a genetic resource. For the user side, that means that transaction costs should not be higher than the monetary and non-monetary value of the exchanged material. For the provider it means that the expected shared benefits should be higher than the costs incurred. The challenge in the food and agriculture sector is double fold. On the one hand, the average value of an individual genetic resource is rather low. On the other, the average profit margin per product is also relatively low, meaning in turn that the individual benefits to be shared are also small. This leads to a situation, in which transaction costs for providing and accessing genetic material can easily be higher than the benefits expected from the use of the genetic resource, and in which both users and providers are discouraged from exchanging GRFA.

In contrast to the effects of additional transaction costs, ABS measures may have an encouraging effect on providers and users of GRFA by enhancing the level of legal clarity and certainty governing the exchange of GRFA, and may thereby stimulate the flow of genetic resources. Whether the overall impact of ABS measures on the volume of exchanges of GRFA is dominated by their influence on legal clarity and certainty or by their effect on transaction costs, depends on the status quo they are compared to. If compared to the first status quo described above, ABS measures are likely to lead to a decrease in the overall number and frequency of exchanges of GRFA, as the effect of increased transaction costs, time requirements and capacity needs would probably prevail. If compared to the second status quo described above, it is possible that ABS measures might lead to higher rates of exchange of GRFA by providing the required (and previously absent) legal clarity and certainty.

The above considerations are again based upon the assumption that the ABS system in question would be fully implemented and operational, and that the responsible authorities would have the necessary resources and competence. If this is the case, the second ABS scenario, reflecting an aggregated and somewhat standardized approach, could have a less negative or even positive effect on the amount of GRFA exchanged. The centralized functions and harmonized procedures under the second scenario have the potential to provide for a more streamlined, simple and clear system, that could offset the discouraging effect of an additional bureaucratic layer once stakeholders become used to it.

One of the main advantages of the second scenario compared to a purely bilateral and case-by-case approach is related to the above-mentioned balance between transaction costs per individual transfer (for both providers and recipients) and the benefits derived from the exchange of an individual genetic resource. By pooling exchange related functions in the hands of a centralized national authority, harmonizing procedures and standardizing terms and conditions for ABS, the second scenario has the potential to considerably reduce transaction costs per individual transaction, and could thereby positively influence the balance. Harmonizing legal conditions under which GRFA are exchanged may also have the advantage of allowing users to mix different genetic resources and their components into their genepools without the risk of "contaminating" them with a multitude of unmanageable contractual obligations. Another positive effect of the second scenario is that the centralized national authority takes over some functions and tasks from the individual providers and users, and consequently reduces the risk of less well-equipped stakeholders being excluded from the exchange of GRFA due to a lack of capacities.

The effect of applying ABS measures also to privately held material would likely have a detrimental effect on the number and frequency of exchanges of GRFA. This is mainly because it would raise considerable concerns among private stakeholders regarding the legal certainty of their rights, and because of the risk that transaction costs would become even higher because of the large numbers of stakeholders and exchange cases involved.

Rather than diminishing overall exchange rates, another possible consequence of the introduction of ABS measures might be that transfers of genetic material happen increasingly outside the legal space. As the exchange of many GRFA was long based on informal exchange practices, the channels for unregulated transactions of genetic material often still exist. In this sense, high costs of complying with ABS measures bear the risk of creating an incentive for escaping legislation.

In the same way that ABS measures may discourage the exchange of GRFA in general, they may also create incentives for stakeholders to switch from the use of foreign genetic resources to those that can be accessed within their own countries. Consequently, it can be expected that the cross-border exchange of GRFA will be more affected by ABS measures than exchanges overall.

ii. Volume of benefits shared

The benefits arising from the utilization of GRFA can be shared in many different ways between the various stakeholders involved in their development, conservation, provision and use. Apart from directly sharing the monetary benefits derived from commercialization, non-monetary benefits can, for example, be shared through the sharing of research results and information with other stakeholders or the broader public, the provision of access to data sets and material collections, cooperation between partner institutions in research and development processes, the provision of access to technologies developed from the use of genetic resources, and the creation of training and capacity building opportunities.

The sharing of non-monetary benefits plays an important role in the food and agriculture sector because of two specific features of GRFA. On the one hand, the use of GRFA in research and development usually generates important non-monetary benefits that may in some cases be even more relevant than the profits that can be made. On the other hand, the potential for non-monetary benefit-sharing mechanisms, such as technology transfer, capacity building and information sharing, is increased by the fact that many countries make use of the same species, establish similar production systems and struggle with the same biotic and abiotic stressors. There is an important opportunity for ABS measures to realize this potential.

