



THE STATE OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE IN RWANDA

COUNTRY REPORT

BY

*Gapusi R. Jean, Tona Isibo, Nyirigira R. Antoine,
Gashamura, R. Freddy, Sirikari Sylvere, Uwimana Jeanne
d'Arc, Byamushana Cassien, Bizeye Barnabe and Patrice
Hakizimana*

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Executive Summary

Rwanda is endowed with a rich variety of plant genetic resources due to its location within the centre of the Albertine Rift. With its specific climatic conditions, there are a remarkable variety of ecosystems this area, and it is considered to have the highest number of species in Africa. Rwanda alone, shelters 2,150 known species of plants found in a range of ecosystems. There are also a rich diversity of cultivated plants in the country, many which are used for food and export. As the agriculture sector represents one of the major shares of GDP (31%) and provides the livelihood for about 80% of the population living in rural areas, (MINAGRI, 2011), plant genetic resources for food and agriculture (PGRFA) is one of the key driving forces to alleviate poverty in the country.

The present Country Report reviews the status of PGRFA in Rwanda, focusing on the state of (i) Diversity; (ii) *In-situ* conservation and on-farm management; (iii) *Ex-situ* conservation; (iv) Use; (v) National programs, trainings and legislation; and (vi) Regional and International collaboration; as well as (vii) Access to genetic resources, sharing of benefits arising out of their use and farmers' rights; and (viii) The contribution of PGRFA management to food security and sustainable development.

In 1994, Rwanda experienced a 3 month genocide which shattered the country's population as well as the agricultural biodiversity. In less than 20 years, the country has made major strides towards recovery; however, it largely remains an under-developed country with an agricultural-based economy. Partly due to little varietal improvement, there still exists a lot of crop diversity in the country, especially in beans, cassava, Irish potato, maize, rice, sorghum, sweet potato and horticultural crops.

The awareness created by various public institutions about the importance of PGRFA has attracted the attention of researchers and Non Government Organizations (NGOs) involved in *in-situ* and *ex-situ* conservation and sustainable use of these PGRFA. Participatory plant breeding programmes and development of small scale seed production systems are mechanisms that have been supported to promote the conservation and use of improved and local varieties through involvement of local communities. However, a lot is still needs to be done in the field of plant taxonomy, on-farm management, management of natural habitats and sustainable public awareness on the importance of PGRFA. For *ex-situ* conservation, a

National Genebank for conservation of PGRFA has been established under Rwanda Agriculture Board (RAB), and a national program is currently being set up. To ensure that the gaps in collection, characterization and evaluation are fulfilled, a lot of efforts are needed to fully operationalize this facility.

Regarding sustainable use of PGRFA, a number of new varieties of beans, maize, rice, sorghum, Irish potato and cassava have been developed which have contributed significantly to food security and rural development. In order to address a range of biotic and abiotic stresses, there is a need for breeders to access and use a larger variety of germplasm. It is, in particular, a demand for traits like tolerance to drought, pests, diseases and soil acidity.

Research programmes involved in plant genetic resources management are coordinated by RAB. These research programmes are focused on plant breeding, agronomic evaluation and characterization, and most of the work is done in collaboration with national and international partners. Strong collaboration exists between national research programmes and the CGIAR Research Centers. Considering capacity building, both public and private universities have included courses on biodiversity conservation in their curricula for both undergraduate and postgraduate students. As far as legislation on access to genetic resources, benefit sharing and farmers' rights are concerned, little effort has been done during the last three decades. However, Rwanda has a national policy and national law on biodiversity, as well as a draft National Strategy and Action Plan for the Conservation of Biodiversity. In addition, a roadmap for the implementation of Nagoya protocol has been developed, and a National PGRFA Strategy is under preparation.

Considering international collaboration, Rwanda ratified the International Treaty on Plant Genetic Resources for Food and Agriculture in January 2011. By becoming a contracting party to the International Treaty, Rwanda has shown that conservation, use and fair and equitable sharing of these resources is a priority on the political agenda. This is illustrated by increasing initiatives to raise awareness of PGRFA, increased capacity building, the establishment of the National Genebank and the ongoing creation of the biodiversity centre of excellence in Rwanda.

Rwanda's location within the centre of the Albertine Rift has resulted in a remarkable variety flora and fauna. Due to its climatic conditions and variety of ecosystems, this area is in fact considered to be having the highest species diversity in Africa. Rwanda alone shelters 2,150 known species of plants (REMA, 2009) found in various eco- and farming-systems. Despite the large variety, most of the food crops and export crops grown in the country have originated outside Rwanda.

