Technological and Policy Developments in Relation to Conservation and Use of Genetic Resources

JMM Engels
Bioversity Intenational, Understanding and Managing Diversity Programme, Rome, Italy

The paper analyses the developments that have taken place in the political framework since the 1970s, in particular the history of conservation and use of plant genetic resources with regard to questions of ownership, access and legal protection. Special attention is paid to the Convention on Biological Diversity and the International Treaty for Plant Genetic Resources for Food and Agriculture. It also examines developments with regard to technologies that have impact on the conservation and use of plant genetic resources, in particular advances in the field of molecular genetics and genetic engineering. The marker technology and use of genomics have enabled the development of tools to allow a thorough assessment of the genetic diversity found in genepools and resulted in significantly improved possibilities for the evaluation of germplasm, and thus, to a better exploitation of existing genetic diversity in germplasm collections. Furthermore, an assessment of the global economic developments that have impact on the conservation and use activities is made, especially from a developing country perspective. The impact of globalization can be observed on one hand in a drastically reduced number of private plant breeding companies, and an increased importance of genetically modified varieties in food production for the major crops, on the other. The implications for conservation of the use of genetically modified varieties are yet to be studied and policies are still to be developed to promote reliable *in situ* and *ex situ* conservation efforts. Based on the aforementioned analyses suggestions are made how constraints that have been identified might be overcome.

Key words: Genetic resources conservation and use, Technologies, Policy framework, Genebanks

Over the past decade substantial progress has been made in the development of a political framework for the conservation and sustainable utilization of agrobiodiversity. The conclusion of the Convention on Biological Diversity (CBD) in 1992 and, more recently in 2001, the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) have been key developments, both addressing the urgent need for long-term conservation of threatened genetic resources world-wide and stressing their sustainable use. With regard to the latter the advances in molecular genetics and information technologies have been dramatic and are very relevant to the conservation and the sustainable utilization of genetic resources.

Coinciding with the aforementioned developments the world experienced the impact of globalization of economies and a drastic shift in the property rights regime, in particular the use of patents to protect biological inventions/discoveries. The impact of globalization can be observed on one hand in a drastically reduced number of private plant breeding companies, and an increased importance of genetically modified (GM) varieties in food production for the major crops, on the other. The implications for conservation of GM varieties are yet to be studied and policies are still to be developed to promote reliable *in situ* and *ex situ* conservation efforts.

E-mail: j.engels@cgiar.org

The above-mentioned developments coincided with the degree of governmental support to agricultural research, including activities such as pre-breeding and conservation, particularly in developing countries. However, these countries usually lack the financial resources to exploit the locally available genetic diversity in order to ensure their contribution to human well-being. Moreover, the technologies and the required human resources are similarly lacking and thus, the benefits of these technological developments do not reach the main guardians of agrobiodiversity, i.e. the farmers and foresters. This, in turn, does not provide them with any real incentive to continue to contribute towards badly needed conservation activities.

This paper analyzes how the existing policy framework as well as the technological and global economic developments impact conservation and utilization efforts, particularly in developing countries, and suggests how identified constraints might be overcome.

Policy Framework

In this section the history of conservation and use of plant genetic resources for food and agriculture (PGRFA, especially with regard to questions related to ownership, access and legal protection) are being assessed. During the past two decades this history has been strongly influenced by several international agreements on

(agricultural) biodiversity and these are briefly described in their historical context.

International Undertaking on Plant Genetic Resources

In 1983, the International Undertaking (IU) was established by the member states of FAO as a legally non-binding agreement on the conservation, use and access to PGRFA. The principle of common heritage of humankind was possibly the most important aspect of that agreement and that reflected the "spirit" of the time. The IU endorsed the idea of "open access" to genetic resources and benefit sharing was very much understood to be "in kind" and for present and future generations (Bragdon, 2004). In fact, the agreement established a kind of global multilateral system for PGRFA. The concept of "Farmers' Rights", an innovative and new aspect included for the first time in an international agreement, recognized the substantial contributions that farmers and farming communities had made to the creation and maintenance of genetic diversity and called for adequate recognition of these contributions. After substantial debate in 1987, particularly instigated by the then already active NGOs that participated in the meeting of the FAO Commission on Plant Genetic Resources (PGR), the concept of Farmers' Rights was declared to be compatible with plant breeders' rights. It should be noted that during the seventies and eighties the main focus of the debate and of the agreed activities was on *ex situ* conservation and on the establishment of genebanks and germplasm collections as part of the Global System. There was a strong focus on technological aspects of conservation, e.g. the establishment of the technical infrastructure, on the development of new technologies, in particular for the conservation and use of crop genetic resources that could be stored as seed. Gradually, the emphasis moved to also include crop plants that could not be stored as seed since such crops either do not set seed or their seeds are recalcitrant. For these types of crops, conservation methods such as *in vitro* storage through slow-growth techniques or cryopreservation have been developed (Engelmann and Engels, 2002). The IU was superseded in 2004 by the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA).