With the fair and equitable sharing of benefits being one of the main objectives of ABS measures, their likely impact on the volume of benefits shared is positive. ABS measures can contribute to increasing benefit-sharing in two ways. The policy debate about the rationale and objectives of ABS as such may raise the awareness and understanding of stakeholders regarding the relevance of benefit-sharing, and thereby stimulate the voluntary sharing of benefits on the initiative of stakeholders themselves. More importantly, ABS frameworks provide the legal basis for benefit-sharing, bind users by concrete obligations to share the benefits of their use activities, and empower providers to demand adequate participation in the benefits generated.

ABS measures have the potential not only to enhance the sharing of benefits, but also their generation. One potential benefit created by ABS measures may, for example, lie in the establishment of information-sharing mechanisms and the compilation of information about the genetic resources held in a given country, and their characteristics and properties. As the availability of information is one of the main limiting factors in locating promising GRFA for research and development, this would greatly facilitate the use of GRFA. The same would be true for the information collected through monitoring the use of exchanged GRFA, which could provide valuable insights relevant to their management and conservation. Another potential benefit generated by ABS measures could arise in the form of enhanced partnerships and greater cooperation between users and providers of GRFA, and between foreign and local users.

Nevertheless, there may be two pitfalls in attempting to increase the volume of benefits shared through ABS measures. One of these is related to the potential negative impact of ABS measures on incentives to exchange and use GRFA, which would in turn lead to a decline in the benefits generated from their use. The other pitfall arises because in the food and agriculture sector the individual monetary benefits to be shared can be rather limited compared to the transaction costs associated with the sharing of an individual benefit. Several specific features of GRFA contribute to this situation. First, the profit margin per product developed with the use of GRFA is on average relatively low. In addition, many products are developed with the contribution of several genetic resources, meaning that benefits have to be shared with several providers. Finally, for every individual genetic resource used, several parties (i.e. providing institution, local community, state) may have the right to participate in the sharing of benefits. Altogether, this leads to rather low average monetary benefits to be shared on an individual level, and makes it very complex and costly to organize benefit-sharing on a bilateral and case-by-case basis.

This is where one of the advantages of the second ABS scenario compared to the purely bilateral and case-by-case approach to ABS can be found. Standardization of benefit-sharing conditions and pooling of benefits in a centralized system reduces the administrative costs of organizing the sharing of benefits and the need to split benefits into a large number of small shares. The aggregated approach to ABS under the second scenario is also better adapted to realizing the full potential of non-monetary benefit-sharing, because it is able to take advantage of additional benefits that can only be generated on a collective basis, such as the development of information-sharing mechanisms. It may also enhance the sharing of non-monetary benefits through better coordination of stakeholder needs and more effective identification of benefit-sharing options of relevance to a wide range of beneficiaries in the country.

The application of ABS measures to privately held material would have the advantage of covering a larger proportion of all benefits generated through the use of GRFA, and could thereby increase the amount of benefits shared. However, this advantaged could be outweighed by the detrimental impact that a reduction in exchange and use activities caused by the disincentives created by ABS measures would have on the generation of benefits from privately held material.

b. Use of GRFA

The indirect impact that ABS measures may have on the use of GRFA is generated by their influence on the availability of genetic material (through modified incentives for the exchange of GRFA) on the one hand, and their effect on the availability of capacities to conduct research, development and conservation activities (through enhancement of capacities via benefit-sharing) on the other hand. ABS measures could thereby have an impact both on the overall level of use of GRFA, and on the relative incentives for carrying out particular types of use activities, involving particular groups of holders and users, and including particular types of genetic material under particular types of ownership.

However, ABS measures constitute just one factor among many influencing the incentive structures for investing in and carrying out activities involving the use of GRFA. The following discussion of the potential effects of ABS measures on the use of GRFA is consequently rather indicative, with actual outcomes being heavily dependent on the specific contexts.

i. Type of use activities

GRFA are used for a broad range of activities including *in situ* and *ex situ* conservation, basic and applied research, breeding and product development, and farming and production activities. ABS measures have the potential to influence the incentive structure for investing in these different types of use, and may lead to changes in the amount and type of activities carried out.