Development goals and policies

The Rwandan genocide, which took place in 1994, devastated both the country's population and its economy. Since then, the country has made major steps towards social, political and economical recovery, and has achieved impressive progress. Rwanda's long-term development goals, embedded in "Vision 2020", seek to reduce poverty and transform the country into a middle-income economy by the year 2020. It envisages attaining an annual per capita income of US\$ 900 and reducing the poverty rate to 20% (Republic of Rwanda, 2001). Poverty is now estimated to be 44.9% at a national level, but the recently published Third Integrated Household Living Conditions Survey (EIVC3), shows that the poverty has been reduced by 12% between 2005/06 and 2010/11, evidence that Rwanda is on the right track towards achieving 'Vision 2020' objectives (NISR, 2012). The economy is largely based on agriculture, and development and transformation of the agricultural sector is one of the highest priorities for the Government of Rwanda. The Rwanda's Economic Development and Poverty Reduction Strategy (EDPRS) provides the medium term framework for achieving Vision 2020 and states that *"in agriculture, the main programmes include the intensification of sustainable production systems in crop cultivation and animal husbandry; building the technical and organizational capacity of farmers; promoting commodity chains and agribusiness, and strengthening the institutional framework of the sector at central and local level"*.

The agricultural policy has been articulated through two key documents published by the Ministry of Agriculture and Animal Resources (MINAGRI): National Agriculture Policy (NAP) issued in early 2004, followed by the Strategic Plan for the Transformation of Agriculture (PSTA I) in October 2004, which was revised and presented as PSTA II in December 2008. The NAP spells out the main areas of agriculture that need to be transformed and lays down guidelines for government intervention in the sector. The PSTA I/PSTA II document was intended to provide the basis for implementing the Policy, and to that end it

defines four overarching Programmes. PSTA II contains the short- to medium term framework for the agricultural sector, and is aligned with the national vision, long-term framework for development as well as the regional development agenda set by the New Partnership for Africa's Development (NEPAD) and the Comprehensive Africa Agricultural Development Program (CAADP).

Agricultural production

Currently, agriculture accounts for almost 31% of the GDP in Rwanda while an additional 4% provided through agro-processing and agricultural commerce. Almost 80% of Rwanda's population relies on the agriculture sector for their income and livelihood and the vast majority practices subsistence farming. Due to scarcity of land, households cultivate less than 0.7 ha on average, which is not economically viable. Extensive cultivation on small pockets of land has resulted in several constraints, including soil degradation. Furthermore, as a result of the need for smallholder farmers to cultivate slopes, much of Rwanda's land remains at a high risk of erosion. The agriculture sector is mainly dominated by the production of staple food crops although some have started production of high value crops including fruits, rice, sorghum and soybeans. Export production is relatively low; the main export crops are coffee, tea and pyrethrum. Table 1 illustrates the increase of the GDP in Rwanda from 2006, and the importance of agriculture to the GDP, especially the production of food crops.

Table 1: Gross Domestic Product by Kind of Activity at current prices (in billion Frw)

	2006	2007	2008	2009	2010
Gross Domestic Product	1,71	2,045	2,574	2,985	3,277
Agriculture	660	729	834	1,012	1,058
Food Crops	546	619	692	858	891
Export Crops	25	18	24	23	28
Livestock	31	32	41	48	50
Forestry	52	53	69	73	77
Fisheries	6	7	9	10	11
Industry	236	285	382	431	491
Mining and Quarrying	11	21	25	16	21
Manufacturing	117	125	159	190	218

Source: National Institute of Statistics, 2011, Statistical Year Book 2011 Edition

The importance of each crop varies geographically based on the different agro-ecological regions, potato and wheat are mostly grown in the highland areas (2000-2800m), coffee, sweet potato, banana and sorghum are mostly grown in the midland areas (1800-2000m) and soya bean and rice are mostly grown in the low altitude areas (<1800m). Banana and sorghum are considered important crops socially particularly because they are used to make local brews. They also constitute an important source of income for smallholder farmers in many rural areas. The most economically important crops are coffee, tea and sugar cane. Pyrethrum, grown in the Northern part of Rwanda is also becoming an increasingly important cash crop (Table 3).

