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# Spending on Conservation of Plant Genetic Resources for Food and Agriculture: How much and how efficient?

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## Abstract

With growing awareness of the dangers of an irreversible loss of plant genetic resources for food and agriculture (PGRFA), there has been a major effort devoted to collecting and conserving plant genetic resources. The objective of this study is to assess the level of investments in PGRFA conservation in different countries and their efficiency.

Few studies of the costs and efficiency of genebanks and other methods of conservation exist so far. This study finds that the order of magnitude of domestic expenditures on the conservation of PGRFA by 37 countries amounts to approximately US $ 475 million for the year 1995. The efficiency of PGRFA conservation varies widely between countries. While a more comprehensive and thorough efficiency analysis of the countries' conservation efforts is called for, the approach taken here does draw attention to practical solutions to the ongoing political discussions on the sharing of benefits and costs of PGRFA conservation and utilisation.

## Kurzfassung

Seitdem die Gefahr des irreversiblen Verlustes von pflanzengenetischen Ressourcen für die Landwirtschaft und Ernährung (PGRFA) allgemein erkannt worden ist, sind zunehmende Anstrengungen für die Erhaltung von PGRFA unternommen worden.

Bisher existieren wenige Untersuchungen der Kosten und Effizienz von Genbanken und anderer Erhaltungsmethoden. Diese Studie ergibt, daß für die Erhaltungsmaßnahmen von PGRFA in den 37 untersuchten Ländern ca. US $ 475 Millionen im Jahr 1995 ausgegeben wurden. Die Effizienz der Erhaltungsmaßnahmen der verschiedenen Länder ist unterschiedlich. Während umfassende und detailliertere Wirksamkeitsanalysen von den Erhaltungsanstrengungen der Länder gefordert wird, weist ein hier dargestellter praktischer Ansatz auf Lösungsmöglichkeiten bei den laufenden politischen Diskussionen um die Beteiligung am Gewinn und an den Kosten von PGRFA-Erhaltung und -nutzung hin.

# 1 Introduction and Objectives

In addition to the sustainable management of soil, water and air, it now seems to be accepted that the sustainable management of genetic resources is one of the four indispensable preconditions for sustainable agriculture. Breeding for improved varieties, in which genetic resources are an essential input, is one of the main elements in any solution to the future challenge of world-wide food security. At the same time, the genetic diversity in farmers' fields is being reduced through the displacement of traditional varieties by modern varieties and introduced crops. Furthermore, a growing share of food is provided by a limited number of crops and varieties. While the supply of genetic resources is decreasing, the demand for genetic resources is increasing. This demand is generated not only by conventional breeding but also by new technologies and new applications of biotechnology in agriculture and in pharmaceutics. Consequently, it is crucial to conserve the existing diversity and to make sustainable use of its components to meet both present and future needs.

With growing awareness of the irreversible loss of plant genetic resources for food and agriculture (PGRFA), there has been an immense effort in terms of human and financial resources devoted to the collection and conservation of plant genetic resources and the establishment of an institutional framework at international, national and local level. Estimates indicate that there are 6.2 million accessions of 80 different crops stored in 1,320 genebanks and related facilities in 131 countries (FAO, 1998).

Conservation activities were intensified as awareness of the importance of PGRFA and their silent depletion rapidly spread reduction, but these activities were seldom managed correctly and efficiently. Consequently, the shelves of the existing ex situ facilities are overloaded but the information on the accessions is often poorly documented (FAO, 1998). This means that key information, e.g. how many and what kind of varieties are conserved ex situ, is lacking. It is now understood that PGRFA conservation is not only a matter of freezing accessions for the generations to come, but above all involves the management of information combined with service functions for all those demanding PGRFA in the present. Furthermore, there is a growing emphasis on the importance of in situ conservation as a complementary conservation activity to ex situ conservation. Although in situ conservation and the accessibility of PGRFA is being promoted, little is known about the contribution and value of in situ conservation or the present utilisation by breeders of conserved PGRFA.

These information gaps and uncertainties make it impossible to develop an economically efficient approach to optimising agrobiodiversity conservation. In particular, since we lack estimates on :

- the value of PGRFA for global welfare (e.g. value of PGRFA for breeding) or the cost of their extinction,
- the rate of PGRFA extinction, and
- the costs of conservation,

investments in PGRFA conservation are most likely sub-optimal at the margin.

Despite the existing uncertainties concerning the economic value of PGRFA for national and global welfare, there is a strong political will to promote genetic resources conservation, as expressed by all governments present at the International Technical Conference on Plant Genetic Resources for Food and Agriculture (ITC) in Leipzig in 1996 (FAO, 1996a). This meeting lent support to continued conservation of PGRFA, even though long-term conservation activities face strong competition for the allocation of financial resources from other, often more short-term, development activities. Given this situation, and especially the difficulty of assessing the value of PGRFA, cost-efficient strategies are needed for PGRFA conservation, in addition to further scientific and economic research. Cost-efficient conservation will reduce the risk of losing unique genetically coded information and help overcome the problem of allocating excessive financial resources to conservation activities.

This study will analyse the cost-efficiency of PGRFA conservation activities at national level and will draw some policy implications for the support of low-income countries implementing PGRFA conservation activities. To do so, this study will estimate the expenditures on the national conservation activities surveyed (Chapter 3) and will evaluate the quality of conservation activities (Chapter 4). On the basis of these results, the study will then discuss the efficiency of the conservation strategies pursued by the various countries surveyed (Chapter 5). This will have policy implications for the allocation of scarce financial resources for further conservation efforts (Chapter 6).

# 2 Conservation Activities: Definitions and Actors

*Agrobiodiversity* is defined broadly as

“ ... that part of biodiversity which nurtures people and which is nurtured by people...“

(FAO, 1995, paragraph 67). For reasons of functionality, agrobiodiversity is defined here as the diversity of existing domesticated plants. In general, the term diversity has no operational value for analysing, valuing and devising efficient conservation options on the basis of economic instruments.

*Plant genetic resources for food and agriculture* (PGRFA) is the general expression for the material growing in farmers' fields and their wild crop relatives, as well as material which is conserved, exchanged, utilised - and threatened. PGRFA as a distinct part of the general plant genetic resources includes resources contributing to people's livelihoods by providing food, medicine, feed for domestic animals, fibre, clothing, shelter and energy. PGRFA are the inputs for breeding on conventional basis as well as for biotechnology-based activities, including genetic engineering.

An *accession* is the planting material of a variety stored in a conservation facility. An accession represents the smallest storable unit of a crop variety. By cereals, an accession consists of approximately 500 to 1,000 seeds, which are dried and usually conserved cold or frozen (Hammer, 1995).

The terminology *ex situ conservation* is applied to all conservation methods of genetic resources in which the species or varieties are taken out of their natural ecosystems and are kept in a surrounding managed by humans. Starting with the collecting activities of N.I. Vavilov, most conservation efforts for agricultural crops have, until recently, concentrated on ex situ conservation; particularly on seed genebanks. Great emphasis was placed on germplasm collecting during the 1970s and 1980s. Defined as the conservation of plants in their ecosystems *in situ conservation*, has been traditionally used for the conservation of forests and of sites valued for their wildlife or ecosystems (FAO, 1998). In recent years, however, the need for in situ conservation was emphasised, above all at the United Nations Conference on Environment and Development in 1992 (UNEP, 1994). During the preparatory process for the ITC the in situ conservation system was acknowledged to be an important complementary conservation system for PGRFA ex situ conservation (FAO, 1996a). In situ conservation is defined here as all activities to conserve PGRFA in their common surroundings, i.e. on farmers' fields (including on-farm management).

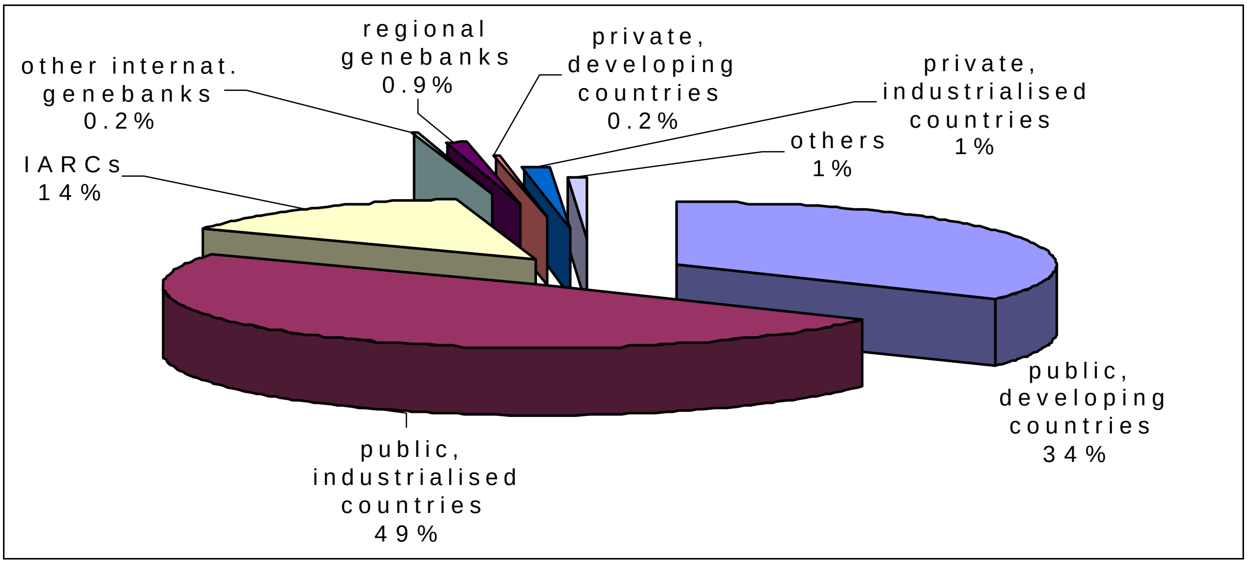
A wide range of different actors at local, national and international level are engaged in maintaining PGRFA. By grouping these actors according to the type of conservation activity they perform, one can identify five major groups:farmers; public conservators at the national level; private breeding companies; regional and international genebanks and; local conservators.

