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Plant Genetic Resources in Africa: Opportunities, Challenges and Priorities

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1.0 Introduction

Africa's strength lies in its natural resources, including the genetic resources that are the foundation for growth and stability in agriculture, forestry, adaptation to climate change and environmental conservation in its entirety. Africa's economies, cultures and political systems are primarily dependent, albeit precariously, on how well plant genetic resources are conserved and utilized. In the light of this, the continent's economic transformation and its ability to integrate itself into the evolving global system, to a large measure, depends on agricultural transformation that is based on plant genetic resources (PGR).

Plant genetic resources are a key component of global biodiversity and it lends itself as a resource to be tapped as human needs and economic demands change. Humanity derives most of its food, many medicines and industrial products from both wild and domesticated components of plant genetic resources. However, the reduction of this biodiversity has been an inevitable consequence of human development as species-rich forests and wetlands are converted to relatively species-poor farmlands and plantations. It is now believed that 17 million hectares of tropical forests are being cleared annually and scientists estimate that at this rate roughly 5-10% of the tropical forest species may face extinction within the next 30 years (IUCN, 1990). Overall, scientists believe that about 60,000 of the world's 240,000 plant species that have been described could be lost within the same time unless deforestation is slowed. This may lead to the loss of vital genetic resources especially wild relatives of crops and other economically important species. The many values of plant genetic resources and its importance for agricultural and economic development are sufficient incentives for development of articulate conservation measures. Their conservation entails a shift from protection to efforts that seek to meet people's needs and economic development from biological resources while ensuring the long-term sustainability of this important biotic wealth and heritage. This involves not only the conservation of natural habitats and wild plants but also safeguarding the genetic diversity of economically important plants.

Plant genetic resources are the biological basis of the world's food security and directly or indirectly support the livelihoods of every person on earth. The International Treaty on Plant Genetic Resources (ITPGR) defines plant genetic resources as "*any genetic material of plant origin that is of actual or potential economic value*". They consist of the diversity of genetic material contained in traditional varieties and modern cultivars grown by farmers as well as crop wild relatives and other wild plant species that can be used as food, medicines, essential oils, gums and resins, fodder and forages, fibres, shelter, wood, timber and fuel wood among others. The conservation and utilization of this vital component of biodiversity is therefore imperative for people's sustainable livelihood, agricultural productivity and economic development.

Today, access to food around the world is not secure Eight hundred million people are undernourished and 200 million children under five years of age are underweight. In the next 30 years, the world's population is expected to grow by over 2,500 million to reach 8,500 million. Reliable and sustainable improvements in yield will be needed to meet the demands of this growing population. The conservation and sustainable utilization of plant genetic resources are the keys to improving agricultural productivity and sustainability, thereby contributing to national development, food security and the alleviation of poverty.

As the worldwide loss of plant genetic resources accelerates, awareness has grown of the potentially disastrous consequences of this trend for the earth's ecological functions and the fulfillment of basic human development needs. This trend is especially important in sub-Saharan Africa where people depend on plant genetic resources to a far greater extent than most other parts of the world. However, ways must be found to raise production and incomes while at the same time developing better biological resources management options.

2.0 The international historical context and the policy environment

Though plant genetic resources have been sought after, collected and conserved, used and improved for centuries, it was only in the 1930's that official concern was voiced regarding the need for conservation. In 1963, an FAO Panel of Experts on Plant Exploration was established to advise the Organization and set international guidelines for the collection, conservation and exchange of germplasm (Bennet, 1968).

Because of the growing alarm over the rapid loss of diverse farmer landraces, the Consultative Group on International Agricultural Research (CGIAR) established the International Board for Plant Genetic Resources (IBPGR) in 1974, to coordinate an international plant genetic resources program. Collecting missions were accelerated, and gene banks were constructed and expanded at national, regional and international levels. In 1983, the FAO Conference established the intergovernmental Commission on Plant Genetic Resources and adopted a non-binding International Undertaking on Plant Genetic Resources. These two are the main institutional components and frameworks for the Global System on the Conservation and Sustainable Use of Plant Genetic Resources.

It was becoming increasingly apparent by the early 1990's that an intergovernmental conference was needed to assess the progress, identify problems and opportunities and help give direction to future activities in the conservation and utilization of plant genetic resources. In 1992, the importance of plant genetic resources was recognized at the United Nations Conference on Environment and Development (UNCED). In particular, Chapter 14 of Agenda 21 included a program area on "Conservation and sustainable utilization of plant genetic resources for food and sustainable agriculture". At the international level, Agenda 21 proposed actions to strengthen the FAO Global System including:

- The preparation of periodic reports on the state of the world's plant genetic resources
- The preparation of global cooperative Plan of Action on PGR and the promotion of an International Conference, which would consider the First Report on the State of the World's PGR and the Plan of Action.