Table 2: Production of Major cash crops in Tons

Crop	2005	2006	2007	2008	2009	2010
Coffee	17,414	22,223	14,683	20,724	16,000	19,312
Tea	16,458	16,976	20,474	19,965	20,535	22,248
Sugar cane	58,665	58,011	97,010	63,001	100,663	115,304

Crop production and food security

The government realizes that significant improvement in the productivity of food crops is required to support the growing rural and urban population in Rwanda, taking into consideration the country's unique challenges. Considering the limited land resources and the demographic pressure on land, intensification of existing production systems represents the most tangible approach to increasing food production in the country. In an effort to increase national agricultural productivity and improve food security, the Government of Rwanda (GoR) launched the Crop Intensification Program (CIP) in 2007. The CIP focuses on six priority crops (beans, cassava, Irish potato, maize, rice and wheat), and is centered around the increase of productive inputs (fertilizers), water use (improvement of irrigation), higher level of land use (marshland development) and land consolidation, forming larger and more rational holdings. For instance the consolidated use of land area under the priority crops has increased from 28,788 Ha in 2007 to 254,000 Ha in 2010 (Fig.2), which has increased productivity without expanding the total area under cultivation of crops. As a result of this program, as well as other initiatives, the crop productivity has increased for the major food crops (Fig.3 and Fig.4).

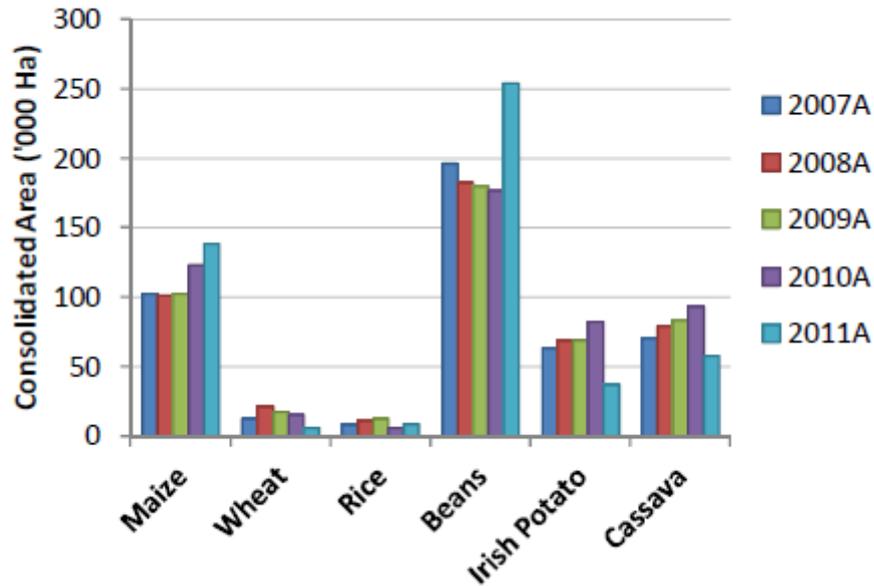


Figure 2: Recent trends in consolidation of land use areas under cultivation of priority crops in Season A in Rwanda

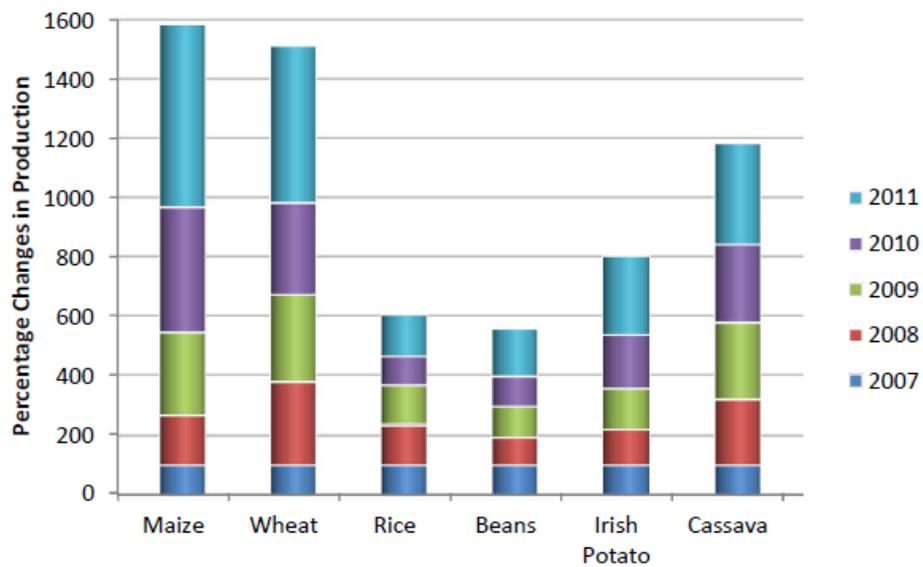


Figure 3: Increments (%) in production of food crops under intensification process. Levels were normalized to production in the base year of 2007.