Because an important part of genetic diversity used today in the food and agriculture sector is of exotic origin and because cross-border exchange plays such an important role in the normal functioning of the sector, reduced exchange rates of GRFA could have a detrimental effect on the overall volume of use activities. Generally speaking, the consequences of increasing the barriers to exchange will be most severe for activities that require the exchange of large amounts of genetic material. This could hamper, for example, the early stages of research when vast amounts of still largely uncharacterized organisms have to be exchanged for screening. It could also adversely affect genetic improvement and breeding activities that rely on recurrent exchanges of germplasm.

It can also be expected that activities relying mainly on public funding and those that do not generate high returns will be more severely affected by costly and time-consuming exchange processes. This is because both factors would make it more difficult for the stakeholders to cover the extra costs involved in complying with ABS procedures. Activities affected would for example include basic research, conservation, and breeding and product development for resource-poor farmers and marginal environments. In more general terms, one of the challenges facing the food and agriculture sector is that there is already a lack of investment in many activities involving the use of GRFA, relative to what would be required in order to meet demand for agricultural products and ensure food security. This is, for example, the case for genetic improvement and breeding activities in nascent sectors such as aquaculture, but also in a wide range of other areas, including the conservation of GRFA. In this context, the risk of further discouraging the use of GRFA through increased costs seems quite high.

Depending on the scope of ABS measures, some activities might be more directly affected than others. It can, for example, be expected that a possible reduction in exchange rates of GRFA would have an immediate effect on research and development activities, while it might not directly affect production or farming activities. However, the latter would also be affected at some point, as they are part of the same value chain.

As some GRFA are held privately and the private sector is strongly engaged in the use of genetic resources in the food and agriculture sector, the potential impact of ABS measures depends also on the question of whether or not they cover privately held genetic material. The difference would obviously be felt most in sectors and activity areas where the private sector plays an important role. For instance, livestock breeding is largely carried out by private actors and would be more heavily affected if ABS measures were to cover also privately held genetic material.

On the other hand, ABS measures have the potential to enhance the use of GRFA. Through increased sharing of benefits they may lead to better availability of financial, technical and human capacities for the various use activities. It can, for instance, be expected that the research and development capacities of providers of GRFA would be enhanced through the transfer of advanced technologies, sharing of research results and provision of training. The use of GRFA could also be promoted in general through the generation and sharing of benefits on a collective level, such as the establishment of information-sharing mechanisms for GRFA.

One particular concern in the food and agriculture sector is the potential influence of ABS measures on the conservation of genetic resources. On the one hand, conservation activities might profit from increased capacities and means provided through effective benefit-sharing mechanisms. On the other hand, some additional costs related to the collection of genetic material and its eventual provision to others (transaction costs for accessing, managing, providing and monitoring or tracking GRFA) would have to be borne. ABS measures could also provide an incentive for investing in the conservation of GRFA, as efforts might be rewarded in the future through the sharing of benefits. However, the returns that can be expected from such an investment in the near- or medium-term future, are usually quite limited in the food and agriculture sector. Most of the potential value of the GRFA that need to be conserved today will only be realized in the far future and remains rather uncertain. In general terms, it is not expected that the resources that could be mobilized through ABS measures, would match those that would be required to effectively conserve GRFA. ABS measures alone could, therefore, not solve the problem of adequately financing the conservation of GRFA. Another consideration in the food and agriculture sector is that the utilization of GRFA in research, development and production is an important means of ensuring their conservation. Hence, if ABS measures negatively affect such activities, they will hinder the conservation of GRFA.

Finally, a well-functioning centralized competent authority as envisaged under the second ABS scenario would potentially reduce the transaction costs associated with the exchange of genetic material, and would at the same time offer promising opportunities to channel both monetary and non-monetary benefits towards the enhancement of capacities for conservation and sustainable use of GRFA. Under such conditions, the second ABS scenario could potentially better realize the redistributive effects expected from ABS in terms of providing additional means for undertaking activities that are usually underfunded.

ii. Type of holders and users of GRFA

In the food and agriculture sector, genetic resources are held and used by a wide range of stakeholders, including subsistence farmers and local communities, the market-oriented farming sector, public and private genebanks and collections, research institutions at national and international levels, and small- and large-scale companies and enterprises. ABS measures could affect the various stakeholder groups differently, as the measures may be better adapted to the practices and capacities of some stakeholders than to those of others. It is also possible that they apply only to certain stakeholders and not to others.