According to the estimates of WOOD and LENNE (1993), 60% of global agriculture depends on the cultivation of traditional varieties. Even though the *farmers* do not predominantly maintain these varieties for one of the conservation objectives, they are de facto conserving them. Besides conserving PGRFA de facto in situ, farmers play only a small roll in ex situ conservation. All other actors are mainly involved in the ex situ conservation, with only some activities relating to in situ conservation. The in situ conservation activities are, however, increasing (Virchow, 1999).

As can be seen in Fig 1 the *public conservators at the national level* dominate the ex situ conservation, storing 83% of all conserved accessions (FAO, 1998). Hereby, 34% of all accessions are stored in public genebanks of developing countries and 49% in public genebanks of industrialised countries (Iwanga, 1993). According to the FAO survey, 15% of all ex situ conserved accessions are held in *regional and international genebanks*. The majority of these accessions are stored in the ex situ collections of the Consultative Group on International Agricultural Research (CGIAR). *Private breeding companies* in industrialised countries store approximately 1% of the accessions, and the relevant private companies in developing countries roughly 0.2% (Iwanga, 1993). Finally, it is estimated that less than 0.2% of all ex situ conserved accessions are held by *local conservators*, i.e. farmers supported by NGOs (FAO, 1998).

The leading role of the national public sector in the conservation activities is supported by the fact that approximately 85% of all estimated expenditures on PGRFA conservation were made by the national public sector in 1995 (Virchow, 1999). In the context of UNCED's reaffirmation of the importance of national sovereignty over the genetic resources (UNEP, 1994), this figure indicates that the states are indeed the most important actors in the conservation sphere. By analysing the national conservation systems and developing policy implications, low-income countries can be supported to implement their conservation initiatives.

**Figure 1: Distribution of ex situ conserved PGRFA**




Source: FAO, 1998; Iwanga, 1993

# 3 Expenditures on PGRFA Conservation at Country Level

Different approaches may be taken to identifying the specific costs of PGRFA conservation. Costs can be identified at different levels and through a variety of categories. Latter may be determined by the conservation methods used: in situ and ex situ conservation as well as the supporting activities and institutional process for PGRFA conservation and access. As for the actors engaged in conservation, costs can arise at the farm level or at national and international levels as well as at the level of conservation activities in the private sector. Thus, the method of estimating costs will depend upon the approach taken.

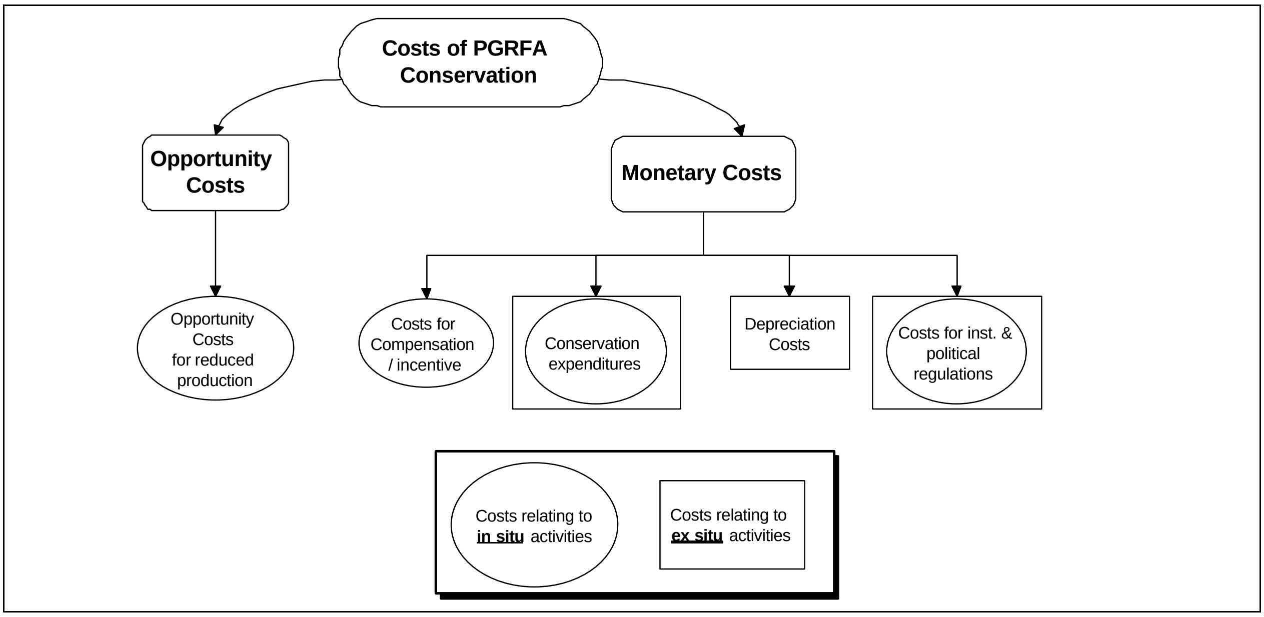
## 3.1 Methodology

### *The approach and the source of data*

The overall costs of PGRFA conservation are made up of monetary costs and opportunity costs (see Fig 2). The monetary costs represent the costs incurred from PGRFA conservation, which have to be budgeted for and then invested at national or international level. These are the costs of planning, implementing and running ex situ and in situ conservation activities. They are determined by the specific conservation activities, the depreciation costs of investments, and the costs of institutional and political arrangements for access to PGRFA. Additionally, compensation and incentives paid for maintaining PGRFA at farm-level must be reflected in this estimate. Furthermore, there are opportunity costs at national level to be taken into account, since these reflect the benefits for the country that are foregone by maintaining the diversity of genetic resources in the field.

The main source of information for this study was a survey conducted in 1995/1996. Each country established a focal point for the preparatory process of the ITC. These focal points were contacted for survey data. As of June 1996, 39 countries out of 154 countries asked to supply information had provided data which could be analysed. Among those responding were countries thought to have substantial programmes in PGRFA (inter alia the USA, France, Germany, the Russian Federation, UK, Japan, China, India, Brazil and Ethiopia), as well as a number of countries with smaller programmes. The inherent difficulties and limitations of compiling data on the current PGRFA expenditures mean that expenditures for 1995 could not be calculated precisely. The national data were estimated based on the available information and an order-of-magnitude estimate was obtained of total expenditures at national level.

Figure 2: Economic concept of the costs of PGRFA conservation at national level




Source: Virchow, 1999

## *Limitations of current expenditure survey*

It was apparent from the Country Reports submitted during the preparatory process for the ITC that the available information on the state of PGRFA in the countries and activities for their utilisation is vague or even non-existent in many countries, while few have supplied very precise figures (FAO, 1996b). This applies especially to the expenditure data for PGRFA conservation and utilisation. Only a few countries have explicit budget lines for these activities. Another problem is that the scope of the conservation and utilisation of PGRFA is so broad that activities with other objectives may have a positive impact on the implementation of conservation activities. Consequently, even if a country has a refined cost monitoring system, the actual expenditures may be made up of allocations from different financial resources than those explicitly dedicated to the conservation and utilisation of PGRFA.

Besides the imprecision of the expenditure data itself, the first expenditure survey revealed a number of other difficulties with collecting and processing the existing data:

- *participation of reporting*: less than 26% of countries involved in the preparatory process actually provided expenditure data;

- *partial information*: significant information was not comprehensively provided by countries, even though the expenditure data should have been known to certain agencies in the countries concerned (e.g. national contributions to multi- and bilateral activities related to the conservation and utilisation of PGRFA);

- *homogeneity of reported data*: the proposed reporting format was not followed, consequently it needed interpretation skills to process the data and to harmonise the data from different sources (e.g.: received data was often not desegregated; or sums were given without indicating whether they applied to conservation, utilisation, or both);

- *defining the scope of activities*: there was no unified definition (and understanding) of the scope of activities related to conservation and utilisation of PGRFA; e.g. some countries included plant-breeding activities, while others only included the conservation of PGRFA in a very narrow sense. Most countries did not clearly define what was covered by expenditure or foreign assistance data. Similarly, some data on financial contributions included only activities closely related to conservation and utilisation of PGRFA. Only a few countries included in situ conservation and utilisation, while others only provided data on the general national contribution to international organisations;

- *multiple-impact activities*: projects or programmes often deal with PGRFA conservation and utilisation as part of a broader initiative including actions not strictly related to PGRFA. This poses the problem of having to estimate the portion of the programme dealing with conservation and utilisation of PGRFA and identifying the expenditures on that portion. This, however, can only be done relatively accurately by those involved in the specific projects and programmes.