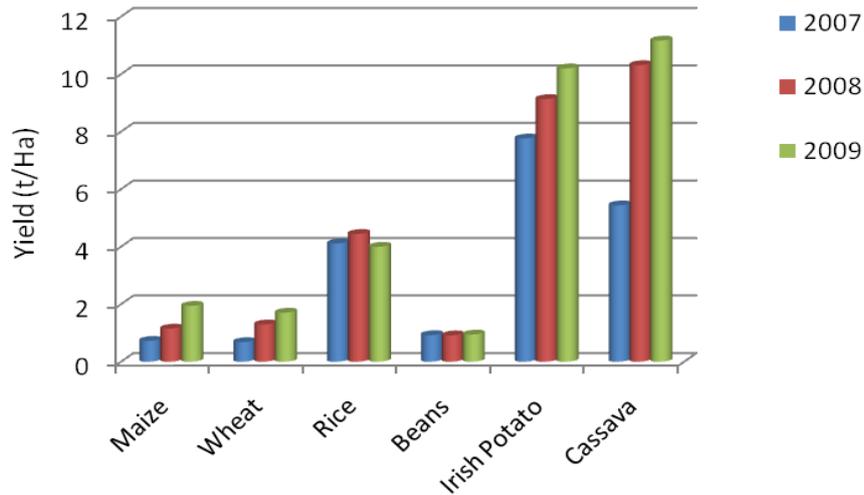


Figure 4: Changes in on-farm productivity of major crops

According to the Comprehensive Food Security and Vulnerability Analysis and Nutrition Survey (2009), the percentage of households with poor and borderline Food Consumption Scores decreased from 35% in 2006 to 21% in 2009 (NISR et al., 2009). This indicates a positive trend towards reaching food security in Rwanda. Based on the recent crop production figures (shown in the table in Annex 1), the Government declared Rwanda a food secure nation in 2009, two years after the President declared “war against hunger and famine in Rwanda” in 2007. Today, all 30 districts of Rwanda produce enough food for their needs and more than half are producing enough surplus to generate income as it was estimated in 2012.