The different holders and users of GRFA vary considerably with respect to their financial, administrative and legal capacities. In general terms, it can be expected that stakeholders who have fewer capacities and resources for coping with lengthy administrative and legal processes, will be more adversely affected than those who are able to absorb the additional costs. It is, for instance, likely that local producers, researchers and communities will have more difficulty in complying with ABS procedures and requirements than large international companies. As many users and holders of genetic resources in the food and agriculture sector have only quite limited capacities and resources, this would imply the risk of excluding them from the exchange and use of GRFA. At the same time, it can also be assumed that better equipped stakeholders may benefit more from the monetary and non-monetary advantages derived from the use of GRFA.

Because of the dual nature of many stakeholders in the food and agriculture sector (i.e. both as recipients and providers of GRFA) and the interdependence among the various stakeholders along the value chain (in terms of the distribution of tasks and functions related to the conservation and use of GRFA), all actors may potentially be affected by ABS measures, independently of whether or not their activities are directly regulated by such measures. For instance, farmers and local communities could be affected as direct users of genetic resources, if such uses are subject to ABS measures. But even if their activities are excluded from the scope of ABS measures, they could still be indirectly affected through the impact that the measures might have on research and product-development activities upon which they depend.

The important role played by *ex situ* collections in some of the subsectors of the food and agriculture also raises some specific issues. The collections often function as intermediaries between provider countries and potential recipients of genetic material, and in addition provide public services such as conservation, storage, characterization and authentication. However, while bearing the administrative costs of ABS measures, they would often not benefit themselves from the potential benefit-sharing derived from the use of the genetic material they provide, as they simply act as brokers between the country of origin and the recipient.

The potential impact of ABS measures on the structure of holders and users may vary according to the ABS scenario envisaged, in particular in relation to the level of aggregation and standardization. For example, under the second ABS scenario the CNA would fulfil some of the functions related to the ABS process and would thereby reduce the burden on individual providers and recipients. On the other hand, the organizing of benefit sharing on a collective basis envisaged under the second scenario would weaken the link between the genetic resources that stakeholders provide and the benefits they receive, which may have implications for the incentive structure for providers. Furthermore, the standardization of ABS conditions under the second scenario has the potential to soften the impact of ABS requirements on the most vulnerable and less-equipped holders and users by overcoming, in particular, imbalances in bargaining power. However, while standardization could potentially lead to more transparency, equity and fairness, it also bears the risk of creating a more inflexible regime that is less adaptive to the various circumstances and needs of different holders and users. In this context, it would be important to actively involve stakeholders in the design and oversight of ABS measures, and adequately take into account existing exchange practices and the capacities of the various groups of holders and users.

iii. Type of genetic material used

ABS measures may also have an indirect effect on the type and diversity of genetic material accessed and used in the food and agriculture sector. They may change the incentives for exchanging and using different types of genetic material by applying different conditions to them or by only covering certain types of material while others continue to be freely available.

A first general observation is that because of differences between countries' ABS systems and the respective obstacles perceived, users may choose certain countries preferentially and avoid others. In particular, users would look for countries and providers that provide legal certainty over the genetic material, have clear and transparent ABS rules, dispose of information about the monetary and non-monetary value of the material they provide, and have established cost- and time-efficient exchange procedures. Consequently, differences between national ABS regulatory frameworks may induce a shift in the geographic distribution of material accessed and used. In the same way, ABS measures may also lead to an increased use of local genetic material at the expense of foreign material.

Furthermore, the choices that users make between different types of genetic material within the context of a given ABS regulatory framework may be influenced by the scope of material covered by the framework. This is because, depending on the level of legal clarity and certainty provided and the degree of administrative burden generated by an ABS framework, some users may have a tendency to give priority to accessing genetic material that is not covered by the ABS measures. This could lead to a situation in which the use of GRFA found *in situ* or stored *ex situ* (which are more often publicly held and covered by ABS measures) decreases relative to the use of GRFA already contained in breeding pools and production populations (which are more often privately held and not covered by ABS measures). In the same way, and independently of whether or not privately held material is also covered, ABS measures could create an incentive for users to resort to genetic diversity that is already under their management instead of accessing "new" material. Increased costs related to the exchange of GRFA could also direct access and use towards genetic material with higher potential value (e.g. well characterized and evaluated). All these factors would run counter the objective of bringing underutilized genetic diversity into use and broadening the genetic base of breeding and production populations. As the utilization of GRFA can be an important tool in their conservation, this could also compromise the effective conservation of genetic diversity in the food and agriculture sector.