## 3.2 Results

National expenditures on PGRFA conservation are difficult to assess, largely because of uncertainties in defining the scope of PGRFA programmes. It seems that most countries' national efforts to conserve PGRFA are in the hand of different departments in different ministries. In addition to the complex administrative structure, other parastatal and non-governmental organisations are involved in the conservation activities as well. Only in certain countries are all efforts coordinated by an overall national programme. Hence, the costs involved are not always visible. Furthermore, countries are involved in PGRFA conservation but do not have specially defined budget lines for these activities. For instance, if a genebank belongs to a national breeding institute and its costs are incorporated in the institute's overall budget, it is difficult to assess its specific costs, without doing an in-depth cost analysis of the genebank.

The data concerning the national expenditures on conservation of PGRFA can be divided into two different groups:

- domestic expenditures on conservation activities within the country, and
- foreign assistance contributions, i.e. financial resources made available for PGRFA conservation in other countries (through bi- or multilateral contributions).

### *Domestic expenditures*

The domestic expenditures are relevant for the present task of analysing the cost-efficiency of conservation activities. Countries receiving financial assistance may have domestic expenditures equalling the financial assistance, i.e. they employ all the financial assistance for conservation activities. Countries may also spend more than the financial assistance for conservation activities, i.e. these countries employ additional domestic financial resources for PGRFA conservation. The point is that domestic expenditures include expenditures derived from financial assistance received. Table 1 indicates the nature of the information obtained from each country. Due to the above-mentioned difficulties concerning the homogeneity of the data, a comparison of all the data received is only possible at a high level of aggregation, i.e. by considering total expenditures on PGRFA conservation.

Based on the data provided, the order of magnitude of domestic expenditures spent for the conservation of PGRFA by 37 named countries amount to approximately US $ 475 million for the year 1995. This figure includes financial assistance of US $ 17 million, which 15 countries received through bilateral and multilateral contributions (Virchow, 1999).

Table 1: Domestic expenditures on PGRFA conservation (in US $ 1,000)

| Country | Domestic expenditures 1995 in US $ 1,000 | Country | Domestic expenditures 1995 in US $ 1,000 |
|---|---|---|---|
| Germany | 113,215 | Madagascar* | 2,385 |
| France | 98,660 | Seychelles* | 2,322 |
| UK | 70,154 | Haiti* | 1,896 |
| Spain | 33,413 | Canada | 1,584 |
| Italy | 27,208 | Russia* | 1,526 |
| USA | 20,433 | Ethiopia* | 1,346 |
| South Africa | 19,000 | Portugal | 1,030 |
| Norway | 16,208 | Suriname* | 1,028 |
| Egypt* | 11,528 | Poland* | 656 |
| Greece | 10,958 | Lesotho* | 615 |
| Brazil* | 8,000 | Romania | 408 |
| India* | 6,776 | Tanzania | 187 |
| Japan | 6,480 | Cyprus* | 186 |
| Peru* | 4,137 | Togo | 151 |
| Switzerland | 3,825 | Belarus | 135 |
| Slovak Republic | 3,608 | Pakistan | 120 |
| Czech Republic | 3,255 | Tonga* | 56 |
| China* | 2,526 | Saint Kitts & Nevis | 20 |
| | | Austria | 10 |
| **TOTAL:** | | | 475,045 |

Note: *: incl. foreign received assistance
Source: Virchow, 1999

### *Foreign assistance contribution*

Of the 39 countries mentioned above, 12 contributed bi- and multilateral financial assistance of approximately US $ 50 million (see Table 2). It is interesting to note that the amount of foreign assistance contributed by these 12 countries varies widely. Countries like France or Portugal contribute 1% of their total expenditures, whereas countries like Switzerland, Canada and Austria contribute 47%, 69% and 99% respectively. Although the results might be biased as a result of the insufficient data, they do show the different levels of international commitment by the various countries.

Table 2: Foreign assistance contribution for PGRFA conservation in 1995 (in US $ 1,000)

| **Country** | **Total expenditures on the conservation of PGRFA in US $ 1,000** | **Foreign assistance contributed 1995 in US $ 1,000** | **Foreign assistance contributed as percentage of total expenditures in US $ 1,000** |
|---|---|---|---|
| Germany | 131,742 | 18,527 | 14% |
| France | 99,160 | 500 | 1% |
| UK | 87,685 | 17,531 | 20% |
| Spain | 34,298 | 885 | 3% |
| Norway | 18,820 | 2,612 | 14% |
| Egypt | 11,772 | 244 | 2% |
| Switzerland | 7,225 | 3,400 | 47% |
| Canada | 5,164 | 3,580 | 69% |
| Portugal | 1,040 | 10 | 1% |
| Austria | 1,510 | 1,500 | 99% |
| Finland | n.i. | 1,180 | |
| Ireland | n.i. | 142 | |
| **TOTAL:** | | 50,111 | |

Note: n.i.: no information
Source: Virchow, 1999

### 3.3 Interpretation of the expenditure data

Concluding the analysis of the international expenditures on PGRFA conservation, the survey results for 39 countries can be summarised as follows: 89% of the expenditures by the OECD countries surveyed (of US $ 456 million) go on their domestic conservation activities (US $ 406 million), mainly the ex situ conservation of their PGRFA accessions. 76% of the expenditures on the conservation activities in the developing countries surveyed (US $ 52 million) were funded nationally, while US $ 17 million, representing nearly one quarter of the domestic expenditures, were funded through bi- and multi-lateral financial contributions. Although the 16 OECD countries are conserving 53% and the 23 developing countries 47% of their combined conserved accessions, the OECD countries spent 85% of the combined total of US $ 475 million. Not surprisingly, the contribution for the international activities originate predominantly from the 16 OECD countries (Virchow, 1999).

When the countries are grouped into agrobiodiversity-rich and -poor countries and furthermore into countries having high and low absolute domestic expenditures on PGRFA conservation, most of the OECD countries analysed can be found among the agrobiodiversity-poor countries with the tendency to higher absolute expenditures[1]. The majority of these genetic resource-poor countries are very interested in building up and maintaining a high level of PGRFA collection from many other countries and need gene centres to supply their breeding industry with sufficient resources and to ensure long-term sustainable food production. In addition, a country like Egypt may be seen as an example of those genetic resource-poor countries that still have a large agricultural sector and have to grow crops under harsh conditions. Consequently, their governments must ensure that the need for a sustainable supply of crucial inputs is met.

Even if the domestic expenditures are expressed as a percentage of the GDP/capita, a country like Egypt still has a high ranking in terms of expenditures (see Fig 3). This perspective also reveals, however, that not only resource-poor countries are interested in the conservation of PGRFA but also some agrobiodiversity-rich countries - India, Ethiopia, South Africa, China and Tanzania. These countries are spending as much on PGRFA conservation in relation to their average income as genetic resource-poor countries like Germany, France and the UK. Especially in India, Ethiopia and China, the estimated value for PGRFA conservation is turns out to be very high. Indeed, these countries are also playing a leading role in international negotiations on the issue of internalisation and compensation with regard to PGRFA conservation in their countries.

The countries fall into four groups when measured in terms of the degree of agrobiodiversity and the level of domestic expenditures expressed as GDP per capita (see Fig 3). Of major interest are the two groups with high relative domestic expenditures. They are countries strongly committed to PGRFA conservation, but for different reasons. On the one side (left top) are the demand-driven spenders. These are agrobiodiversity-poor countries which spend a large amount on PGRFA conservation. The governments of these countries see the need for their breeding industry to safeguard its supply of genetic resources as inputs for breeding. On the other side (right top) are the supply-driven spenders which are agrobiodiversity-rich countries. These countries invest a great deal in the conservation of PGRFA not only for their own country's breeding efforts but above all to be able to operate as PGRFA suppliers on a market for genetically coded information that is yet to be developed.

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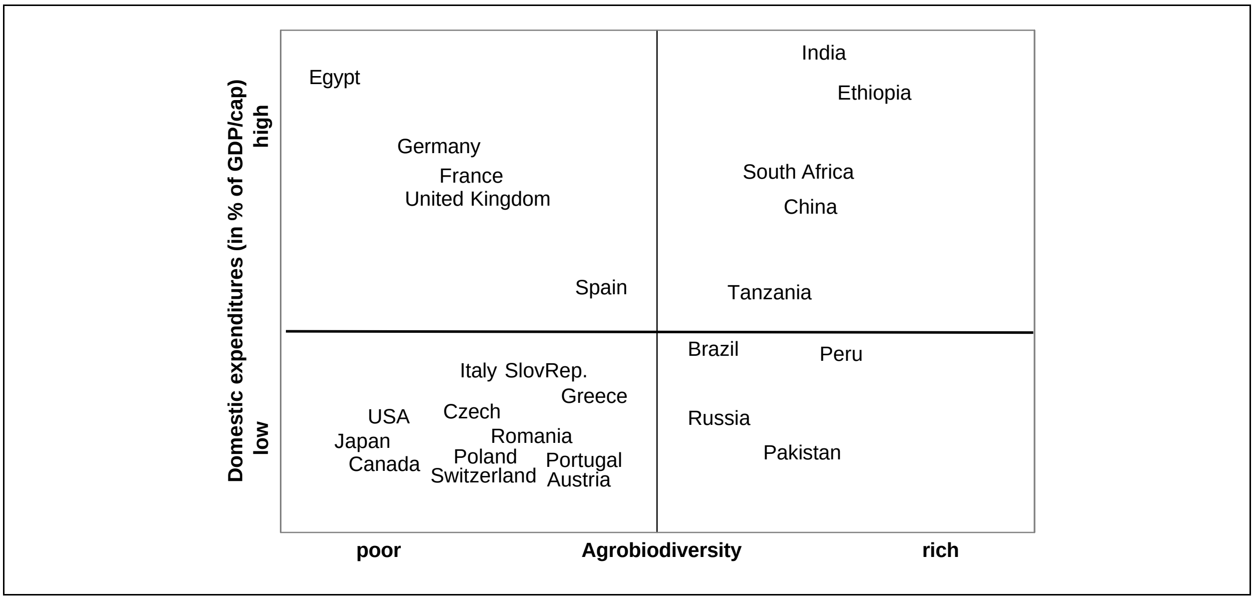
[1] The concept of agrobiodiversity-rich and -poor countries can be summarised as:
agrobiodiversity-poor country: country is not part of a gene centre or has less than 10,000 accessions stored ex situ;
agrobiodiversity-rich country: country is part of a gene centre and has more than 10,000 accessions stored ex situ.
See Virchow, 1999 for more detail.