Figure 1. Estimated food security outcomes, September 2012

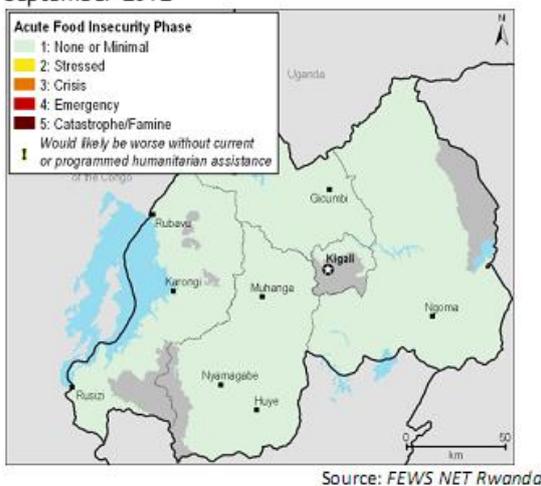


Figure 2. Estimated food security outcomes, October to December 2012

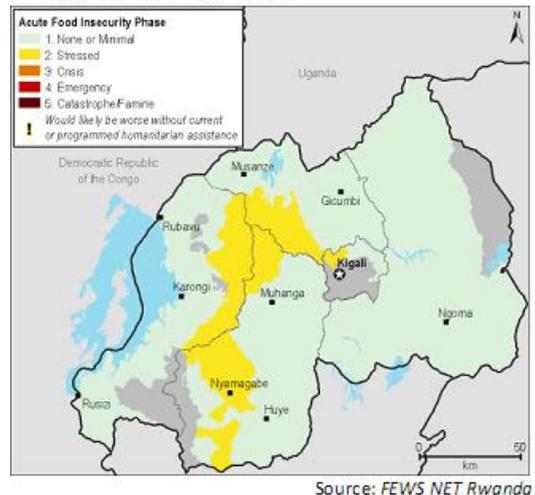


Figure 5: Estimated food Security for the last quarter of 2012 in Rwanda

Chapter 1: The state of diversity

1.1 Plant Genetic Resources in Rwanda

Rwanda's agricultural systems are characterized by widely diversified food and forage species. The main food crops are bean (*Phaseolus vulgaris*), maize (*Zea mays*), rice (*Oryza sativa*), banana (*Musa spp.*), Irish potato (*Solanum tuberosum*), cassava (*Manihot esculenta*), sweet potato (*Ipomea batatas*), sorghum (*Sorghum bicolor*), wheat (*Triticum aestivum*), and soybean (*Glycine max*). The most essential horticultural species are orange (*Citrus sinensis*), lemon (*Citrus limon*), mango (*Mangifera indica*), avocado (*Persea americana*) and pineapple (*Ananas comosus*). The main agricultural export products from Rwanda are coffee (*Coffea arabica*), tea (*Camellia sinensis*) and pyrethrium (*Chrysanthemum cinerariifolium*). Other plant species that are important in Rwanda due to their adaptability and high-yield potential are amarante (*Amaranthus spp.*), pumpkin (*Cucurbita pepo*), green pepper (*Cucurbita annuum*), garlic (*Allium sativum*), pepper (*Capsicum spp.*), eggplant (*Solanum spp.*), cabbage (*Brassica, spp.*), sunflower (*Helianthus annuus*), and onion (*Allium cepa*). Major forage and agroforestry species include *Tripsacum laxum*, *Setaria spp.*, *Desmodium spp.*, *Pennisetum purpureum*, *Chloris gayana*, *Calliandra calothyrsis*, *Leucaena diversifolia*, *Sesbania sesban* and *Cajanus cajan*. Some other species (indigenous vegetables and medicinal plants) that are currently underexploited are Isogi (*Cleome gynandra*) and Isogo (*Amaranthus spinosus*). Several indigenous forest species are located in the natural forests (Congo-Nile watershed and Eastern savannah zones). Table 3 provides an overview of the number of species for the key food crops in the country.

Table 3: Number of species for key food crops

Crops	Number of Species
Cereal crops	4
Legume crops	4
Roots and tubers crops	5
Horticulture crops	10
Oilseed crops	3
Fiber crops	2
Drug crops	5
Forage crops	3
Trees and Shrubs	3
Sugar crop	1
Total	40

A baseline survey intending to get knowledge on institutions engaged in the exchange of plant genetic resources and factors influencing the International Treaty's Multilateral System (MLS) in Rwanda, was carried by RAB in early 2012 with funding from Bioversity International. The survey revealed which crops were perceived as the most important ones by people in Rwanda. In the category "legumes", beans (66%), soybeans (23%) and peas (7%) were perceived as the most important ones; of cereals the three most important crops were considered maize (46 %), rice (24%) and wheat (15%); and for tubers the three most important crops were considered cassava (41%), sweet potato (31%) and Irish potato (27%). Although sweet potato is indicated as more important than Irish potato, it is not considered at the as a food security crop at the national level. Cabbage (30%), carrot (16%) and tomatoes (16%) were listed as the most important vegetables; and citrus (36%), banana (19%) and tree tomato (16%) were listed as the most important fruits.

1.2 Minor Crops and Underutilized Species

Underutilized species in Rwanda include Taro (*Colocasia esculenta*), Yam (*Dioscorea quadrata*), Pigeon pea (*Cajanus cajan*), finger potato and indigenous vegetables including woolly nightshade (*Solanum villosum*), cow pea (*Vigna unguiculata*) and finger millet (*Eulesine coracana*). Given the potential of these and other underutilized species for improved nutrition, greater food security through diversification and potential for income generation and also taking into account that these species require minimal input, efforts have been put in place to promote production of these species and these efforts are also being supported by national development strategies. The Government of Rwanda has put in place strategies to promote and maintain indigenous species through kitchen garden projects throughout the country; the RAB horticulture research program is also focusing on indigenous vegetables namely amaranthus, egg plants, nightshade. The East African Plant Genetic Resources Network project (EAPGREN) is also promoting indigenous vegetables in secondary schools in Rwanda.