Conversely, if an ABS regulatory framework provides clear and transparent rules and efficient and streamlined procedures, the material covered by such a system might become more attractive than the material not covered. Because of the legal certainty and low-risk conditions it would provide compared to an unregulated situation (where, for example, reputational risks are incurred), such an ABS system could induce a shift in favour of genetic material targeted by regulation.

Finally, another risk associated with ABS measures that needs to be taken into account in the food and agriculture sector, is that of interfering with agricultural commodity trade. This risk arises because many agricultural products can, at least potentially, be used as genetic resources for further research and development, and because the purpose for which they will be used (i.e. only as biological resources or also as genetic resources) is often uncertain at the time of transaction. This creates the need for any ABS regulatory framework to clearly define its scope in terms of the types of genetic material and types of use covered.

Part 4
Principles and approaches for addressing ABS in the food and agriculture sector

After having identified the common features of GRFA and assessed the potential impact of ABS measures on their use and exchange, this part of the report aims to draw some conclusions and outline possible principles and approaches for the design and implementation of ABS measures and regulatory frameworks for GRFA. The underlying questions are:

- What can be done to accommodate the specific features and needs of the food and agriculture sector in addressing ABS?
- What are the options for overcoming some of the shortcomings of addressing ABS in a bilateral way at the national level?

The principles and approaches outlined are also derived from experience gained and lessons learned from existing ABS arrangements established by some stakeholders in the different subsectors of food and agriculture. Three examples[27] of such arrangements were presented and discussed during the multistakeholder expert dialogue. The arrangements presented in the examples act at different levels of governance and are driven either by governments or by stakeholders themselves. They also imply different degrees of formalization of rules and address different issues related to the management of ABS processes, such as the reduction of transaction costs, the management of tracking requirements, the sharing of information, and the appraisal of the value of genetic resources.

While the conclusions that can be drawn from Parts 2 and 3 of this report, together with the lessons learned from existing ABS arrangements, allow the identification of some general principles and approaches relevant to addressing ABS for GRFA, it has to be noted that they reflect only very initial analysis and that much further work is required.

The principles and approaches identified can be grouped into the following three clusters, each of which are discussed in more detail below:

- means of reducing administrative bottlenecks;
- aggregation and standardization of ABS processes; and
- decoupling benefit-sharing from individual providers and individual genetic resources.

Means of reducing administrative bottlenecks

Administrative bottlenecks bear the risk of dramatically restricting international exchanges of genetic resources in the food and agriculture sector. Considering the high degree of interdependence between countries, along with the strong need for access to genetic resources in the sector, such a situation has potential to cause significant adverse effects on the sector and its capacity to sustain agricultural production and ensure food security. In order to limit administrative bottlenecks in the exchange of GRFA, some general principles should be taken into account in the set-up of ABS systems, structures and procedures. These principles include competency, inclusiveness, transparency and clarity.

ABS is a complex issue that involves multiple dimensions including conservation of genetic diversity, promotion of innovation, equity and development. These objectives do not necessarily compete with each other, but their interaction needs to be monitored and managed properly. In this context, it is crucial that competent authorities are able to articulate and adjust their

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[27] The three examples were: Treebreedex, a European project for tree improvement researchers, which involves the establishment of contractual arrangements for the exchange of material and data between the members of the project and with outsiders; the World Federation for Culture Collections ABS policy, which involves structured collaborative approaches such as a code of conduct, a standardized MTA, global exchange of information web portals, and traceability tools through global unique identifiers; the International Treaty on Plant Genetic Resources for Food and Agriculture, which establishes a multilateral system of ABS, which pools genetic material coming from the different Contracting Parties along with material coming from international agricultural research centres.

administrative tasks to a strategic vision of the kind of use of genetic resources that is to be promoted, the type of benefit-sharing that would prove most useful to the country, and the overall objectives to be achieved through ABS. The level and type of competencies that need to be available to competent authorities in order for them to be able to fulfil their task properly include, for instance, an assessment of the existing genetic diversity, a better appraisal of the actual and potential value of GRFA, and the identification of technology and information requirements. Competent authorities would, therefore, have to be equipped with the necessary expertise in scientific, commercial and legal areas related to the management of ABS and the exchange of GRFA. Only then they could efficiently fulfil their mandate and realize the full potential of ABS measures.