The signing and ratification of the Convention on Biological Diversity (CBD) in 1992 further underscored international commitments to the conservation of plant genetic resources as one of the key components of biodiversity (UNEP, 1992). The CBD's key objectives are the a) conservation, b) sustainable utilization and, c) equitable sharing of benefits arising from the use of biodiversity. In 1993, the 27th Session of the FAO Conference strongly emphasized the importance of the Fourth International Conference and endorsed its aims and strategy. The Report of the State of the World's Plant Genetic Resources and the Global Plan of Action were developed through a consultative preparatory process and were adopted by the 4th International Conference in Leipzig, Germany in June 1996 (FAO, 1998a; FAO, 1998b). The world has continued to recognize the clear inter-dependencies on plant genetic resources and after Leipzig, international negotiations and discussions on a multilateral system for exchange of germplasm continued under the aegis of the International Undertaking established by the FAO Commission. These negotiations have culminated in the establishment of the International Treaty on Plant Genetic Resources (ITPGR), which was adopted by the FAO Conference in November 2001 and came into force in 2004. So far, 123 countries have signed the treaty.

At the regional level, efforts to enhance the development of PGR policies and legal frameworks have continued unabated. In an attempt to assist the African nations to domesticate international treaties and conventions, the Organization of African Union has developed a model legislation, which may form a good basis for developing the policies and legal frameworks for the conservation and sustainable use of plant genetic resources in Africa. The model legislation has been discussed in many African regional fora

but individual countries have to review its suitability as generic document on which their national PGR policies and legal frameworks can be based.

3.0 Plant Genetic Resources Opportunities in Africa

Opportunities in endowment with PGR

Africa has given the world some of its most important crops. Out of the 150 food crops consumed by man, 115 are indigenous African species. The world's major regions of crop diversity include the Ethiopian highlands, the Sahelian transition zone, the delta of the Niger River and the humid forest zone of West and central Africa.
The highlands of Ethiopia are a centre of origin for coffee, and a centre of diversity for sorghum, lentil, wheat and barley (Vavilov, 1931; Harlan, 1971; 1976). Tropical West Africa is a centre of origin and diversity for African rice (*Oryza glaberrima*), oil palm, yams and cowpeas. There is considerable inter- and intra-specific diversity of crops, herbaceous and forestry species in Africa. Those that contribute significantly to subsistence agricultural requirements, at least locally, include five cereals, four legumes, three cucurbits, five oil seeds, twelve vegetables, four roots and tubers and five to ten fruits. Introduced crops such as maize, rice (*Oryza sativa*), cassava, beans and cacao also contribute significantly to African agriculture, and some have developed secondary diversity on the continent. In addition to the widespread staple crops, there are many species that are very important in relatively restricted geographic areas. Among these are teff, fonio, Bambara groundnut and some other minor millets as well as vegetables, fruit trees and medicinal plants (IPGRI, 2001). Concerning forages, some estimates suggest that there are a minimum of 63,000 species of higher plants in Africa and about 3,500 species play major roles in feeding livestock and wild herbivores. African forage species contribute 70-75% of grasses and 25-30% of legumes to the world fodder and pasture genetic diversity, playing particularly important roles in Latin America and Australia.

Endemism, which is the proportion of species not found anywhere else in the world, is high in Africa. For example, the level of endemism in Madagascar is 68.8%, Mauritius 37.7%, Cape Province in South Africa 68% and Tanzania is 11%. In the arid areas, major centers of endemism include Somalia, Ethiopia and Namibia (IUCN, 1990). A number of species endemic to this continent include millet (*Pennisetum* spp.), sorghum (*Sorghum* spp.), cowpea (*Vigna unguiculata*), voandzou (*V. subterranea*), African rice (*O. glaberrima*), fonio (*Digitaria exilis*) and yams (*Dioscorea* spp.), among others. Such endemic species have specific genetic constitutions that confer resistance to diseases and pests, the ability to produce in marginal soils, and resistance to some environmental hazards or stresses such as drought. These species are also consumption preferences (e.g culinary qualities) of the population, and they probably hold the key to food security and sustainable development in the region. In addition, a wide range of wild species including roots and tubers, leafy vegetables and fruits provide ready sources of high nutritional values for resource poor households and contribute significantly to health.

Economic opportunities through production, development and commercialization of plant products

Efforts to address the twin goals of genetic resources conservation and economic development are beginning to emerge in some parts of Africa through sustainable production and commercialization of natural products derived from biodiversity (Sunderland *et al.* 2004). Policy makers and practitioners are now beginning to look at the opportunities offered by the sustainable commercialization of genetic resources products and the development of viable natural products sectors. The global, natural products industry, including the key sub-sectors of food and beverages, cosmetics, herbal medicines and pharmaceuticals, is currently valued at US$65 billion per annum and is booming with a 15–20 percent annual growth rate in

the last few years (Keynote, 2005). For instance, current formal natural products trade in Southern Africa is estimated at only US$12 million per annum, although it may have the potential to grow by US$3.5 billion per annum (Bennett, 2006). It is a market that appears set for steady long-term growth.

The potential world market of phyto-medicines or herbal medicines is very large although its significance to the global economy can only be inferred from a few sources of diverse and inadequate data. The World Health Organization (WHO) estimated in the late 80's for instance, that the world trade in medicinal plants amounted to US $ 500 million a year (Lambert *et al.*, 1997). However, information from diverse sources suggests that the overall trade in herbal medicines has since then greatly increased. It is primarily in tropical regions of the earth, within which a large section of Africa lies, where ethno-botanical investigations are yielding the richest harvest with potential for high economic returns (Ayensu, 1978). WWF (1993) estimates that the turnover of pharmaceutical trade in Western Europe in 1989 was US$65 million compared to US$ 2.2 billion for plant based medicines and about 25% of all pharmaceutical drugs dispensed in the USA contain one or more substances of plant origin. A large number of these medicinal plants are found in Africa. For example, the flora of Ghana reveals that there are 754 medicinal plant species used by the local people, while the flora of Zaire has 51 genera with 160 medicinal plant species. It is now possible to extract many new therapeutic substances from 260 plant species found in Haut-Zaire (Irvine, 1961; INEAC, 1963; Printz and Heke, 1986).