On the other hand, there are countries, poor as well as rich in agrobiodiversity, which show a low domestic expenditure level in relation to the national average income. Countries with high agrobiodiversity like Russia or Pakistan do not invest much in conservation programmes in spite of being genetically resource-rich. These countries lack the financial resources to enlarge their conservation activities (e.g. Pakistan) or face a steady decline in these financial resources (e.g. Russia), which undermines their ability to maintain a high quality of conservation. In both cases, the lack of funds and relatively low investment in PGRFA conservation makes the threat of PGRFA loss highest in this group.

Finally, there is a group of agrobiodiversity-poor countries with low financial commitment. This group mainly consists of countries with few or no activities in the breeding and seed industry (e.g. Switzerland, Austria, Poland and Romania). Other countries (e.g. USA, Canada), however, do not seem to fit into this group due to their intensive activities in the breeding and seed industry. This leads us to the recognition that conservation expenditure on its own is a fundamental but not sufficient criterion for characterising and comparing the efforts made to conserve PGRFA at national level.

Figure 3: **Relative domestic expenditures on PGRFA conservation for selected countries**[2]




Source: Virchow, 1999

[2] low domestic expenditures in % of GDP/cap: less than 200% of GDP/cap for PGRFA conservation; high domestic expenditures in % of GDP/cap: more than 200% of GDP/cap for PGRFA conservation.

# 4 Quality of PGRFA Conservation

The expenditures and the correlation between expenditures and the degree of a country's agrobiodiversity are the first approach to characterising the conservation activities undertaken by each country. This approach is, however, not sufficient to derive any policy implications. The expenditures on PGRFA conservation have to be correlated with the quality of the conservation activities. So far, the expenditures on PGRFA conservation have been regarded as similar qualitative investments into an effective conservation system. This is, however, not a valid assumption. It has been shown, for instance, that countries with the same amount of conserved accessions may have very different unit costs for each accession or that countries with the same expenditure structure have very different quality standards (Virchow, 1999).

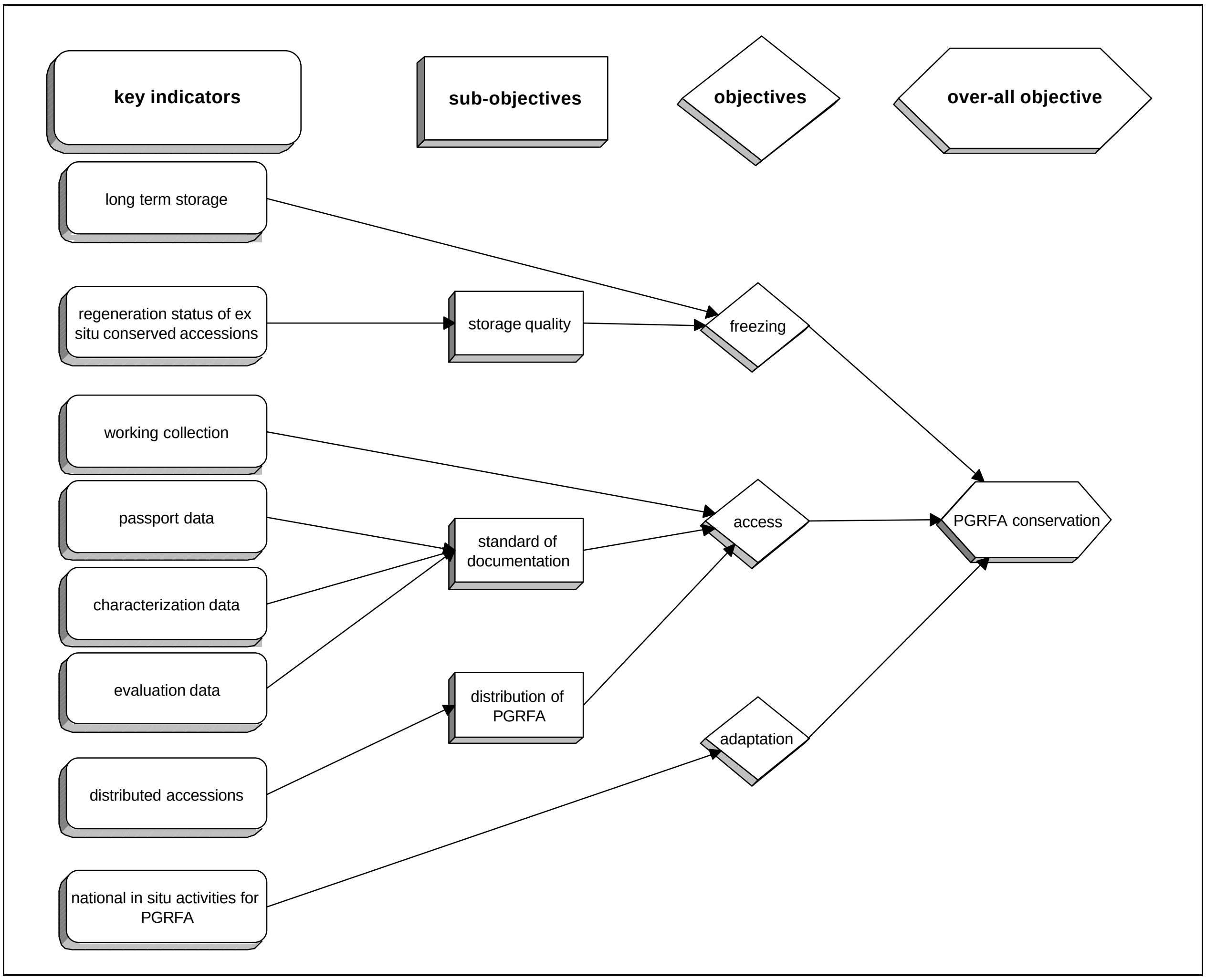
The amount of financial resources allocated to PGRFA conservation activities does not guarantee that these resources are utilised in an efficient way. Consequently, there is a need for indicators to asses the quality of the financed activities being implemented. These indicators will be defined by the main objectives of the PGRFA conservation activities:

- to ensure the conservation of PGRFA as a basis for food security, which can be differentiated into two objectives:
    - (ex situ) conservation for future use ('*freezing*'), and
    - (in situ) conservation for adaptation to changing environmental conditions ('*adaptation*'); as well as
- to promote sustainable utilisation of PGRFA in order to foster development and to reduce hunger and poverty, particularly in developing countries ('*access*').

According to this approach, the three objectives identified above have to be divided into more operational sub-objectives and quantifiable indicators to assess the quality of conservation activities. Because of the general difficulties with data availability, the assessment is restricted to a few key indicators (see Fig 4).

Operational sub-objectives and indicators for the first objective - freezing for future utilisation - can be defined as the existence of long-term storage facilities on the one hand and as storage quality on the other hand (see Fig 4).

**Figure 4: Operational indicators for the assessment of PGRFA conservation**




Source: Virchow, 1999

*Storage quality:* The existence of long-term storage facilities is a necessary but not sufficient condition for the safe and high-quality long-term conservation of genetic resources. Hence, the storage quality is an additional sub-objective to be incorporated into the evaluation. The present situation in the ex situ conservation facilities concerning the accessions to be regenerated has been chosen here as a key operational indicator (see Fig 4). Several other indicators could be employed to indicate the quality standard of the storage facilities, e.g. health indicators, loss of genetic resources etc. But in view of the limited information available on these aspects, the details of the accessions still to be regenerated represent the most useful information, because regeneration of any reproductive plant material in storage is an important part of the work of every genebank and characterise the general conditions of a genebank (FAO/IPGRI, 1994). If the viability falls below 85% of its initial value, the accession is threatened with extinction (Holden and Williams, 1984). Whereas some genotypes may lose their viability more quickly than others, it is a general rule that regeneration takes place every 10 years in order to guarantee the viability of the accessions. Taking the average over a time horizon of 10 years, a genebank must regenerate approximately 10% of its stored germplasm every year if it is to meet this standard in the long-term. On this basis, the quality standards of the national ex situ conservation facilities are graded in three categories:

- good quality standard, if less than 20% of the facility's accessions were in need of regeneration;
- basic quality standard, if more than 20%, but less than 50% of the facility's accessions were in need of regeneration;
- poor quality standard, if less than 50% of the facility's accessions were in need of regeneration.