Convention on Biological Diversity (CBD)

The negotiation of the Convention on Biological Diversity (CBD) in the eighties and early nineties, under the auspices of the United Nations Environment Programme, did result in drastic changes in the aforementioned focus. Besides creating a legally-binding framework for the conservation and sustainable use of biodiversity, after it came into force in 1993, it provides that access to valuable biological resources be carried out on "mutually agreed terms" and subject to "prior informed consent" of the country of origin. The national sovereignty of states over biodiversity within their borders was recognized as a key principle in the CBD and, as a consequence this became the "driving force" in the thinking and approaches of the negotiations and future developments. Besides the fact that states were encouraged to "look after their own biological resources and conserve them, whenever possible in their own country", this caused also a strong incentive to countries to favour bilateral rather than multilateral arrangements for the exchange of genetic resources. From an agricultural perspective it should be noted that the negotiations that eventually led to the CBD convention were strongly influenced by environmentalists and nature conservationists and, as a consequence, a bias towards wild (i.e. non-domesticated and non-agricultural) plant and animal species can be observed. In fact, agriculturalists were hardly present in the negotiations and it was only through a separate resolution (Resolution 3 of the Nairobi Final Act) that FAO was asked to address two important but unresolved agricultural genetic resources issues, i.e. the question of Farmers' Rights and the need to address the legal status of existing genetic resources collections established prior to 1993 (Bragdon, 2004).

The negotiation process of the CBD caused a dramatic shift with regard to the overall conservation approach, i.e. from a rather technologically driven *ex situ* conservation approach ("putting the germplasm safely away for the future"), towards a much more people-centered conservation, with a strong emphasis on *in situ* and on-farm conservation and sustainable utilization efforts. Alongside, due attention was being paid to participatory research activities in order to recognize the important role of local communities in the management of and their dependency on biodiversity. This also led to the recognition of traditional and indigenous knowledge to be an important component of biodiversity that needs to be collected and/or conserved. In addition, environmental issues were closely interwoven with conservation activities. Furthermore, there is also due recognition given to the importance of technology for the conservation and use of genetic resources and for the importance of providing access to such enabling technologies. These aforementioned aspects facilitated

(and required) a much closer link between conservation and development and led to a greater participation of local communities and small subsistence farmers (frequently assisted by development-orientated NGOs) in conservation and use related activities. It is in this context that the access and benefit-sharing guidelines were developed and agreed upon in 2002 within the framework of the CBD by an *Ad Hoc* Open Ended Working Group on Access and Benefit-Sharing (Anonymous, 2002). Unfortunately, the so-called Bonn Guidelines also have a bias towards wild species, with a strong focus on nature conservation and seem to ignore, to a large extent, the specific requirements of agricultural crops.

The CBD recognized the application of intellectual property rights (IPRs) on biological materials as a means of protecting inventions and stimulating innovation. This led to a further expansion of the scope and/or application of IPRs, especially patents and plant breeders rights (PBRs), in agricultural research, including plant breeding. The latter was also stimulated by the fast development of molecular genetics, genetic engineering and information technologies that gave rise to the development and cultivation of GM plant varieties. Due to concerns that the latter could cause a threat to the environment it was felt that a legal framework on biosafety aspects was needed and, as a consequence, the so-called Cartagena Protocol on Biosafety was developed as a legal framework for biosafety legislation, also as part of the CBD implementation process. Biosafety legislation is currently being developed and implemented by many nations around the world (Cartagena Biosafety Protocol can be found on the CBD's website (http://bch.biodiv.org).

International Treaty on Plant Genetic Resources for Food and Agriculture

The ITPGRFA was adopted in 2001 by the FAO member states, entered into force in June 2004 and is the result of the revision of the International Undertaking. It addresses the conservation and sustainable use of PGRFA as well as the fair and equitable sharing of benefits that derive from their use, in harmony with the provisions of the CBD. It includes, among others, a multilateral system for 35 crop genepools and 29 forages, listed in Annex I of the Treaty. This multilateral system is based on the principles of the CBD, recognizes the specific requirements of agricultural crops and it undertakes to respect the free "flow" of genetic resources that are maintained in the public domain and included in Annex I as well as those made voluntarily available. Specific access and benefit-sharing (ABS) arrangements for the Annex I crops are being negotiated whereas Farmers' Rights, defined as a range of political and social rights, should be realized through national instruments. It can be stated that the IT has a strong focus on the sustainable use of PGRFA and reflects the interests of both developing and developed countries (Moore and Tymowski, 2006).