Many African countries are reaping benefits from the production and sale of plant extracts in both domestic and international markets. For example, about 11 companies are known to export *Harpagophytum* sp. from Namibia and its harvest has become an important source of revenue for local communities with retail levels in western markets being as high as US $180/kg (Marshall, 1998). South Africa exports approximately 700 tons of *Aloe ferox* per year to Europe, Asia and North America, with the main importing countries being Germany and U.S.A. It is estimated that in 1992 alone, South Africa made US $ 1 million from the sales of a wild species of *Aloe* and over 200 people are employed as aloe tapers (IUCN, 1993).The overall size of the national market for medicinal plants is believed to be considerable, with an estimated trade value of at least US$ 128 million per annum in 1995. This has promoted additional economic activity and made an important contribution to job creation, with several hundred thousand people directly employed in the industry (Mander *et al.*, 1996)

Opportunities for agriculture and food security

Plant genetic resources for food and agriculture are the biological basis for food security and directly or indirectly support the livelihoods of the rural majority in Africa. These resources are the raw materials used in the production of new cultivars either through traditional plant breeding or biotechnology. Whether used directly by farmers as raw materials or by modern plant breeders, these resources are a reservoir of genetic adaptability that can acts as a buffer against potentially harmful environmental and economic change (Hoyt, 1988).

The vast majority of the African people depend directly on the land and natural resources, including plant genetic resources, for their sustenance and over the years, a vast array of agricultural systems have evolved. Overall, only about 6% of Africa's land is cultivated but even so, the agricultural sector is the largest source of employment and provides a high percentage of export and foreign currency earnings. It accounts for about 35% of the continent's GDP, 40% of the export and 70% of the employment. Although commercial agriculture is important in some areas, agriculture is predominantly small-scale subsistence or near subsistence farming.

In the past, agricultural development has aimed at replacing traditional practices with farming systems based on exotic cash and food crops with chemical inputs, large-scale irrigation and mechanization. More

and more, however, it is being recognized that plant genetic resources inherent in indigenous African farming systems, practices, crops and varieties are finely tuned to prevailing eco geographical conditions and must largely form the basis of sustainable agricultural development.

Plant genetic resources and the genetic diversity they contain are the basis for plant breeding and crop improvement. It helps in risk reduction while optimizing the use of diverse resources as well as to respond to diverse situations and end-uses both at the macro and micro levels. It is also important for adaptation to changes over time – climatic and economic changes. Plant genetic diversity, both at intra- and inter-specific levels, is therefore an integral part of the farming systems and its value can be distinguished in relation to the four functions namely:

1. Providing income and food security stability for farming communities at the local, national and global levels by smoothening yield variability through the maintenance of a wide range of crops and intra-crop diversity. Yield losses resulting from the failure of a particular crop or variety due to biotic and abiotic stresses are compensated for by yields of other crops and varieties. By using a wide range of locally adapted varieties, or mixtures of varieties, farmers are able to spread the risk of crop failure resulting from pest and disease epidemics or adverse environmental conditions such as drought.

2. Providing insurance against future adverse conditions as needs are constantly changing. Hence genetic resources may later prove to provide useful characteristics, such as resistance to new diseases or adaptation to changing climatic conditions. It therefore provides a reservoir and a continuous source of genes for crop improvement and breeding programs.

3. Constituting a "treasure chest" of potentially valuable but as yet unknown resources. This is the reason for maintaining both wild ecosystems and traditional farming systems, as plants in these habitats are likely to contain and develop new and valuable genetic characteristics as the evolutionary process continues and the characterization/evaluation techniques improves.

4. Providing the essential raw materials for conventional breeding and biotechnology, which of late has proved to be instrumental in not only addressing issues relating to yields and disease resistance but also the nutritional value of a number of crops. The building blocks are genetic resources in the form of genes, genotypes, gene complexes, plants, traditional varieties and their wild relatives.

Opportunities offered by networks and institutional frameworks

Currently, work on plant genetic resources in Africa is undertaken by several networks and other institutional frameworks that provide opportunities for collaboration, creation of synergy, and making use of comparative advantages that exist in different organizations. These include the following:

National frameworks

UNEP, FAO/IBPGR, IPGRI/BIOVERSITY assisted several national research institutions (NARS) in sub-Saharan Africa in setting up mechanisms for conservation and use of plant genetic resources. National frameworks comprise networking of, and collaboration among national institutions working on various crop plants of importance to the countries facilitated by National PGR Co-ordination Committees which have representation from these institutions as well as other key stakeholders including NGOs. National committees developed strategies and action plans that are implemented through a centralized approach by National Plant Genetic Resources Centers and Gene Banks or through a complementary approach where

different institutions share roles and responsibilities in the conservation and use of specific plant genetic resources. Many countries in Africa now have these institutional structures but co-ordination mechanisms and often operations in most cases need to be strengthened.