1.3 Factors influencing plant genetic diversity

A number of factors are threatening Rwanda's plant diversity, including variety replacement, genetic erosion, over-exploitation of wild plant species, encroachments on natural reserves, invasion of introduced species, overgrazing, climatic conditions (floods and recurrent drought), land clearing and deforestation, urbanization and human population growth. Many of these threats have been made worse by habitat fragmentation and ecosystem degradation. Financial constraints have prevented the government in taking appropriate and effective measures to counter-balance the negative factors. There is also a problem of high soil erosion and risk of land-degradation in the country, especially because many smallholder farmers are forced to cultivate on steep slopes that are not suited for agricultural production (Fig. 6). Previous studies estimates that soil erosion results in a loss of 1.4 million tons of soil per year, equivalent to an economic loss of US \$ 34,320,000, or almost 2% of Gross Domestic Product (GDP), (Republic of Rwanda, 2006). Consequently this also limits the number of species and varieties suitable for production. Furthermore the Crop Intensification Program (CIP) is focusing on limited number of high yielding varieties within the six priority crops namely Maize, Wheat, Rice, Cassava, Potato and Beans and that would enhance somehow genetic erosion as long as there is no parallel and clear plan to conserve other under exploited germplasm *in situ* and *ex situ*.



Figure 6: Hills prone to soil erosion. Source: Republic of Rwanda (2006).

1.4 Needs and priorities with regards to conservation and use of diversity

In Rwanda, several aspects of the conservation and sustainable use of plant genetic resources for food and agriculture (PGRFA) need to be strengthened to meet current and future challenges. Needs and priorities that have been identified and formulated in collaboration with stakeholders are shown below.

Needs:

- (i). More stakeholders need to be involved in the conservation and sustainable use of PGRFA, including researching institutions, universities, farmers' cooperatives as well as national, regional and global expertise. The cooperation and coordination among these stakeholders also needs to be improved,
- (ii). In order to know and understand the diversity present in the country, an inventory of plant genetic resources must be carried out. This would help policy makers to guide the development and implementation of the National Programme and ensure that appropriate actions are taken,
- (iii). A monitoring and evaluation framework on plant genetic resources should be established at the national level under the active coordination of a national committee for the conservation and sustainable use of plant genetic resources,
- (iv). A mechanism for financial support to local communities needs to be put in place,
- (v). There needs to be a stronger awareness among ministries of Agriculture and Natural Resources with regards to the conservation and use of PGRFA. Joint policy actions should be supported,
- (vi). International agreements and policies, such as the International Treaty and the Convention on Biological Diversity (CBD) both of which Rwanda is a party to, need to be implemented. RAB which is mandated to follow up with regards to agricultural research and biodiversity, needs to be strengthened to spearhead these efforts,
- (vii). Laws and regulations regarding PGRFA need to be established and implemented,

Priorities:

- (i). To secure funds for and begin a national inventorying of existing PGRFA, using modern tools and techniques including Geographical Information Systems (GIS),
- (ii). Develop and implement systems for monitoring and evaluation of PGRFA, building on the efforts that has already been done,
- (iii). Improve the systems of *in-situ* and *ex-situ* conservation, including genebank- and on-farm management.
- (iv). Create awareness among all stakeholders and networks, as well as in the general public, to further improve the understanding of the importance of PGRFA, their conservation and sustainable use,
- (v). To implement the Second Global Plan of Action, as part of the fulfillment of the commitments set forth in the International Treaty and the Commission on Biological Diversity (CBD).

Chapter 2: The state of *in situ* conservation and on-farm management

There are two complementary approaches to *in situ* conservation, which will both be referred to in this chapter. Whereas *in situ* conservation of wild plants and crop wild relatives (CWR) refers to the protection these in their natural habitat, on-farm management of PGRFA are concerned with the use and maintenance of local crops and varieties grown in agricultural systems and home gardens. Both aspects are recognized as essential in order to ensure the maintenance of a genetically diverse portfolio. Despite an increased awareness of *in situ* conservation and on-farm management in Rwanda, major gaps and needs with respect to their conservation, management, research and sustainable use still remain.

2.1 *In-situ* conservation of Crop Wild Relatives (CWR)

Rwanda has three major conservation areas, of which include Akagera National Park, Volcanoes National Park and Nyungwe forest. Of these, each protects an ecosystem with a large array of different plants. Nyungwe forest which holds many endemic species of the Arbertine Rift was gazetted as National Park in order to ensure the conservation of genetic diversity. Parks and natural reserves have been protected against fires, encroachments and poaching as well. Management plans for parks and natural reserves have been elaborated and their implementation already started. Also IRST botanists found some CWR in natural reserves such as for sorghum and sweet potato. There are also other CWR for strawberry.