Other International Legal Instruments

Other important international instruments and agreements that have contributed to the shaping of the international policy framework for the conservation and use of genetic resources include the Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources (the GPA, agreed upon in 1996 in Leipzig, Germany by more then 150 countries), agreements of the World Trade Organization (WTO) such as the Trade-Related Aspects of Intellectual Property Rights (TRIPS) as well as of the World Intellectual Property Organization (WIPO).

The agreements of the WTO that have relevance for the political framework is in particular the TRIPS agreement as it requires countries to provide for the protection of animal breeds and plant varieties either by patents, an effective *sui generis* protection, or by a combination thereof. The WIPO already provides for the protection of plant breeders rights under the Union for Protection of Plant Varieties (UPOV) agreement and recently established an Intergovernmental Committee on Genetic Resources, Traditional Knowledge and Folklore. In many of these international fora one can observe an increased presence and influence of developing countries and/or their interests. However, many of the aforementioned developments have led to a much more restrictive attitude in providing access to genetic resources and there have been systematic and dramatic changes (i.e. a drop from about 30,000 new germplasm samples accessed every year to the genebanks from the Consultative Group on International Agricultural Research –CGIAR- to less than 5,000 (Figure 1; SINGER communication, 2005).

It can be summarized that, in general terms, for the (long-term) conservation and utilization of PGRFA a conducive policy environment has been created and the international policy framework for the conservation, sustainable use and equitable sharing of benefits of

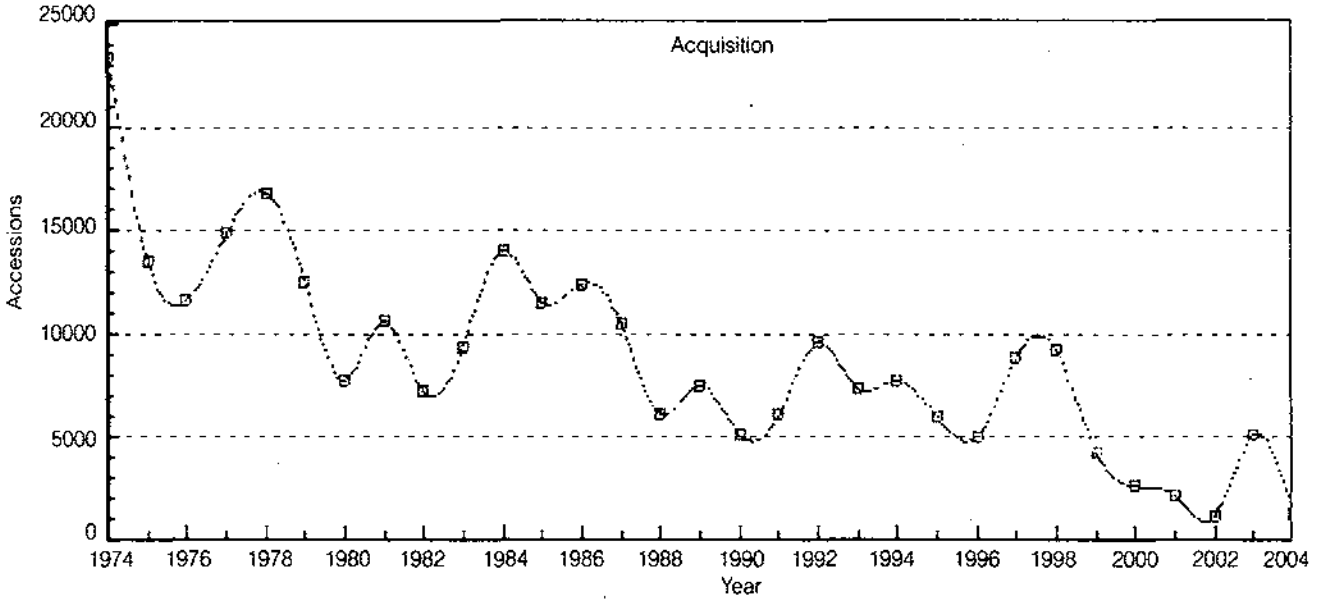

***Fig. 1:** Acquisition of new germplasm samples by the CGIAR Centres since 1974.*

PGRFA has been established, through processes in which developing countries have been participating more and more. These developments have certainly contributed to a clearer recognition that conservation activities are important and need to be addressed within the national as well as international context.