Regional and sub-regional frameworks

Regional and sub-regional agricultural research organisations such as FARA, SACCAR, CORAF and ASARECA have several on-going activities and programs on various components of PGR conservation and sustainable use. Three main PGR networks established with the assistance of IPGRI/BIOVERSITY are linked to them. These are: the SADC Plant Genetic Resources Centre and Program (SPGRC) established in collaboration with the Nordic Gene Bank in 1988, within the framework of the Southern African Centre for Co-operation in Agriculture and Natural Resources Research and Training (SACCAR); the Eastern Africa Plant Genetic Resources Network (EAPGREN) established in 1997 in collaboration with ASARECA and the Genetic Resources Network for West and Central Africa (GRENWECA) which was established in collaboration with the Conference of Directors of Agronomic Research in West and Central Africa (CORAF).

In addition, some regional and sub-regional frameworks or partnership platforms exist, whose activities touch upon PGR and which also contribute immensely to their conservation and/or sustainable utilization. Such frameworks are the African Ministerial Conference on the Environment (AMCEN) and the Alliance for a Green Revolution in Africa (AGRA).

The CGIAR Centers

The CGIAR (Future Harvest) Centers are key players in the conservation and sustainable use of plant genetic resources in Africa. The CG System was established in 1971 and today comprises 16 International Centers, each with a different research mandate within the agricultural sector. One of CGIAR's principal research objectives is to contribute mainly to the preservation and use of biodiversity for food and agriculture by establishing *ex situ* collections of plant genetic resources. The collections comprise over 700,000 accessions of more than 3,000 crops, forage and pasture species. The collections are held in trust and are now part of the FAO Global System through an agreed protocol of the Convention on Biological Diversity. After FAO/IBPGR, the International Plant Genetic Resources Institute (IPGRI) now BIOVERSITY International is the Convening Centre for plant genetic resources in the CGIAR System. IPGRI has helped many African countries establish and maintain national conservation centers and PGR programs. ILRI and ICRAF have their Headquarters in Africa while several CG Centers maintain regional offices in Africa.

4.0 Overview of conservation status

Ex situ conservation

The conservation of threatened genetic resources in particular is gaining more and more importance in a rapidly changing world. The impetus for conservation was earlier led by FAO and UNEP and later accelerated by recent global initiatives such as the Convention on Biological Diversity (CBD), UNCED and more recently, the FAO Global Plan of Action. Traditionally, conservation of genetic resources has primarily been through *ex situ* conservation (King and Roberts, 1980; Ford-Lloyd and Jackson, 1981; De Langhe, 1984).

The objectives of *ex situ* conservation of genetic resources are the collection, maintenance and regeneration of the genetic diversity of a gene pool ensuring its existence and availability on the long term. This demands that collection methods initially capture maximum variation and subsequently conservation and regeneration techniques minimize losses through time (FAO/IBPGR, 1992). This is by far the most prevalent conservation method particularly for crop genetic resources in most of the national programs in Sub-Saharan Africa. According to country reports and second draft of the State of the World's Plant Genetic Resources for Food and Agriculture the breakdown on germplasm conserved *ex situ* on sub-regional basis is as follows: Eastern Africa 145,000 accessions; Southern Africa 70,650 accessions, Western Africa 109,831 accessions, Central Africa 20,271 accessions and Indian Ocean Islands 4,604 accessions. Among the countries with well advanced capacities and substantial *ex situ* collections are Ethiopia which has about 60,000 accessions and Kenya with 44,000 accessions. Most of the countries in the SADC region have very good capacities both in human resources and conservation facilities mainly as a result of synergies created by the SADC Plant Genetic Resources Centre, which holds a base collection of about 10,500 accessions on behalf of the collaborating countries. In West Africa, Benin, Cameroon, Cote d'Ivoire Ghana, Nigeria and Senegal are good showcases as they have fairly good capacities and *ex situ* collections ranging from 2,000 to 10,000 accessions in various gene banks.

However, there is increased realization that *ex situ* conservation alone is not adequate for conservation of the various gene pools due to increased and diversified user demands and requirements. The CBD and the FAO Global Plan of Action have specifically called for both *in situ* and *ex situ* conservation measures for biodiversity and genetic resources conservation (UNEP, 1992; FAO, 1998b). The decision on the choice(s) of conservation methods is not only a matter of available technology and resources but it is also influenced by biological, economical, management, socio-economic, cultural and political considerations (Astley, 1992; Frankel and Soule, 1981).

In situ conservation

The objective of *in situ* conservation is to maintain viable breeding populations in their natural habitats and for crops, in land use systems and cultural heritages in which they have continually evolved and are adapted to (Hoyt, 1988; FAO, 1989). The Convention on Biological Diversity defines *in situ* conservation as "the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties."

From an environmental point of view, *in situ* conservation refers to the conservation of an ecosystem viz. the variation between and within species and the dynamics of their interdependence and interaction with their environment. The various forms of *in situ* conservation include biosphere reserves, forest and nature reserves, national parks and game reserves, plant sanctuaries and designed genetic reserves for wild relatives (Hoyt, 1988). *In situ* conservation is a vital component of a complementary approach to conservation of plant resources as it ensures the preservation of biological diversity at genetic, species and ecosystem levels; it ensures continued provision of life's important basic necessities such as medicines, fodder, food, fodder, cosmetics, industrial products, fuel wood and timber upon which a great majority of humankind depend on. It also ensures the conservation of wild species including relatives of cultivated plants which are crucial in crop improvement programs as sources of genes for disease and pest resistance, environmental adaptability and nutritional qualities among others (Hoyt, 1988).