The capacity to acquire such competence would, *inter alia*, depend on the active involvement and participation of stakeholders (holders and users of GRFA) in the design and oversight of ABS systems. The overall impact of ABS measures is strongly influenced by the degree to which they are informed of the technical realities dealt with, the nature of the activities regulated and the actual costs involved. The active involvement of stakeholders is also a good way to ensure that ABS rules and regulations build upon existing exchange practices and modalities, and adequately reflect the often dual role (both as providers and users) taken by stakeholders in the food and agriculture sector.

ABS frameworks could also be designed in a way that they facilitate communication and interaction between stakeholders and thereby stimulate a process of self-regulation among the stakeholders within a given sector. Involvement of user communities would in addition contribute to raising the awareness of stakeholders that are not yet familiar with ABS issues. The active participation and increased awareness of stakeholders would in turn be the best guarantee that the different capacities of the huge diversity of providers and access-seekers are reflected adequately in the design of any ABS system. Finally, the involvement of stakeholders is also a way to realize potential synergies with existing regulatory frameworks related to the exchange of GRFA, such as sanitary measures or intellectual property protection instruments.

The principle of transparency and clarity is, *inter alia*, related to the scope of ABS measures or regulatory frameworks. Because of the often dual nature of GRFA (i.e. many GRFA can potentially be used both as biological resources and as genetic resources) and the fact that a significant part of genetic diversity is privately held, a lack of clarity regarding the material covered under an ABS framework may have important consequences. In particular, it is important that potential interfaces with agricultural commodity trade are taken into account and that the implications of the scope of ABS measures in this regard are carefully considered.

In other words, competency, inclusiveness, transparency and clarity are not simply good organizational principles that are an end in themselves. Neither are they simply technical capacities that can easily be provided through technical cooperation or additional budget lines. On the contrary, they involve complex and multidimensional capabilities and need to be articulated in the context of broader national strategies for the conservation and sustainable utilization of GRFA and/or agricultural development and food security. The full realization of these capabilities is crucial to ensuring the best use of ABS measures in the achievement of broader national or global objectives such as food security, innovation and trade promotion, and conservation of biological diversity.

Aggregation and standardization

The complexity of managing ABS at the level of individual transactions between individual providers and recipients is described in previous parts of this report. The extensive exchange of GRFA between the various stakeholders along the value change on the one hand, and on the other hand the fact that products are often developed from several genetic resources, each of them contributing to a different extent to the final product, and each of coming from a different provider and transferred at a different point of time under different ABS conditions, imply complex ABS processes that might easily become very cumbersome and costly. Furthermore, for many GRFA it can be quite difficult to identify the country of origin and the rightful holder of the genetic material. Moreover, the relatively low average value of individual genetic resources and the relatively low profit margin of most products, mean that it is easy for the costs of managing ABS processes on an individual basis to exceed the expected benefits. Finally, the high redundancy of exchange events in the food and agriculture sector offers the opportunity to realize economies of scale.

One way to realize economies of scale and decrease the transaction costs associated with the management of ABS on an individual basis, is the aggregation (or pooling) of genetic material and exchange procedures, and a certain degree of harmonization of ABS terms and conditions. This could for example be implemented through the establishment of an organization to manage collective rights (i.e. on behalf of individuals) and define standardized ABS procedures and conditions for a whole set of transactions and genetic resources. This approach has already been implemented by some actors in some sectors. Examples can be found at the level of professional networks as well as at national (e.g. a national competent authority functioning as a one-stop shop for access seekers) and international levels (e.g. International Treaty on Plant Genetic Resources for Food and Agriculture).

Aggregation and standardization is not only a way of reducing transaction costs for the exchange of genetic material. It also reduces the difficulty of handling genetic material under a multitude of different legal conditions, for example in genetic improvement processes. By providing harmonized or even standardized ABS conditions for a whole set of material, aggregation also facilitates the management of benefit-sharing, for example in the case of commercialization. In addition, it encourages the use of a wider range of diversity (because the whole range is available under the same conditions) rather than focusing access on the genetic material provided by particular providers.

Despite potential advantages, aggregation and standardization may also involve some costs and disadvantages. First, there is a balance to be struck between the use of standardization to lower transaction costs, and ensuring the flexibility needed to address the specificities of different cases involving different types of genetic resources, various use purposes and diverse stakeholders. Hence, the degree to which the potential for aggregation and standardization can be realized depends upon the quality of their implementation. In this context, the general principles described above (competency, inclusiveness, transparency and clarity) play an even more important role than in the implementation of a completely decentralized and case-by-case approach to ABS.