Technological Developments

Over the past two decades or so we have seen rapid advances in the field of molecular genetics and genetic engineering. The marker technology and use of genomics have enabled the development of tools to allow a thorough assessment of the genetic diversity found in genepools and resulted in significantly improved possibilities for the evaluation of germplasm, and thus, to a better exploitation of existing genetic diversity in germplasm collections. With the possibility of identifying specific genes in collections, and the availability of the technology to transfer such genes into a desirable genetic background, a significant improvement in the utilization of germplasm has been observed over the past 10 years or so. At the same time the fast spread of genetically modified varieties worldwide and their significant increased cultivation over the past 8 years or so brings new challenges to conservation. The replacement of traditional landraces by GM varieties and, as a consequence, the potential spread of non-desirable genes through uncontrolled geneflow, causes threats to the genetic diversity of those crops and their wild relatives, both, to those conserved in genebanks as well as *in situ* / on-farm (Engels *et al.*, 2006).

Almost in parallel to developments in genetic engineering and in the area of genomics the world observed a revolution in information technology. The wide-spread use of computers, in developed and developing countries, has facilitated greatly the area of genetic resources conservation and use and has meant that conservation approaches can be implemented in a much more targeted and efficient manner. These developments helped in particular existing networks to become more effective and efficient. It has also allowed users to be better informed about the content of germplasm collections and to target the material to be included in their breeding efforts much better. One good example is the SINGER database that provides details of the germplasm collections maintained by the centres of the CGIAR. With the more recent developments in the area of bioinformatics, not only the understanding of the actual content of the collections has significantly increased but also enormous progress has been made with regard to the taxonomy, relationships and evolution of our crop plants and their wild relatives. This, in turn, results in a better understanding of the conserved genetic resources and, thus, to a better use.

However, it should be noted that these technological developments have not occurred evenly across countries. Developing countries, in particular, frequently lack the necessary trained personnel, technical resources and infrastructure, as well as the financial resources to be

able to take full advantage of these developments. Despite this, it can be concluded that in general terms the technological developments have significantly contributed to improved and more rational conservation and utilization of PGRFA, also in developing countries.

Global Economic Developments

Agricultural Research

For several years there has been a tangible and steady decrease in the availability of funds for public agricultural research. This decline is most likely correlated with and possibly caused by a steady decline of general and political interest in agriculture. An indicator of this development is the fact that in a number of countries ministries of agriculture have been closed and/ or merged with other related ministries. In parallel, research institutes have been merged with others, changed their mandates and/ or were closed down all together. Unfortunately, this trend can also be observed in developing countries, despite the fact that they still depend to a large extent on agriculture both as an important source of revenue and food production. According to FAO the proportion of the total agricultural gross domestic product spent on research is about 0.5 % in developing countries compared to 2-4% in developed countries. In terms of intensity of investment the gap between rich and poor countries has grown. In 1995 rich countries spent $2.64 on public research for every $100 of agricultural output, 4.3 times more than the 62 cents on research per $100 of output invested by poor countries. In addition to these developments, technical assistance and development aid to developing countries is at its lowest level ever. It has fallen from 0.5% GDP in the early sixties to about 0.22% today, i.e. $52 billion a year compared to $350 billion for agricultural subsidies in the United States and Europe, and $900-1,000 billion for defence.

Most likely as a consequence of the above a brain-drain of young and dynamic researchers from the public to the private sector, both in developing and developed countries, as well as a migration of promising scientists from developing countries to developed countries has been observed. This, in turn, has resulted in an increased role of the private sector in agriculture. According to the World Bank (Ian Johnson, personal communication) public sector spending on agricultural research has taken a nosedive, leaving it to the mercy of the private sector. This had a direct effect and impact on the types and areas in which research and investments are being conducted, i.e. a stronger focus of potentially profitable areas (e.g. export orientation, focus on major food crops; use of imported varieties; etc.) and resulted in a concentration of the agricultural business and a more narrow focus on relatively few commercial producers and crops, including a withdrawal of public research organizations from plant breeding and seed production activities in many developing and developed countries (Morris and Ekasingh; 2002). This had a direct negative impact on the utilization of genetic resources and thus hit the sustainability of the conservation efforts twice.