Lately, *in situ* conservation has included the continued cultivation and maintenance of landraces by farmers "**on farm**" i.e. in the areas they have continued to evolve and developed their distinctive properties (Brush, 1985; Maxted *et al*., 1996). This offers the possibility of providing incentives to local farmers to continue to act as custodians of traditional varieties and selections nurtured in their fields and backyards (Altieri and

Merrick, 1987). In this case crop diversity cannot be conserved *in situ* without simultaneously encouraging the traditional culture and land use systems which fostered it, protected it and under which it has continually evolved. The cultural integrity of the local peoples and the conservation of genetic resources are therefore closely linked (Smith *et al*., 1992).

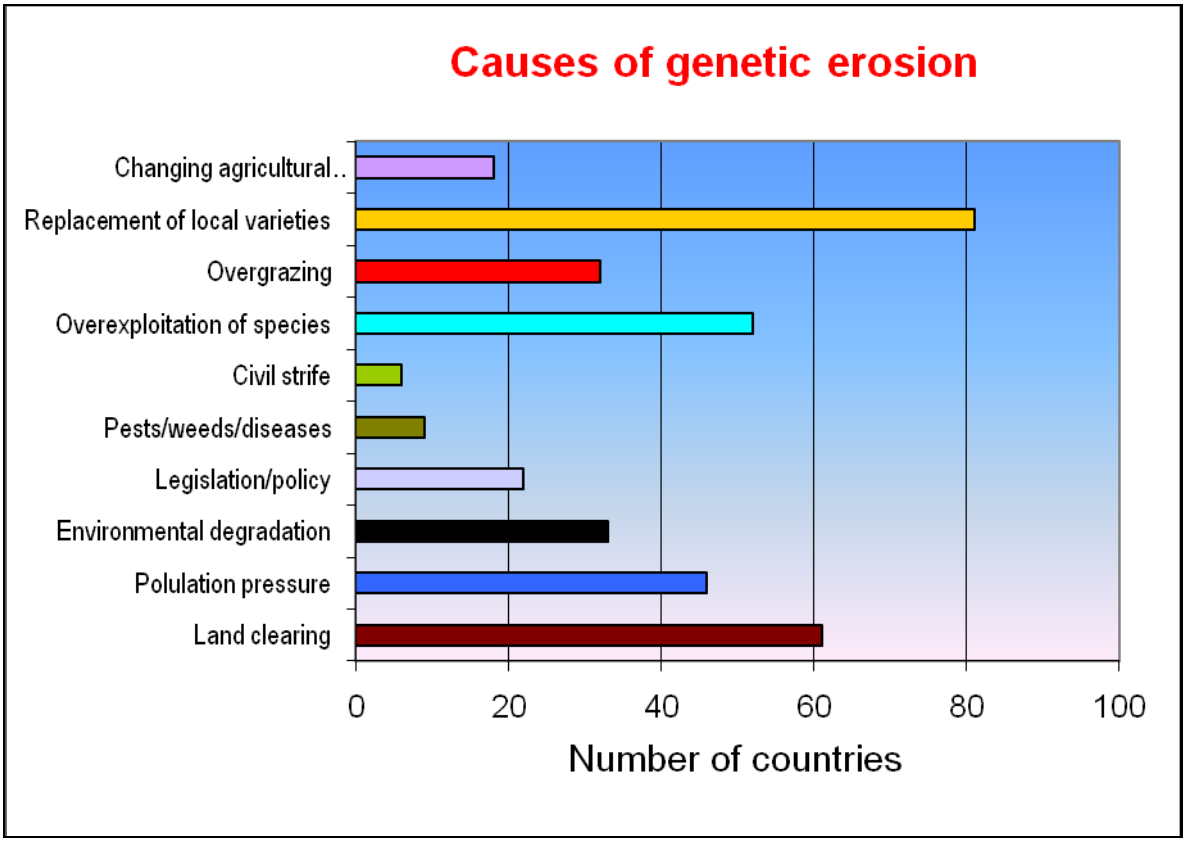
In Africa, on farm conservation approach is the more prevalent method for conservation and sustainable use of plant genetic resources. IPGRI/Bioversity International has over the years been studying the scientific basis and developing scientific guidelines for on farm conservation in collaboration with national programs in Burkina Faso, Ethiopia and Mali. The latter two countries are now on the forefront of farmers' involvement in on farm conservation of plant genetic resources. In addition there are other initiatives such as the Community Biodiversity Development and Conservation (CBDC) mainly spearheaded by NGOs in collaboration with the Institute of Biodiversity Conservation in Ethiopia, COMMUTECH in Zimbabwe and the Rokupur Rice Research Center in Sierra Leone. Other initiatives include the Seeds of Survival for Africa Program that has activities in Ethiopia and Zambia among other countries. Many African countries are now expressing interest in developing on farm conservation projects and some already have tangible projects and activities on in situ/on farm conservation including Ethiopia and Uganda.