As can be seen in Appendix 1, only eight (24%) of all the countries analysed can be classified as having a good quality standard of long-term facilities. Fourteen countries (41%) have basic quality standards, and twelve countries (35%) still have poor quality standards, although the latter group includes countries without any long-term storage facilities. It is worth highlighting that only Japan, Ethiopia and Poland report that less than 10% of total genebank accessions require regeneration (FAO, 1996b). Because of the lack of information, certain assumptions had to be made concerning the state of regeneration in some storage facilities.

After analysing the sub-objectives and key indicator, the degree of goal achievement for the objective "freezing" can be assessed by combining the quality standard of the storage facilities with the existence of long-term storage facilities according to the following matrix (Table 3). The results can be seen in Appendix 1. The key question for the first objective was whether a country's conservation activities may guarantee the long-term conservation of PGRFA - highlighting the conservation of genetic resources for future use. It has been shown that even though all the countries analysed have conservation activities, over 50% of these countries have of poor quality of long-term PGRFA storage.

**Table 3: Assessment of the degree of goal achievement for freezing**

| | **Quality standard of storage** | | |
|---|---|---|---|
| **Long-term storage** | **Good:** | **Basic:** | **Poor:** |
| Existent: | Good | Basic | Poor |
| Non-existent: | - | Poor | Poor |

The key question for the second objective relates to the present use of PGRFA. At present, the demand for PGRFA mainly comes from the conventional breeders, but the demand by the biotechnology industry is increasing. The more demand there is for specific genetically coded functions and for even more detailed genetically coded information, the more important will be the accessibility of genetic resources. The accessibility will depend upon the physical access to the germplasm as well as on its state of processing. Therefore, the degree of goal achievement for the second conservation objective, i.e. the quality standard of the accessibility of PGRFA in a country, can be divided into 3 sub-objectives: (1) the existence of working collections, (2) the documentation of stored accessions, and (3) the number of accessions distributed. The first two mentioned sub-objectives describe the potential accessibility of germplasm for users, whereas the third sub-objective describes the actual accessibility of germplasm in 1994 (see Fig 4).

Users of PGRFA will try to minimise their search costs by looking for specific genetically coded functions or genetically coded information. Search costs are determined by allocating resources to find the specific information necessary. Initially, search costs are incurred by physical movement, i.e. excursions to farmers' fields (expenses for travel, utilised material and opportunity costs for travelling) to look for specific traits in specific crops. The search costs can be reduced significantly by storing genetic resources in more centralised storage facilities than farmers' fields, which means an increase of the accessibility of existing national genetic resources. Therefore, a first indicator for the degree of accessibility of genetic resources in a country could be the coverage of existing diversity in the country by national storage facilities. But at present, there is not enough information to assess the degree to which current ex situ collections are representative of total national diversity. This would require a comprehensive inventory of PGRFA. Over 50% of the analysed countries have stressed their lack of knowledge of existing indigenous plant genetic resources[3] and the other countries did not mention the degree of coverage at all.

*Working collection:* In assessing the degree of goal achievement for the accessibility of conserved genetic resources, we must first see whether the physical presence of the germplasm is properly secured. Long-term storage facilities are the best mechanism to conserve genetic resources for future needs, but these facilities are not very flexible in regard to the present demand. It takes time to cautiously unfreeze the germplasm and it has a negative impact on the viability of the germplasm each time the accession is taken out of the cold chamber. A working or active collection is needed to provide germplasm to demanding users and still maintain high quality standards for the germplasm conservation. The working collection may be used for documentation purposes as well as for the exchange of accessions. In other words, a conservation system with long-term storage facilities, but without working collections, significantly reduces the accessibility potential of genetic resources for immediate use. Hence the

[3] Austria, Brazil, China, Cyprus, Egypt, Ethiopia, Germany, Haiti, India, Ireland, Japan, Norway, Poland, South Africa, Spain, Tanzania, Togo, the United States of America.

existence of a working collection is the first indicator for good accessibility to conserved genetic resources.

As can be seen in Appendix 1, all relevant countries, except Haiti, Seychelles and Suriname, have working collections. Most of the countries analysed have the potential to provide germplasm to whoever requests it.

*Documentation:* In addition to the physical existence and the flexible handling of germplasm in working collections, the quality standard of the documentation of stored germplasm also indicates the degree of accessibility to PGRFA. The documentation of stored germplasm is a key aspect for the users of PGRFA in terms of their decision-making and research processes. Better information results in lower search costs. Apart from the costs of actually locating the material, one main factor in the search costs is the time spent producing the necessary information where it is not available. In this case, the user is only able to collect most of the necessary data by cultivating the germplasm. Not only the information quantity, but also the information availability determines accessibility to genetic resources. Even though accessions may be well documented within a specific storage facility, as long as this information is not accessible for all the potential users, for instance via the Internet, the actual exchange of specific accessions will not occur, even though there is a demand for it. Thus, as the facilities increase information content and information availability, they also enhance accessibility to PGRFA.

A good quality standard in the germplasm documentation is necessary for the accessibility of the accessions. The more data is available, the greater will be the specific information value. Hence, we can use the percentage of available passport, characterisation and evaluation data for the germplasm collection as key indicators in determining the quality standard of the documentation. In this context, good quality standards for the documentation are defined by the existence of more than 80% passport data and more than 50% other data (characterisation and evaluation data) in the whole collection. Basic quality standards must have more than 80% passport data and 30 to 50% other data. If a collection has less than 80% passport data and less than 50% other data, or even 100% passport but no other data, then the documentation of the collection is considered to be of poor quality.

It must be stressed once again: although international standards for PGRFA conservation exist, the amount and quality of information included in the passport data of accessions in many collections may be minimal or uneven. Some passport data only contain information about country of origin (Peeters and Williams, 1984).

As we pointed out when assessing goal achievement for the first objective, i.e. freezing, the scale of measurement chosen here only provides rough estimates. Other indicators for determining the accessibility of accessions would be more precise, e.g. the existence of more user-friendly documentation systems with standard formats or computerised data available on the Internet, but they are not included due to the present lack of necessary information from the majority of countries. The complexity of the problem is increased by the fact that the documentation standard in some countries may be better than this assessment process indicates. Where a country has a decentralised national conservation policy, the documentation data are not always well distributed and may not even appear in the Country Report. The negative externalities of an uncoordinated decentralised conservation and information management are the reduced accessibility of genetic resources for the various users. These users may search for specific genetically coded information or functions by utilising the information accessible on national level and consequently fail to find the existing information, which is not to be found on national level. The transaction costs of searching for genetically coded information will be high in a decentralised conservation system without proper information management. In this situation, the potential users of the specific genetically coded information will either find the same or similar information in another country or will change the direction of research. In other words, the accessibility of germplasm stored in ex situ storage facilities decreases in relation to the degree of national decentralisation of PGRFA conservation combined with the lack of proper information management. The Country Reports' information on the national documentation standard provide an indicator that reflects this situation (FAO, 1996b).

According to the rough estimation made here, 56% of the countries analysed have poorly documented ex situ storage facilities (see Appendix 1) and only 25% of the countries show a good quality standard in their documentation of ex situ stored PGRFA. This assessment is essentially based on no or only very little data other than passport data.

*Distribution of accessions:* The third and final key indicator for the degree of goal achievement of the second objective is the distribution of accessions in 1994. An important role of conservation facilities is to promote and facilitate the distribution of their stored germplasm. This involves international movement of germplasm as well as the distribution at the national level - usually to plant breeders and other researchers, but only seldom directly to farmers. In general, germplasm has been freely available to bona fide users upon request. Consequently, annual germplasm distribution best reflects the actual state of accessibility of the conservation facilities; in part, this may also be an issue of insufficient effective demand in the country concerned. If there had been sufficient data for every surveyed country, germplasm distribution might have been the only key indicator needed for assessing the goal achievement of accessibility. Only 10 countries, however, reported the germplasm movement in their storage facilities (see Appendix 1). Hence, this indicator was used in addition to the other two indicators discussed above. If the distribution of germplasm in 1994 was 10% of the stored accessions or more, the standard of distribution was judged as a good quality standard. If the conservation facilities distributed by less than 10% but more than 3% of the stored accessions, they received a basic quality standard. If the conservation facilities distributed less than 3% of their stored material, their quality standard is defined as poor. Only three countries have a good quality standard of germplasm distribution: the USA which distributed approximately 128,000 accessions in 1994 (23% of their stored material), Ethiopia with 6,000 (11%) and Germany with 19,000 (10%). It is interesting to note the existence of countries with a high amount of stored germplasm but with only very little germplasm movement. Russia (with over 300,000 accessions stored) and Brazil (over 190,000) distributed less than 1% of their germplasm in 1994. This substantiates the impression gained from the information provided in the Country Reports and discussions over recent years that genebanks are still seen and managed mainly as pure conservation facilities. In these facilities the diversity of PGRFA is stored with little or no reference to the utilisation of the stored material (FAO, 1996b). Even a country like Japan, with well-equipped storage facilities and one of the largest genebanks world-wide (over 200,000 accessions) distributed less than 7,000 accessions in 1994 (amounting to 3% of their stored accessions). (FAO, 1996b).

The goal achievement for the accessibility of stored accessions is determined by the quality of the key indicators and sub-objectives discussed above. An overall quality standard for the accessibility can be defined for all the relevant countries (see Appendix 1 for the results). The most important result is that only 6 countries have a good standard of access to their conserved accessions - making up less than 17% of all surveyed countries.