As a consequence of the above developments, the public sector national agricultural research systems (NARS) in developing countries have been further weakened; they frequently lack the flexibility and responsiveness to client demand and are susceptible to political interference. Unfortunately, these developments have also led to a decrease in support for the conservation and utilization of PGRFA and, certainly, they will not help genebanks and conservation programmes that were already chronically under-funded. Long-term conservation efforts in particular suffer as the amount of operational funds being made available are insufficient and, thus lead to inappropriate management of conserved material, including losses of viability of stored germplasm and subsequently genetic erosion. Furthermore, hardly any characterization and evaluation activities are being conducted by genebanks and this, in turn, has a negative influence on the utilization of the conserved material as well as on the "utility" of the conservation efforts at large.

Globalization

We have seen a rapidly evolving global seed industry over the past twenty years or so, characterized by many mergers and thus, resulting in a concentration of plant breeding companies and an increased domination by a handful of multinationals. This trend is also characterized by an increased commercial attitude as a basis for decision-making, more and more privatization as well as an increased interest in legal arrangements. These developments were further fueled by stronger links between the chemical and the seed sector and by an increasing application of biotechnological inventions, in particular genetic engineering. This resulted in an increased importance of GM plant varieties worldwide (Figures 2 and 3) as well as in an increased number of crops for which GM varieties are being commercialized. At the same time, an increased application of intellectual property protected inventions in plant breeding could

be observed, predominantly by the aforementioned multinationals. About half a dozen major firms hold substantial number of key patents on germplasm and on related enabling technologies such as gene guns. These factors make it difficult for developing countries to take advantage of these technologies and thus, it makes them more dependent on the GM varieties produced elsewhere. In addition, it becomes increasingly more difficult to get access to these varieties, also as they require specific and expensive chemicals (Falcon, 2000).

In 1995, the first commercial GM varieties of maize and cotton were released on a larger scale, either based on the *Bt* (*Bacillus thuringiensis)* insect resistance genes, or possessing tolerance to (specific) herbicides. Since then there has been a dramatic increase both in the acreage and the number of crop GM varieties. According to James (2004) the estimated global area of commercialized GM crops in 2004 was 81.0 million hectares. This was due to as much as 60% of soybean, followed by maize (23% of global area), cotton (11%) and canola (6%). Of this acreage, approximately 34% was in developing countries, especially Argentina, Brazil, Mexico, China, India, the Philippines and South Africa. Details of the increases in the cultivation of GM crops are shown in Figures 2 and 3. In 2004 only about 1% of GMO crops were grown in (South) Africa (James, 2004). Furthermore, it should be noted that of the more than 50 GM crop products released in developed countries none was specifically designed to address "African" problems and this might well apply to most of the other developing regions of the world as well. Most/ all of the GM varieties are being produced outside the developing countries and address those problems that exist with farmers that want to buy such varieties, i.e. commercial farmers in the developed countries and not those of