5.0 Major challenges and constraints

Genetic erosion

One of the major challenges facing African plant genetic resources is the threat from genetic erosion. The genetic base of Africa's plant diversity is being seriously eroded, largely as a result of a multiplicity of environmental, socio-economic and political factors. The main cause of genetic erosion in crops, as reported by almost all countries signatories to the Global Plan of Action on plant genetic resources for food and agriculture (GPA) (FAO, 1998a), is the replacement of local varieties by improved or exotic varieties and species. There are many other causes of this erosion, which has been accelerating throughout the 20th century in parallel with the demands of an increasing population and greater competition for natural resources and land (Figure 1). These include:

- The rapid expansion of intensive industrial production that cultivates relatively few improved crop varieties in monocultures.
- Globalization of the food system and marketing, and the extension of intellectual property systems, which have led to the widespread cultivation and rearing of fewer varieties for more uniform, less diverse but more competitive global market.
- Land degradation: as lands become eroded, deforested or increased in salinity, dry land habitats and the genetic resources they support are destroyed.
- The breakdown of traditional systems of natural resource management with parallel loss of local plant varieties, and associated cultural knowledge.
- Components of agricultural development polices, including the displacement of traditional plant varieties by improved ones (ITDG, 2001a; 2001b).
- Natural disasters, including droughts, floods and pests and diseases, which have led to widespread losses of diversity from both farmers fields and natural habitats e.g. the cassava mosaic virus attack in Uganda
- Political instability and civil unrest that have led to loss of genetic resources in fields as farmers flee from war torn areas and as *ex situ* conservation facilities are destroyed for example in Angola, Burundi, Rwanda and Somalia.



Climate change

Climate change poses a great threat to diversity as many plants are unable to cope or adapt to changing temperatures and moisture gradients caused by global warming and the associated change of climate. This is a major challenge to conservation of plant genetic resources as predicted models reveal that in many parts of Africa, both rainfall and temperature patterns are changing. This may lead to loss of species that may not be able to adapt to the new changes. It may also lead to re-distribution of crop growing limits and loss of inter- and intra-specific diversity in both crop wild relatives and traditional varieties since research has revealed clear relationships between climate variables and genetic diversity.

Insufficient capacities

Despite the many initiatives undertaken in the past and also recently, insufficient capacities in almost all aspects of genetic resources management remains a big challenge in Africa. This is more critical in some areas then others: characterization and evaluation of indigenous vegetables and the so called underutilized species; regeneration and repatriation of germplasms; rationalization of the on farm conservation approaches; training of African scientists/breeders on the use of indigenous vegetables and underutilized species**.**

Weak policies and legal frameworks

In most country reports, the need to develop and adopt strategies, policies, legal frameworks and regulations that promote the use of PGRFA, especially landraces and under-utilized crops, has been

elaborately expressed. Furthermore, an associated need is the development of appropriate seed legislation that recognizes traditional/informal seed systems. Also the need for the development of policies and laws governing the use of genetically engineered crop varieties and other GMO products and to increase public awareness on related issues. Many countries have reported some progress in the development of relevant PGRFA policies and legal frameworks. However, there is still a need to increase efforts in the development of appropriate, non-conflicting and complementary national policies and legislation to govern the conservation, exchange and use of PGRFA. This includes development of policies on phyto-sanitary regulations, intellectual property protection, Farmers' Rights and bio-safety. Capacity is also needed in the development of these policies and legal provisions which are at different stages of development in various countries.

Poor capacities for domestication and implementation of international treaties and conventions

Many African countries are signatories of at least two or more international conventions or treaties on biodiversity and/or PGRFA. The ratification and implementation of international agreements, treaties and legal provisions, particularly the ITPGRFA, CBD and GPA are the key prerequisites to foster regional and international collaboration. However, in many countries, these treaties have not been fully domesticated since the formulation of national policies is either incomplete or the legal provisions are inadequate. Many countries also lack the necessary technical, scientific and legal capacities to domesticate these international laws and agreements.

Weak national programs and institutional framework

Although substantial progress in national program development has been made over the years, coordination mechanisms and institutional frameworks are still weak in many countries. Many national programs still require better collaboration and wider representation that includes relevant ministries, government institutions, universities, NGOs, farmers' groups and the private sector. Many countries do not have National Biodiversity Strategies and Action Plans (NBSAPs) that govern the operations of the national programs and PGRFA activities. Where they exist, implementation and monitoring mechanisms are either lacking or weak. Moreover, the roles and responsibilities of institutions participating in national program activities need to be better defined in order to avoid duplication of efforts, build synergy and make better use of available resources. In order to benefit from most of the regional and international opportunities for collaboration, mechanisms for internal coordination among different ministries and institutions, and between the public and private sectors need to improve. At the national level, the links between conservation institutions and those entrusted with the use of germplasm especially breeders are still very weak and resulting in under-utilization of the genetic resources.

Insufficient funding and sustainability mechanisms

By and large, in most African countries, implementation of PGR activities is constrained by insufficient funds through government budgetary allocations to support recurrent costs and sustain the conservation and use of local genetic material.

6.0 Plant genetic resources priorities in Africa

Several issues need to be addressed if significant progress is to be made in the conservation and sustainable use of plant genetic resources in Africa. These issues are scientific, institutional and political in nature and include the following:

Development of early warning systems for monitoring genetic erosion

The loss of genetic diversity is widespread in Africa and threats and trends in genetic erosion need to be better understood and arrested. Both genetic vulnerability and genetic erosion of indigenous crops are poorly documented and therefore development of better indicators is needed. Moreover, development of early warning systems (including integration of indigenous knowledge) for effective monitoring and assessment of the trends and extent of genetic erosion for plant genetic resources are urgently needed, including building the necessary scientific capacities and competencies.