Decoupling

Another approach to overcome the difficulties in managing ABS on a purely bilateral and case-by-case basis is decoupling the sharing of benefits from the individual level. This might be done on two different levels:

- Level 1: delinking the sharing of benefits from the individual provider. Benefits would be shared and managed on a collective basis rather than on an individual and case-by-case basis.
- Level 2: delinking the sharing of benefits from the use of an individual genetic resource. Benefits would not be shared based upon the use of an individual germplasm sample, but upon the use of GRFA on a more aggregated level.

The first level of decoupling is a logical continuation of the aggregation approach applied on the benefit-sharing side. Delinking the sharing of benefits from individual providers breaks the usual “give and take” logic of ABS by acknowledging the collective and incremental nature of the innovation process. In the case of GRFA, it is often very difficult to identify the extent of individual contributions to a product. When it is possible, the average value of individual contributions remains in most cases rather low. Consequently, the costs of organizing benefit-sharing on an individual basis would often be higher than the individual benefits to be shared.

Decoupling the sharing of benefits from the individual provider and lifting it to a collective level, would allow for a reduction in the administrative costs associated with the sharing of benefits. It would also make better use of the potential lying in some benefits that can only be realized at the collective level (e.g. many non-monetary benefits, such as information sharing tools).

This approach has already been implemented at the international level within the framework of the multilateral system of access and benefit-sharing of the International Treaty on Plant Genetic Resources for Food and Agriculture. But it could also be implemented at the national level or at the level of a user community.

The second level of decoupling is much more speculative in the sense that it has never, to our knowledge, been tried in any existing ABS framework. The decoupling of benefit-sharing from the actual use of an individual genetic resource would have the enormous advantage of completely removing the need to track the use of individual genetic resources. In the food and agriculture sector one of the most complicated and burdensome steps in the ABS process is the monitoring and tracking of the use of exchanged GRFA. This is due to a variety of circumstances, including the sheer number of samples of genetic material that are transferred, the fact that many different genetic resources coming from a wide range of providers under varying terms and conditions may be included in the innovation process at different points of time and contribute to different extents in the development of a specific product, the fact that for some GRFA there are no or only very initial monitoring systems in place and that some of them might be released to the environment and move on independently from human action, and lastly the fact that in the case of genetic improvement GRFA do not preserve their genetic identity throughout the development process and become a moving target for tracking.

In general terms, as products are usually developed with the contribution of many genetic resources, it is often quite difficult to assess the contribution of a specific GRFA to a product, and the average value of that individual contribution will on average be rather low. Decoupling the sharing of benefits from the use of individual genetic resources is consequently a promising way to keep monitoring costs as low as possible, at least below the expected added value of an individual transaction of GRFA.

If such an approach were implemented, there would be a need to address the question of how it could be guaranteed that the actual benefits derived from the use of GRFA would still be shared. The solution would lie in triggering benefits from use activities in general. Benefits could be shared at two points of the value chain: at the point of sale of reproductive material; or at the point of sale of consumption products derived from GRFA. The costs involved could be borne by the producers of reproductive materials or consumption products, the consumers of those goods, or the taxpayers if benefits are managed at the national level through budgetary means. It could also be a combination of these three groups and could be implemented to different degrees at national, regional and international levels.

Many of the potential benefits of decoupling are related to the special nature of innovation processes with GRFA, which are often incremental and based on multiple individual shares that contribute to one product. However, it is also important to consider some of the possible drawbacks of decoupling. First, if benefit-sharing is decoupled from the individual provider, this might decrease the incentive of the provider to make material available. Second, decoupling benefit-sharing from use, even if there are important transaction-cost gains for all, might in some cases lead to less willingness to pay, as the level of payment would be determined in accordance with the benefits from use activities in general, without necessarily differentiating between high added value uses and low added value uses. In this regard, a proper balance between general cost-sharing (such as in a tax system) and more targeted contribution from those who have the highest willingness to pay, because they are the direct beneficiaries of a specific added value or service (such as in a mandatory insurance or a liability system), would have to be carefully considered. In general, therefore, careful consideration would have to be given to the various possible models of decoupling, which may be partial or total and which may be more or less use specific.

Annex

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