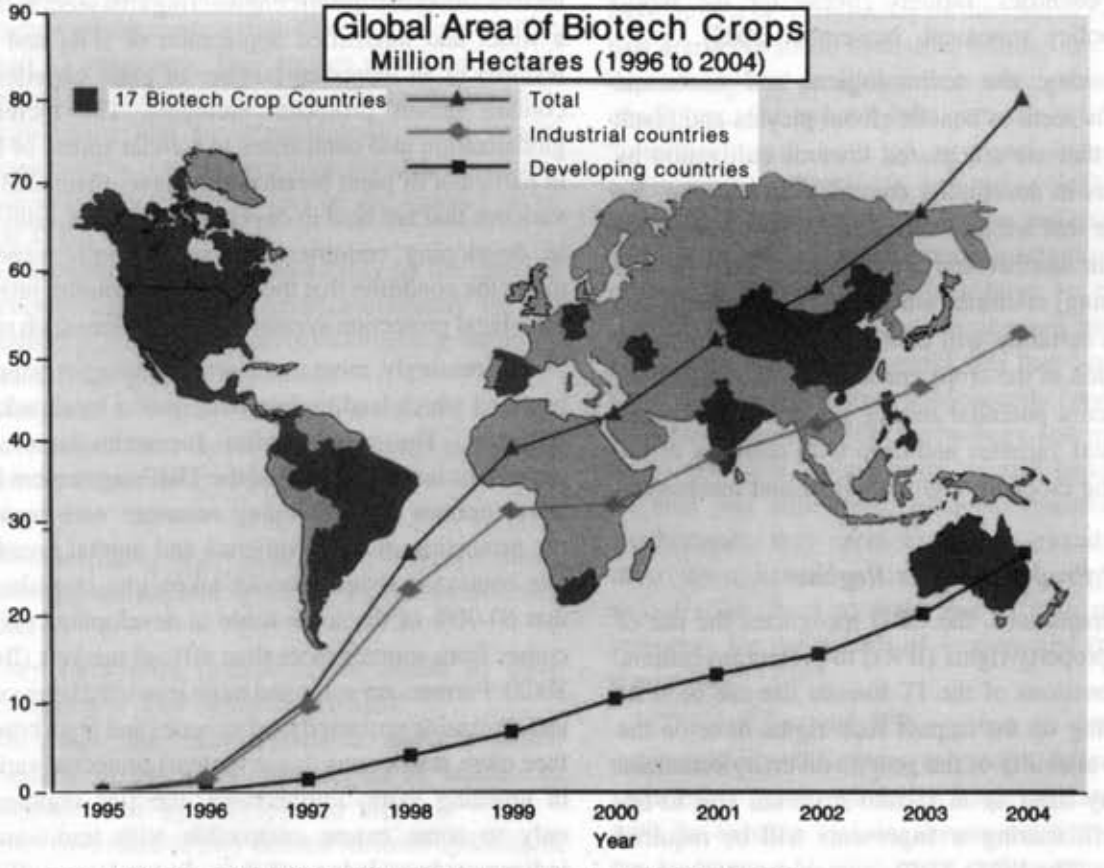

***Fig. 2:** Area under cultivation of genetically modified crops in developing and industrialized countries (James,2004)*

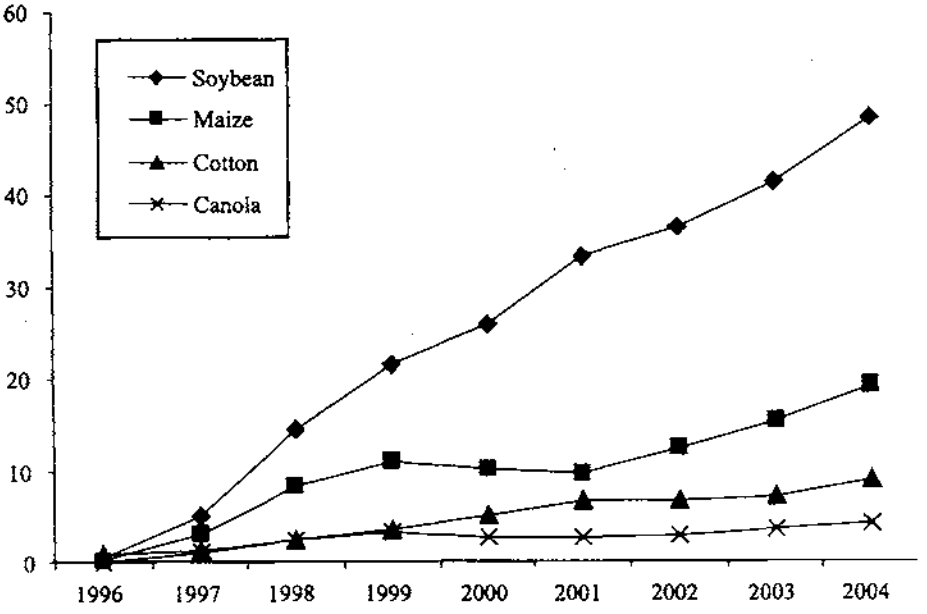

Fig. 3: Global area of genetically modified crops (James, 2004)

developing countries' farmers (Bread for the World Institute's policy statement, November 2002).

In summary, the technological and economic developments seem to benefit global players and result in products that are not geared towards cultivation by small farmers in developing countries. In addition, the GM varieties that are marketed in developing countries are limited in number and are in general bred outside the (developing) countries where they subsequently are grown. This certainly will contribute to an increase of genetic erosion in the crops concerned and, in addition, will introduce a potential risk of spreading transgenes into traditional varieties and crop wild relatives of the corresponding crops through geneflow and mechanical mixtures.

Intellectual Property Rights Regime

As already mentioned, the CBD recognizes the use of intellectual property rights (IPRs) to protect inventions. Also the provisions of the IT foresee the use of IPRs and, depending on the impact such rights have on the continued availability of the genetic diversity contained in the variety itself or in related material, still to-be-agreed benefit sharing arrangements will be required in such cases. The WTO-TRIPs agreement requires the acceptance of patents, a *sui generis* system or a combination thereof, for the protection of plant varieties. Furthermore, the fast developments in the biotechnological/genetic engineering area seem to favour a wider and intensified application of IPRs and have resulted in an increased number of plant varieties that contain patent protected elements. The increasing globalization also contributes to a wider spread of IPRs, in particular of plant breeders rights on ornamental crop varieties that are bred in developed countries, cultivated in developing countries and subsequently exported, under the condition that the cultivating country provides for a legal protection system that recognizes such rights.