Germplasm value addition and stronger links between conservation and use

The major crops sustaining agriculture in Africa have a narrow genetic base and this makes them vulnerable to diseases and environmental pressures. The more than 350,000 germplasm accessions already held in various African gene banks therefore needs to be characterized and evaluated to unlock their potential for use in national crop improvement programs to broaden the genetic base of agricultural production systems and increase productivity. This necessitates the development of stronger linkages between genetic resources conservation programs and use components by developing an integrated approach at the national level that provides for effective linkages between conservation, breeding and seed production and distribution system in both private and public sectors in order to enhance effective delivery and adoption of improved varieties. AGRA is trying to achieve this through the work if its seed systems program, using the seed value chain approach and conventional breeding. This work needs to be scaled up nationally and regionally.

A lot of technologies for use in germplasm value addition and unlocking its potential are now available and are already in the public domain, with no proprietary rights. These include biotechnology applications such as molecular markers in the assessment of intra-specific diversity, germplasm characterization evaluation and pre-breeding, development of core collections, marker assisted selection, gene mining and functional genomics among others. In addition GIS applications could contribute significantly to the understanding of inter-specific diversity and its spatial distribution thereby enabling scientists to develop more articulate *in situ* and *ex situ* conservation strategies. The onus is therefore on the African nations to acquire and develop the necessary capacities to make the best use of these technologies Africa.

Mitigation and adaptation to climate change

Africa is a center of diversity and/origin for many crops of regional and global importance and therefore harbors tremendous diversity of these crops and their wild relatives. Unfortunately, Africa is one of the most vulnerable continents to climate change and climate variability, a situation aggravated by low adaptive capacity to interaction of 'multiple stresses' occurring at various levels, putting the vast unique gene pools at great risk of extinction. African nations therefore, need to stay abreast of climate change prediction models and develop clear early warning and monitoring systems to detect these changes. Studies on expected diversity redistribution patterns and climate change mitigation/adaptation strategies are urgently needed. These may include collection and conservation of germplasm in areas where climate change impacts are expected to be highest. Moreover, characterization and evaluation of the germplasm already conserved in gene banks is needed in order to retrieve adaptive traits for climate-ready improved varieties that confer resistance to both biotic and abiotic stresses emanating from climate variability.

There is urgent need to review complementary conservation strategies and approaches, to ensure a level of co-evolution that will safeguard the genetic material locked up in gene banks. Lessons may be learned from some practices of smallholder farmers in indigenous/native communities (indigenous knowledge).

Institution building and strengthening of national PGR frameworks

Though substantial progress in national program development has been made over the years, many countries still have weak national institutional frameworks for PGR conservation and sustainable utilization. Efforts needs to be made to strengthen national coordination mechanisms, enhanced collaboration and wider representation including ministries, government institutions, universities, private companies, NGOs, farmers' groups and the private sector. The development, implementation and monitoring of nationally endorsed strategies and actions plans, including National Biodiversity Strategies and Action Plans (NBSAPs) that govern the operations of the national programs and PGRFA activities is also needed. Many national programs need to strengthen their information technology and communications capacity, particularly in acquiring skills in bioinformatics, high capacity computers, reliable internet connectivity, wide band e-mail and websites to enhance information dissemination. National Information Sharing Mechanisms including comprehensive and standardized information systems and database need to be developed or strengthened to facilitate and enhance information generation, documentation, exchange and dissemination. In order to benefit from many of the regional and international opportunities for collaboration, there is a need in many countries for greater internal coordination among different ministries and institutions, and between the public and private sectors.

Capacity strengthening and mobilization

At the moment, the capacity of African nations to effectively conserve and use their plant genetic resources and derive the maximum benefits from them is hampered by inadequate expertise/knowledge in the science of plant genetic resources and insufficient conservation and evaluation/pre-breeding infrastructures and facilities. It is urgent for Africa to strengthen her technical capacity for *in situ* and *ex situ* conservation and utilization of plant genetic resources at the national and sub-regional levels, with a special focus on human resource strengthening and infrastructural development in the following key areas:

- Conducting research, especially application of modern tools and technologies such as molecular techniques, genomics and bioinformatics to increase and improve precision breeding as a complementary approach to traditional/conventional breeding methods. Capacity is needed in biotechnology applications, particularly the training of a critical mass of scientists and technicians in different areas of biotechnology, genetic transformation, bio-safety, risk assessment and management and promotion of participation of local biotechnologists and breeders in the development of GM crop plant varieties and products to satisfy African agro-ecologies and regional needs.