*National in situ activities:* Because of the lack of information, the existence of in situ conservation activities has been taken as the only available indicator to assess the goal achievement of the third overall objective - the adaptation of PGRFA to changing environmental conditions. In situ conservation activities in the field of conservation of PGRFA diversity are still uncommon. Therefore, it is not surprising that only 30% of the surveyed countries mentioned in situ conservation activities (see Appendix 1). There are probably more in situ activities, but they were not mentioned in the Country Reports, often because these unspecified activities are supported by NGOs and are not linked to national programmes (FAO, 1996b).

The quality of PGRFA conservation is defined here as the degree of goal achievement of the national conservation activities. The aggregate results of the quality analysis of PGRFA conservation in the different countries can be seen in Table 4. It shows that only five (15%) of the surveyed 34 countries may be classified as countries with a high conservation quality. Only two countries (6%) were classified as having a medium over-all conservation quality in their conservation efforts. 27 countries, representing 79% of the surveyed countries, had a low overall quality. It is interesting to note that quality of PGRFA conservation does not necessarily relate to income level of the countries. The group with a high quality of conservation efforts consists not only of high-income countries like the US, Japan and Germany but also low-income countries; Ethiopia and a country in transition like Poland also belong to this group. On the other hand, countries like Switzerland, Madagascar, France and India belong to the group representing countries with low quality PGRFA conservation efforts.

Based on the relative domestic expenditures on PGRFA (see Fig 3), countries from three out of the four defined groups are identified as providing high conservation quality. These are Germany (high relative expenditures – low agrobiodiversity); Ethiopia (high relative expenditures – high agrobiodiversity); as well as Japan, Poland and USA (low relative expenditures – low agrobiodiversity). All countries with high agrobiodiversity and low investment are found in the group having a low conservation quality. This indicates the danger of PGRFA loss in the countries of that group.

Table 4: Rate of total quality of PGRFA conservation in different countries

| **Rate of total quality of PGRFA conservation** | **Classified countries** | **% of surveyed countries** |
|---|---|---|
| High | Ethiopia, Germany, Japan, Poland, USA | 15% |
| Medium | Czech Republic, Canada | 6% |
| Low | Austria, Belarus, Brazil, China, Cyprus, Egypt, France, Greece, Haiti, India, Ireland, Madagascar, Pakistan, Peru, Portugal, Romania, Russia, Seychelles, Slovak Republic, South Africa, Spain, Suriname, Switzerland, Tanzania, Togo, Tonga, United Kingdom | 79% |

Note: The rate of total quality of PGRFA conservation is defined as the degree of goal achievement of the national conservation activities. See Appendix 1 for the detailed rating.
Source: Virchow, 1999

These results are based on the disaggregated assessment of the indicators described above[4]. Each of the three objectives was assessed according to the goal achievement of the underlying indicators. Finally, the total quality of PGRFA conservation according to the objectives defined can be obtained by merging the results of the three partial quality analyses. This was done by designing a matrix with all three objectives and their different levels of quality to determine the total quality of the conservation efforts in the countries (see Table 6). The assessment was based on the following assumptions and calculations and depicted as can be seen in Table 5.

[4] For detailed information on the assessment, see Virchow, 1999.

**Table 5: The underlying matrix for the goal achievement**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Freezing** | good | 3.9 | 5.9 | 6.9 | 7.9 | 1 | existent | **Adaptation** |
| | | 3.9 | 4.9 | 5.9 | 6.9 | 0 | non-existent | |
| | basic | 2.6 | 4.6 | 5.6 | 6.6 | 1 | existent | |
| | | 2.6 | 3.6 | 4.6 | 5.6 | 0 | non-existent | |
| | poor | 1.3 | 3.3 | 4.3 | 5.3 | 1 | existent | |
| | | 1.3 | 2.3 | 3.3 | 4.3 | 0 | non-existent | |
| | | | 1 poor | 2 basic | 3 good | | | |
| | | | | **Access** | | | | |

The quality is:

| | | | | | |
|---|---|---|---|---|---|
| <5: | low | 5 – 6: | medium | > 6: | high |

Source: Virchow, 1999

If, with regard to the long-term conservation perspective, a country's conservation activities are assessed as being of good quality, this partial goal achievement scores 3.9 points; the scores are 2.6 and 1.3 points if it is of basic or poor quality, respectively. The same scoring principle was applied to the second objective of conservation activities, assessing the accessibility of stored material. If the quality of accessibility was assessed as poor, the partial quality of a specific country's conservation activities scores 1 point. If it is estimated to be basic, it scores 2 points. If it is assumed to be of good quality it scores 3 points. An additional point is scored if in situ conservation activities were existent and therefore the potential of the germplasm for adaptation existed.

As seen in Table 5, the rating for the partial quality is higher for the long-term conservation objective (good quality scores 3.9 points, whereas for the accessibility, good quality scores only 3 points). The theory behind this approach reflects the idea that a good long-term conservation quality is the major contribution to the overall goal achievement of PGRFA conservation. Consequently, the scores are adjusted upwardly by 30% as an approximation.

The overall quality standard for the accessibility of PGRFA germplasm conserved can be concluded from the calculations described. A good quality standard is achieved by a value over 5, basic standard is still possible over 3, and a poor standard is defined to be less than 3. In this way, all surveyed countries can be classified into one of the three quality standards, as done in Table 6.

The quality of the countries' conservation activities may be assessed and ranked in accordance to the system outlined above. Appendix 1 summarises the assessment for the single objectives as well as the rating for the total quality.

Table 6: **Overall quality of PGRFA conservation determined by the conservation objectives**

| Freezing | | Access: Poor | Access: Basic | Access: Good | Adaptation |
|---|---|---|---|---|---|
| Good | | | | **Ethiopia, Japan, USA** | Existent |
| Good | | **Austria, China, Switzerland** | | **Poland** | Non-existent |
| Basic | | | **Canada** | **Germany** | Existent |
| Basic | | **Ireland, Portugal, Romania** | **France, Greece, Pakistan, UK** | **Czech Rep.** | Non-existent |
| Poor | | **Egypt, Haiti, India, Suriname** | **Peru** | | Existent |
| Poor | | **Belarus, Madagascar, Russia, Seychelles, Slovak Rep., Tanzania, Togo, Tonga** | **Brazil, Cyprus, South Africa, Spain** | | Non-existent |
| | | Poor | Basic | Good | |
| | | Access | | | |

The overall quality is illustrated by:

| | |
|---|---|
| low: | (dark grey) |
| medium: | (light grey) |
| high: | (white) |

Source: Virchow, 1999

# 5 Cost-efficiency of PGRFA Conservation in Different Countries

The overall objective is to develop a definition of successful investment in conservation of PGRFA in different countries. To do so, it is necessary to compare the conservation expenditures of the surveyed countries with the benefits of PGRFA conservation. Because of the problems associated with the valuation and monetisation of the benefits of PGRFA conservation, i.e. the intergenerative and the non-market values of PGRFA as well as the information deficit, no cost-benefit analysis can be made to identify profitable conservation investments. Instead, the evaluation of the cost-efficiency of national conservation activities has to be undertaken as a substitute for evaluating the investments. By assessing the degree of goal achievement of the national conservation activities and comparing it with the financial resources invested, we can identify a successful investment.

The national annual expenditures on PGRFA conservation are determined by the fixed costs of long-term investments, e.g. buildings, and the variable costs of short-term costs, e.g. the day-to-day management of the conserved germplasm. Hence, a comparison of the efficiency of PGRFA conservation in different countries must be based on the average expenditures, i.e. the annual expenditures for one conserved accession. Table 7 indicates the wide differences in the average expenditures on the conservation of PGRFA. It is shown that for US $ 10,000, approximately 2,280 accessions are conserved in Russia, whereas the UK only can maintain 16 accessions for the same investment. These huge differences in the preliminary conservation efficiency are explained by an assortment of factors:

1. The price level is significantly different in the surveyed countries. However, we still find that countries with similar price levels can have very different average costs for PGRFA conservation (e.g. USA and Germany).

2. Economies of scale determine the average costs of the conservation of germplasm. The institutional costs of maintaining a national conservation system will not vary greatly in relation to the number of accessions conserved. So, for instance, Tanzania with 2,510 accessions has approximately the same institutional costs as other countries with significantly more conserved accessions, e.g. Kenya or India with approximately 50,037 and 342,108 accessions respectively.

3. The above mentioned difficulties with the existing data have to be taken into consideration as well (see 0). The results are biased due to the fact that some countries did a thorough cost-calculation, including figures for the depreciation of long-term investment (e.g. Germany), while others only supplied the annual expenditures (e.g. USA). Consequently, the average conservation costs will differ significantly.

4. Finally, the variations in average conservation costs will partly depend on the different management systems involved.