Increasingly, more and more technologies/genes are patented which lead to decreased access for developing countries. The same applies for technologies. The provisions in Art. 27.3 (b) of the TRIPs agreement leave fewer options for developing countries with regard to the protection of plant varieties and animal breeds. In this context it should also be taken into consideration that 60-90% of the seeds sown in developing countries comes from sources other than official markets (Butler, 2002). Farmers are more and more restricted from saving and replanting protected seed varieties and plant breeders face more restrictions to use (patent) protected varieties in breeding work. Furthermore, the IPR regimes are only to some extent compatible with traditional or indigenous knowledge and thus, do not leave sufficient room for protecting traditional resource rights and indigenous knowledge. Lack of financial resources and the absence of any type of bargaining limit the access

by developing countries to protected technologies and to products generated by these technologies.

In summary, when analyzing the global economic and IPR developments it can be concluded that these are less favourable to or even harmful for the conservation and sustainable utilization of PGRFA, from a developing country perspective. In fact, several of the developments run directly counter to their interest, especially for small farmers, the custodians of a significant part of the still existing plant genetic resources world-wide.

Impact of Aforementioned Developments on Conservation and Use of PGRFA

The impact of the aforementioned developments on the conservation and sustainable use of PGRFA will be briefly analyzed from a developing country perspective. In general terms, it can be concluded that these developments have resulted in some overall conditions that are conducive to the conservation and sustainable use of genetic resources, including:

- A much more conducive political and policy framework for conservation and utilization activities than 15 years ago. This applies also to questions related to access and benefit sharing, to biosafety regulations and to international/ multi-lateral conservation (i.e. in particular through the multi-lateral system for the species on the Annex I list of the IT);
- An accepted political responsibility by the member states of the CBD to conserve, sustainably use and equitably share the benefits of biodiversity, including that of the genetic resources;
- Compared to twenty and even ten years ago, we have a much more favourable technological situation for the conservation and especially the utilization of genetic resources.

However, developing countries face severe problems in conserving and exploiting their own genetic resources, because:

- They have only limited or no access to these technologies and research products
- They lack trained human resources and institutional capacity to use such technologies as well as to improve their local crops and breeds
- They have none or only limited national agricultural research capacity to take advantage of these more favourable conditions.

The aforementioned conditions do have a direct bearing on the degree that developing countries are able to conserve the still existing but increasingly threatened genetic resources. The severe lack of infrastructure and human resource capacity, lack of funds as well as non-functional or ineffective institutional frameworks and the fact that breeding activities focus to large extent on crops that are being dealt with by centres of the CGIAR and not on minor local crops that are of importance to subsistence farmers, there is little or no effort being made to assist the local non-commercial farmers to improve their crops and to tackle their problems. This leads to little or no incentives for the local communities to contribute to conservation efforts since such efforts usually do not result in any form of income or even food.

As a consequence, conservation efforts do not result in sufficient benefits for either the country or for the small farmers/local communities to create incentives that could in the long run contribute to the maintenance of currently existing genetic diversity, both in farmers' fields and genebanks. Furthermore, developing countries have limited or no influence on the kind of GM varieties that are being made available, leading to an increased dependency and possibly to less sustainable production conditions. On top of this, the same GM varieties "interfere" with both *ex situ* and *in situ*/on-farm conservation efforts. In countries with biosafety regulations that regulate the import and export of GM varieties it might well be that genebanks as well as on-farm conservation schemes have to monitor the possible introgression of transgenic genes into conserved germplasm and thereby avoid that they would violate the law when distributing subsequently "contaminated" germplasm material. The technology and methodology to do this on a routine basis are still lacking. This is an area that still needs adequate research attention. Furthermore, they seem to lose or already have lost their own breeding and research capacity that would allow them to make use of their own genetic resources for the benefit of farmers and the countries themselves.

The international IPR regimes do not help local communities and farmers to protect their indigenous knowledge. These regimes are frequently not compatible with the existing traditional resource rights, including the landraces and other traditional varieties that have evolved over hundreds of years.

Finally, there is a decreasing "return" of the benefits that are being generated in developed countries

(predominantly by the seed industry) by using genetic diversity that originated in developing countries, to developing countries through the provision of economic or technical assistance. In addition, through the agreement to accept the implementation of Farmers' Rights as a national obligation the developing countries have lost this "instrument" as a means of securing a contribution from developed countries for the continuing efforts to generate and maintain genetic resources.