- taxonomy and plant breeding for minor/under-utilized crops GIS techniques in eco-geographic surveys and distribution of diversity;

- Use of molecular techniques in genetic diversity studies, inventories and crop improvement;

- Establishment and/or further development of facilities for conservation and utilization of genetic resources including laboratory facilities for biotechnology research activities better gene banking facilities or both gene bank and biotechnology facilities and establishment of *in vitro* conservation facilities;
- Strengthening of quarantine facilities, centralization of germplasm movement and enforcement of relevant policies in order to keep track of germplasm movement, curb biopiracy and minimize the spread of diseases and pests;

- Increase the countries' capacity in negotiation skills and domestication of international agreements and other legal instruments on PGRFA, particularly CBD and ITPGRFA and integrate plant genetic resources imperatives into national economic development plan;
- Mainstreaming of PGRFA into all academic levels training and capacity building by highlighting the need to educate senior managers and policy makers about the complex legal and policy issues relating to the conservation, exchange and use of PGRFA.

A proper inventory of the current capacity and available expertise as well need assessment must be carried out and documented. Incentives and enabling environment for constructive engagement in genetic resources conservation and utilization must be provided to the practitioners.

Research and development of under-utilized crops and wild relatives

More efforts are needed in research and development of the myriads of Africa's under-utilized crops that have the potential to increase food security, diversification of nutritional base and enhancement of food sufficiency and income generation at the household levels. Current research is not clearly linked to user or market demands.

As an incentive for promotion of conservation and sustainable utilization of underutilized crops, there is a need to create demand and expand potential markets for these crops. Smallholder farmers and small-scale enterprises involved in the development, sustainable use and marketing of underutilized crops may require encouragement and support along the value chain.

Regional conservation strategy and safety duplication

Africa is prone to both natural and man-made disasters. A regional strategy to enhance long term conservation and safety duplication is therefore required through establishment of sub-regional *ex situ* conservation nodes serving as centers of excellence for specific crops. These should be linked to regional and national institutions and programs to harmonize PGRFA activities as well as to develop regional plans and strategies. Due to vulnerability, safety duplication of the genetic resources of many nationally and regionally important crops and underutilized species, conserved *ex situ,* is of paramount importance. The need is even highest and most urgent for vegetatively propagated species and species with recalcitrant seeds. There will be need to streamline and rationalize the regional networks to reduce duplication and make better use of available resources. Repatriation of resources conserved outside Africa can then be addressed.

Regional information sharing mechanism

Sharing, exchange and dissemination of information is quite an important pre-requisite for advancing PGR work on the continent. A lot of information on African plant genetic resources is available but it is all scattered and not well documented. A Regional Information Sharing Mechanisms is therefore needed, and should include a comprehensive and standardized information systems and database driven websites for available expertise, catalogues of gene bank holdings of germplasm of African origin and making the information readily available to potential users. This should be a comprehensive information mechanism for both *in situ* and *ex situ* conservation that links national information systems to regional and possibly to international data bases and information systems. The regional information system should help support existing networks and program.

Policy Development advocacy, awareness creation and public education

Though progress has been made there is still a need to increase efforts in the development of appropriate, non-conflicting and complementary national as well as regional policies and legislation to govern the conservation, exchange and use of PGRFA. This includes development of policies on phyto-sanitary regulations, intellectual property protection, Farmers' Rights and bio-safety. Capacity is also needed in the formulation of these policies and legal provisions which are at different stages of development in various countries.

Despite efforts that have been made so far, there is still insufficient awareness and inadequate appreciation, at all levels, of the value of PGRFA and its potential for contribution to increased productivity and food security. For this reason, PGRFA are not adequately integrated into key economic sectors such as agriculture, science and technology. There is lack of development of the relevant policies and legal instruments. Lack of appreciation as well masks the importance of PGRFA and its links to key developmental issues such as poverty alleviation, food security, nutrition and health.

At the community level, lack of appreciation of PGRFA leads to genetic erosion through displacement of landraces by improved varieties or the loss of wild relatives or forest resources through land conversion and other activities. These concerns therefore underscore the need for more policy advocacy and creation of awareness on the importance and value of PGRFA, including biotechnology, bio-safety and risk management. This awareness needs to be created at all levels including community, scientific, policy makers levels using diverse strategies such as the mass media (television, print media), open days, workshops, seminars, participation in agricultural shows and community seed fairs, national farmers' technical conferences and organization of short courses on PGR management and biotechnology/bio-safety related issues.

7.0 Conclusions and way forward

It is projected that agriculture will be the main engine to power African nations' economic development and this will depend on achieving high agricultural productivity. Agricultural productivity will increase only if Africa uses the potential of her crop plant genetic resources (agro-biodiversity) to the fullest, to ensure sustainable food security and also help lift majority of smallholder farmers out of the poverty trap.

What we have been able to achieve a lot so far, we've done it with the help of our development partners throughout the continent and we indebted to them all. This is the time to congratulate and thank everyone for having arrived at this level, then fold our sleeves and decide on an agenda for the rest of the journey.

An African Agenda will require careful and deliberate efforts to integrate agro-biodiversity development into both short and long term agricultural research and development plans and commitments to implement programs that have been identified. It will among other thing, ensure sustainability, will require the development of enabling policies, will require building of the necessary technical and infrastructural capacities and commit the necessary financial resources required to develop this vital resource for the improved livelihood of the people's well being and overall economic development of the African nations.

It will also be imperative to develop an integrated African agenda that involves public and private partners, the farming and scientific communities as well as development partners to ensure a) the systematic and sustainable use of agro biodiversity in a rapidly changing climatic environment, b) capacity development and institutional strengthening, c) mobilization of adequate funding for the implementation of all activities, c) development of strategic partnerships and alliances, d) and the development of an enabling environment across the region.

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