Table 7: Annual expenditures on PGRFA conservation in different countries

| | Domestic expenditures 1995 in US $ 1,000 | Number of accessions | Annual expenditures for one conserved accession in US $ / accession | Number of accessions conserved for US $ 10,000 accessions/10000 US $ |
|---|---|---|---|---|
| Austria | 10 | 7,891 | 1 | 7,891 |
| Romania | 408 | 93,000 | 4 | 2,279 |
| Russia | 1,526 | 333,727 | 5 | 2,187 |
| Pakistan | 120 | 18,000 | 7 | 1,500 |
| Poland | 656 | 91,802 | 7 | 1,399 |
| China | 2,526 | 350,000 | 7 | 1,386 |
| Canada | 1,584 | 212,061 | 7 | 1,339 |
| India | 6,776 | 342,108 | 20 | 505 |
| Ethiopia | 1,346 | 54,000 | 25 | 401 |
| Japan | 6,480 | 202,581 | 32 | 313 |
| Portugal | 1,030 | 29,200 | 35 | 283 |
| USA | 20,433 | 550,000 | 37 | 269 |
| Togo | 151 | 4,000 | 38 | 265 |
| Brazil | 8,000 | 194,000 | 41 | 243 |
| Czech Republic | 3,255 | 51,571 | 63 | 158 |
| Tanzania | 187 | 2,510 | 75 | 134 |
| Peru | 4,137 | 44,833 | 92 | 108 |
| Switzerland | 3,825 | 17,000 | 225 | 44 |
| Slovak Republic | 3,608 | 14,547 | 248 | 40 |
| South Africa | 19,000 | 48,918 | 388 | 26 |
| France | 98,660 | 249,389 | 396 | 25 |
| Spain | 33,413 | 78,174 | 427 | 23 |
| Germany | 113,215 | 200,000 | 566 | 18 |
| UK | 70,154 | 114,495 | 613 | 16 |
| Greece | 10,958 | 17,556 | 624 | 16 |
| Egypt | 11,528 | 8,914 | 1,293 | 8 |

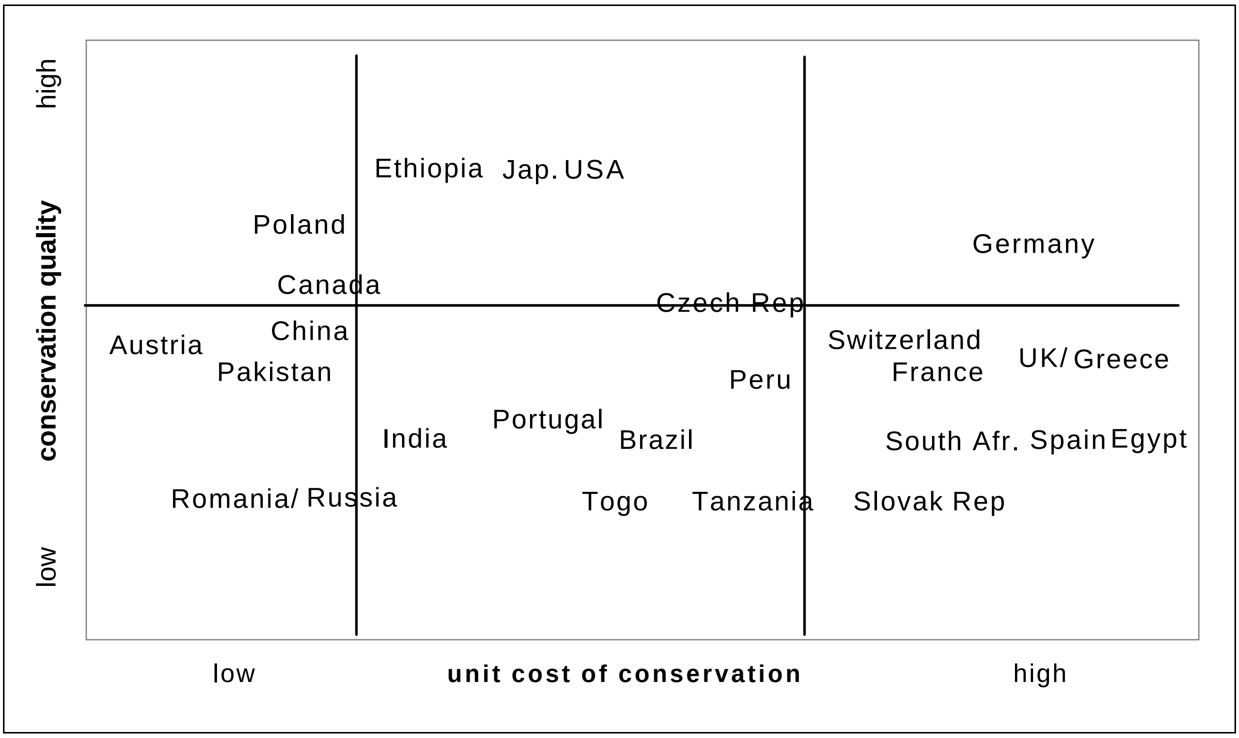
Source: Virchow, 1996; FAO, 1998

Due to the differences in conservation quality, the high heterogeneity of the product 'conserved germplasm' does not allow the cost-efficiency of conservation to be assessed solely by the costs per accession. The quality aspect has to be integrated, and this is determined by the goal achievement as discussed above (see Chapter 4). The cost-efficiency of PGRFA conservation is high when the unit costs of conservation are low and the conservation quality is high. As can be seen in FigFig 5, the cost-efficiency increases from the bottom far right to the top far left. Even though Germany, for instance, has a good conservation quality, the efficiency of countries like Ethiopia, the USA or Japan is higher, due to their lower less unit costs.

If cost-efficiency is based on the relative expenditures per accession, a shift to the right occurs for low-income countries. A country like Ethiopia has much higher relative unit costs for maintaining their good quality standard of conservation as Japan and the USA have, if costs are set in relation to the country's GDP per capita.

It is evident that a country like Poland, with a high conservation quality and low unit costs for PGRFA conservation, has a higher cost-efficiency than Tanzania for instance. It is more difficult to assess the differences in the efficiency between other countries, for instance between China with low conservation quality and comparatively low unit costs and the Czech Republic with a high conservation quality but high unit costs as well.

**Figure 5: Cost-efficiency of PGRFA conservation systems**



In order to make a comparative assessment of the countries' relative performances in PGRFA conservation, we need an *efficiency-deficit ratio* (EDR). Taking a reference point, defined by low annual costs per accession (e.g. US $ 1) and by an optimal quality level (e.g. 8 points, which is higher than that of the best performed countries), every country can be rated according to the deviation of its average expenditure as well as quality level. The US $ 1/accession reference point is simply taken as a benchmark, against which relative performance is measured. For instance, a country like Brazil is US $ 40 away from this benchmark. Furthermore, being rated in the conservation quality level (3.3 points – see Appendix 1) Brazil would need to increase its conservation quality by 4.7 rating points (see Table 8). By applying the following equation (5-1), the EDR for Brazil is calculated at 1.14. By proceeding similarly with all countries, we can rank them according to the EDR. Those countries with the lowest EDR (e.g. Poland with 0.87) are the countries with the most efficient PGRFA conservation systems at present (see Table 8).

$$EDR_c = \sqrt{\left(\frac{ER_c}{E_c}\right)^2 + \left(\frac{QI_c}{QM}\right)^2} \qquad (5\text{-}1)$$

whereby:

*$EDR_c$:* *Efficiency-deficit ratio of a country's PGRFA conservation system (see G in Table 8)*

*$ER_c$:* *necessary expenditure reduction of a country to US $ 1 / accession (see B in Table 8)*

*$E_c$:* *existing annual expenditures in US $ / accession of a specific country (see A in Table 8)*

*$QI_c$:* *quality increase of a country's PGRFA conservation to a quality maximum of 8 points(see E in Table 8)*

*QM:* *quality maximum*

It has to be stressed again that the above calculations are provisional, beingbased on rough data (see Chapter 3.1). Consequently, the rating of the different countries may not reflect the true expenditures and quality situation in a country. Furthermore, the premise that germplasm can be sustainable conserved by annual costs of US $ 1/accession is only a working assumption. There may be doubts as to whether good conservation quality can be achieved and maintained a such a low cost. It is indicative that countries like Pakistan, Romania and Russia (and Austria as well) were found in the low cost / low quality conservation quarter of FigFig 5. Very low conservation costs may reflect unsustainable conservation rather than high conservation efficiency.

Although the existing data do not allow a more comprehensive and thorough efficiency analysis of the countries' conservation efforts, the approach may help to foster practical solutions of relevance to the ongoing political discussions on the sharing of benefits and costs of PGRFA conservation and utilisation.

Table 8: The efficiency-deficit ratio for PGRFA conservation of selective countries

| Country | Expenditure | | | Quality | | | |
|---|---|---|---|---|---|---|---|
| | Annual in US $ / accession | Reduction in US $ / accession | Reduction in % | Rating in points | Increase in points | Increase in % | Efficiency -Deficit-Ratio |
| | A | B | C | D | E | F | G |
| | | | (B / A) | | | (E / max quality of 8 points) | |
| Austria | 1.1 | 0.1 | 9 | 4.9 | 3.1 | 0.39 | 0.40 |
| Poland | 7 | 6 | 86 | 6.9 | 1.1 | 0.14 | 0.87 |
| Canada | 7 | 6 | 86 | 5.9 | 2.1 | 0.26 | 0.90 |
| China | 7 | 6 | 86 | 4.9 | 3.1 | 0.39 | 0.94 |
| Pakistan | 7 | 6 | 86 | 4.6 | 3.4 | 0.43 | 0.96 |
| Ethiopia | 25 | 24 | 96 | 7.9 | 0.1 | 0.01 | 0.96 |
| Japan | 32 | 31 | 97 | 7.9 | 0.1 | 0.01 | 0.97 |
| USA | 37 | 36 | 97 | 7.9 | 0.1 | 0.01 | 0.97 |
| Germany | 566 | 565 | 100 | 6.6 | 1.4 | 0.18 | 1.01 |
| Czech Rep. | 63 | 62 | 98 | 5.6 | 2.4 | 0.30 | 1.03 |
| Romania | 4 | 3 | 75 | 2.3 | 5.7 | 0.71 | 1.03 |
| Switzerland | 225 | 224 | 100 | 4.9 | 3.1 | 0.39 | 1.07 |
| Russia | 5 | 4 | 80 | 2.3 | 5.7 | 0.71 | 1.07 |
| France | 396 | 395 | 100 | 4.6 | 3.4 | 0.43 | 1.08 |
| UK | 613 | 612 | 100 | 4.6 | 3.4 | 0.43 | 1.09 |
| Greece | 624 | 623 | 100 | 4.6 | 3.4 | 0.43 | 1.09 |
| Peru | 92 | 91 | 99 | 4.3 | 3.7 | 0.46 | 1.09 |