What can be Done to Change and Improve this Situation?

The above described technological, economic and IPR related developments seem, from a global perspective, to be favourable for conservation and sustainable use activities. When analyzing the situation from a developing country perspective the picture looks much less positive. This situation can certainly be explained by the fact that most of the international instruments that have a direct or indirect impact on the conservation and use of PGRFA are being negotiated and agreed upon in international fora in which developing countries usually have less influence and/or are being traditionally dominated by the rich countries. It is against this background that potential solutions are being sought that can lead to an improvement of the situation and, thus, to a more sustainable and acceptable situation for the developing countries. The major suggestions include:

1. To provide equal opportunities to all at conference tables and in business. In general, the influence of developing countries on the negotiations of international agreements has been rather limited. In order to create PGRFA/biodiversity conservation and utilization schemes (and for any other negotiation process) it seems critically important to treat each other as equals and to make an effort to understand the needs and priorities of the developing countries well.
2. To ensure equitable benefit sharing arrangements between all parties involved. The agreed Access and Benefit Sharing (ABS) guidelines seem to provide a good basis for meaningful benefit-sharing arrangements. However, it has to be understood that such regulations are as strong as the will of the developed countries to level the playing field and to accept the very disadvantageous position of most developing countries to be able to actually reap benefits from using PGRFA/biodiversity.
3. The further strengthening of the agricultural research capacity and of the overall institutional framework in which conservation and utilization activities take place is a pre-condition to allow changes for the better.
4. In order to achieve the necessary changes in developing countries it will be important to establish strategic alliances and partnerships between public sector research institutes and the private sector, including national as well as regional/ international research institutions such as the CGIAR, ensuring that both genetic resources and technologies are available and that capacity building is at the heart of the business.

While keeping these general provisions in mind it will be important to also address approaches and principles at the local and national level that will strengthen the situation of the local communities and farmers to allow sustainable long-term conservation and utilization efforts of the precious but dwindling genetic resources found predominantly in developing countries. These include:

- The active participation of stakeholders in developing countries in any decision-making processes that include or affect the conservation and sustainable use of PGRFA at the national and local level is a pre-requisite to ensure necessary ownership of the activities as well as for a sustainable and long-lasting arrangement or initiative.
- The principle of self-determination should, wherever possible and relevant, also be applied to the conservation and use of PGRFA. In fact, this principle should be applied at any level where people traditionally manage genetic resources.

References

Anonymous (2002) Bonn Guidelines on Access to Genetic Resources and Fair and Equitable Sharing of the Benefits Arising out of their Utilization. Secretariat of the Convention on Biological Diversity. Montreal, Canada.

Bragdon S (ed.) (2004) International Law of Relevance to Plant Genetic Resources: A practical review for scientists and other professionals working with plant genetic resources. Issues in Genetic Resources No. 10, March 2004. International Plant Genetic Resources Institute, Rome, Italy.

Butler LJ (2002) Conflicts in intellectual property rights of genetic resources: implications for agricultural biotechnology. *In:* Evenson RE, V Santaniello, D Zilberman, (eds.). *Economic and social issues in agricultural biotechnology.* Wallingford, UK: CAB International.

Engelmann F and JMM Engels (2002) Technologies and strategies for *ex situ* conservation. *In*: Engels JMM, VR Rao, AHD Brown and MT Jackson (eds.). *Managing Plant genetic Diversity*. CABI, Wallingford, UK Pp. 89-103.

Engels JMM, AW Ebert, I Thormann and MC de Vicente (2006). Centres of crop diversity and/or origin, genetically modified crops and implications for plant genetic resources conservation. *Genetic Resources and Crop Evolution* **53:** 1675-1688.

Falcon WP (2000) Globalizing germplasm: barriers, benefits and boundaries. Paper presented at the 23rd International Conference of the International Agricultural Economics Association, Berlin, 14-18 August 2000.

James C (2004) Preview: global status of commercialized biotech/GM crops: 2004. ISAAA briefs No. 32. ISAAA: Ithaca, NY.

Moore G and W Tymowski (2006) Explanatory guide to the International Treaty on Plant Genetic Resources for Food and Agriculture. IUCN Environmental Policy and Law Paper No. 57. IUCN-ELC, Bonn and IPGRI, Rome.

Morris M and B Ekasingh (2002) Plant breeding research in developing countries: what roles for the public and private sectors? *In:* Byerlee D and RG Echeverria (eds.), 2002. *Agricultural research policy in an era of privatization*. CABI, Wallinford UK. Pp 199-225.