.... continued over page

Table 8: The efficiency-deficit ratio for PGRFA conservation of selective countries ....... cont d.

| Country | Expenditure | | | Quality | | | |
|---|---|---|---|---|---|---|---|
| | Annual in US $ / accession | Reduction in US $ / accession | Reduction in % | Rating in points | Increase in points | Increase in % | Efficiency-Deficit-Ratio |
| | A | B | C | D | E | F | G |
| | | | (B / A) | | | (E / max quality of 8 points) | |
| Portugal | 35 | 34 | 97 | 3.6 | 4.4 | 0.55 | 1.12 |
| India | 20 | 19 | 95 | 3.3 | 4.7 | 0.59 | 1.12 |
| Brazil | 41 | 40 | 98 | 3.3 | 4.7 | 0.59 | 1.14 |
| South Africa | 388 | 387 | 100 | 3.3 | 4.7 | 0.59 | 1.16 |
| Spain | 427 | 426 | 100 | 3.3 | 4.7 | 0.59 | 1.16 |
| Egypt | 1,293 | 1,292 | 100 | 3.3 | 4.7 | 0.59 | 1.16 |
| Togo | 38 | 37 | 97 | 2.3 | 5.7 | 0.71 | 1.21 |
| Tanzania | 75 | 74 | 99 | 2.3 | 5.7 | 0.71 | 1.22 |
| Slovak Rep. | 248 | 247 | 100 | 2.3 | 5.7 | 0.71 | 1.22 |

# 6 Policy Implications

The 1996 International Technical Conference on Plant Genetic Resources for Food and Agriculture (ITC) in Leipzig reaffirmed and agreed that the conservation of PGRFA is crucial to maintaining the genetic resources required for the breeding efforts of the future. Funds are needed to fulfil the target of implementing the Global Plan of Action for the Conservation and Utilisation of PGRFA, adopted at Leipzig. It will be necessary to allocate scarce financial resources in a way that optimises their impact. As we have shown in this study, the efficiency of PGRFA conservation varies widely between countries. Consequently, the allocation of financial resources for PGRFA conservation through multi- or bi-lateral channels should be driven by an attempt to close efficiency-deficits in the countries' PGRFA conservation systems.

In those countries, which have low average costs but have a poor conservation quality the major objective should be to improve the quality of PGRFA conservation and to maintain the low average costs at the same time. Those country programmes marked by poor conservation quality but high average costs for PGRFA conservation have to be assessed in two ways before financial resources can improve their situation. The constraints on conservation quality have to be identified as well as the reasons for the high average costs. Additional funds should only be provided after the reasons for high unit costs have been identified and the plans for cost reduction and quality improvement have been outlined and implemented.

Improving the quality of the conserved germplasm as well as reducing the average conservation costs will increase the efficiency of the national conservation systems. This efficiency increase needs prioritised funding. It seems that improved management, including the rationalisation of collections through institutional as well as international collaboration, can reduce the unit costs as well as increase the conservation quality. Furthermore only a constant quality and cost monitoring process can ensure efficient utilisation of scarce financial resources and improve the cost-efficiency of the national PGRFA conservation systems.

Two further implications can be derived from this study. As this study was based on the first global survey of national expenditure data, it involves all the difficulties of interpretation already discussed, underlining the need for further, more detailed, surveys. Surprisingly little research on the costs of genebanks and their efficient management has been done so far. This even applies to the large genebanks of the CGIAR centres. The data derived from further surveys will have to be much more detailed and comparative so as to enable us to assess the efficiency-deficit ratio of each country with greater precision and reliability. Furthermore, the national conservation systems and their cost structure have to be analysed in more depth. The conservation costs for different crops and different techniques applied have to be taken into account. In this sense, country studies analysing the conservation costs of different crops and different conservation methods should become a further step towards enhanced cost-efficiency of the national PGRFA conservation systems.

# Appendix

Table 1: Quality of conservation of PGRFA in national programmes

| | Partial Quality of the Conservation and Utilisation of PGRFA in National Programmes | | | | | | | | | | Total Quality of PGRFA Conservation | Quality rating in points |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Freezing | | | Access | | | | Adaptation | | | | |
| | Long-term storage | Quality standard of storage | Freezing | Working collection | Standard of documentation | Standard of distribution of PGRFA (1994) | Access | National in situ PGRFA activities | Adaptation | | | |
| Austria | e. | good | good | e. | poor | n.i. | poor | n-e. | n-e. | | low | 4.9 |
| Belarus | n-e. | basic | poor | e. | poor | n.i. | poor | n-e. | n-e. | | low | 2.3 |
| Brazil | e. | poor | poor | e. | basic | poor | basic | n-e. | n-e. | | low | 3.3 |
| Canada | e. | good | good | e. | basic | basic | basic | n-e. | n-e. | | medium | 5.9 |
| China | e. | good | good | e. | poor | n.i. | poor | n-e. | n-e. | | low | 4.9 |
| Cyprus | n-e. | basic | poor | e. | basic | n.i. | basic | n-e. | n-e. | | low | 3.3 |
| Czech Rep. | e. | basic | basic | e. | good | basic | good | n-e. | n-e. | | medium | 5.6 |
| Egypt | e. | poor | poor | e. | poor | n.i. | poor | e. | e. | | low | 3.3 |
| Ethiopia | e. | good | good | e. | good | good | good | e. | e. | | high | 7.9 |
| France | e. | basic | basic | e. | good | n.i. | basic | n-e. | n-e. | | low | 4.6 |
| Germany | e. | basic | basic | e. | good | basic | good | e. | e. | | high | 6.6 |
| Greece | e. | basic | basic | e. | basic | n.i. | basic | n-e. | n-e. | | low | 4.6 |
| Haiti | n-e. | poor | poor | n-e. | n-e. | n.i. | poor | e. | e. | | low | 3.3 |
| India | e. | poor | poor | e. | poor | n.i. | poor | e. | e. | | low | 3.3 |
| Ireland | e. | basic | basic | e. | poor | n.i. | poor | n-e. | n-e. | | low | 3.6 |
| Japan | e. | good | good | e. | good | basic | good | e. | e. | | high | 7.9 |

.... continued over page

Table 1: Quality of conservation of PGRFA in national programmes
.......... cont d

| | Partial Quality of the Conservation and Utilisation of PGRFA in National Programmes | | | | | | | | | Total Quality of PGRFA Conservation | Quality rating in points |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Freezing | | | Access | | | | Adaptation | | | |
| | Long-term storage | Quality standard of storage | Freezing | Working collection | Standard of documentation | Standard of distribution of PGRFA (1994) | Access | National in situ PGRFA activities | Adaptation | | |
| Madagascar | n-e. | poor | poor | e. | poor | n.i. | poor | n-e. | n-e. | low | 2.3 |
| Pakistan | e. | basic | basic | e. | basic | basic | basic | n-e. | n-e. | low | 4.6 |
| Peru | n-e. | basic | poor | e. | basic | n.i. | basic | e. | e. | low | 4.3 |
| Poland | e. | good | good | e. | good | basic | good | n-e. | n-e. | high | 6.9 |
| Portugal | e. | basic | basic | e. | poor | n.i. | poor | n-e. | n-e. | low | 3.6 |
| Romania | n-e. | basic | poor | e. | poor | n.i. | poor | n-e. | n-e. | low | 2.3 |
| Russia | n-e. | basic | poor | e. | poor | poor | poor | n-e. | n-e. | low | 2.3 |
| Seychelles | n-e. | poor | poor | n-e. | poor | n.i. | poor | n-e. | n-e. | low | 2.3 |
| Slovak Rep. | n-e. | basic | poor | e. | poor | n.i. | poor | n-e. | n-e. | low | 2.3 |
| South Africa | e. | poor | poor | e. | basic | n.i. | basic | n-e. | n-e. | low | 3.3 |
| Spain | e. | poor | poor | e. | basic | n.i. | basic | n-e. | n-e. | low | 3.3 |
| Suriname | n-e. | poor | poor | n-e. | n-e. | n.i. | poor | e. | e. | low | 3.3 |
| Switzerland | e. | good | good | e. | poor | n.i. | poor | n-e. | n-e. | low | 4.9 |
| Tanzania | e. | poor | poor | e. | poor | n.i. | poor | n-e. | n-e. | low | 2.3 |
| Togo | n-e. | poor | poor | e. | poor | n.i. | poor | n-e. | n-e. | low | 2.3 |
| Tonga | e. | poor | poor | e. | poor | n.i. | poor | n-e. | n-e. | low | 2.3 |
| UK | e. | basic | basic | e. | good | n.i. | basic | n-e. | n-e. | low | 4.6 |
| USA | e. | good | good | e. | good | good | good | e. | e. | high | 7.9 |

Note: e.: existent; n-e.: non-existent
Source: Virchow, 1999

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