2.2. On-farm management of local crops and varieties

Based on the results of the baseline survey carried out by RAB in early 2012 in collaboration with Biodiversity International and intending to get knowledge on institutions engaged in the exchange of plant genetic resources and factors influencing the Multilateral System in Rwanda, about 47% of the conservation of PGRFA is done through *in situ*/on-farm. On-farm management of PGRFA is still not yet formally organized at county level, and strategies for farmers to enhance on-farm management of local crops and varieties including landraces need to be established. In addition, farmers are largely encouraged to use improved varieties, instead of landraces, especially with regards to the key food security crops. The fact that very

few efforts are targeting the conservation and enhanced use of local crops and varieties poses a threat for genetic erosion. There are however a number of species which are mainly kept at farmers' level. These include finger millet, yam, finger potato, *colocasia spp* and *xhantosoma spp*. Other species, including indigenous vegetables and medicinal plants, exist but are underexploited because of lack of knowledge on their use and nutritional values are Isogi (*Cleome gynandra*), Isogo (*Amaranthus spinosus*).

Most efforts to promote the conservation of local varieties have been done through participatory crop improvement and support to local seed producers. Through participatory plant breeding programmes, local communities have been involved in the selection of varieties and in the improvement/breeding process. There are several examples of small scale seed production units such as INGABO association for cassava, URUGAGA IMBARAGA for Maize and Irish Potato and Beans, IMPUYABO for Soybean etc. that have been developed and set up by local communities as part of participatory plant breeding programmes. Additionally, farmers in some areas, still growing bean, sorghum, banana, sweet potato landraces. These landraces are grown due to farmers' preferences linked to traditional values and genetic traits like earliness, resistance/tolerance to diseases etc.: In highlands there are pigeon pea, sorghum, finger millet and banana landraces grown there while in mid and low altitudes there are bean, sorghum, taro, yam, ground nut, sweet potato, banana and vegetables landraces that are still grown. This is particularly important in areas that are experiencing periodic shortages of seed of improved varieties, and for farmers that cannot afford the cost of certified seed.

2.3 The informal and formal seed sector

The Rwanda seed commodity chain is characterized by the coexistence of formal and informal seed systems. The informal seed system, which by far is the most important, consists of all actors who produce and market seeds without interacting with governmental institutions, which regulate seed production, control and marketing activities. It is mainly based on traditional practices of farmers who select and keep a portion of their production as seeds for the next seasons. It is also characterized by multiple transactions and exchanges between farmers themselves, or through traders from whom farmers can also purchase food commodities some of which are sorted to be used as seeds. The formal seed system is rather recent and has been developed in response to an increase in the agricultural productivity. It is

based on services provided by the public sector stakeholders such as Rwanda Agriculture Board for the production of foundation-, basic- and certified seeds. This production is done either by the State or under contract with people and seed multiplication groups. Participation of the private sector in seed production and conditioning is still very low. It is only limited to certain associations, cooperatives and enterprises, which produce and market seeds in collaboration with RADA Seed Production Unit.

The production of the foundation seeds and the selection of the varieties constitute the starting point for the construction of a modern seed sector. The foundation seeds allow the starting of the production of the basic seeds which in return allow the production of the commercial seeds, directly usable by the farmers. Over the last decade, RAB has carried out activities to support varietal conservation and production of foundation seeds, especially through the “Appui à la Filière Semencière du Rwanda 2 (AFSR 2)” programme. This programme was funded by bilateral cooperation between the governments of Belgium and Rwanda, and is being implemented jointly by the Ministry of Agriculture and Animal Resources and the Belgian Technical Cooperation (BTC). The objective of the programme is to ensure that quality seeds, suited to the local agro-biological and climatic conditions, are produced in adequate quantities and accessible to farmers (MINAGRI, 2005). This involves support to the following activities:

- Produce the foundation seeds and to carry out varietal conservation,
- Place basic material for large scale multiplication of selected seeds at the disposal of extension services,
- Carry out the preservative selection of the germplasm,
- Obtain starting plant material to ensure conservation of the plant genetic resources,
- Ensure partnership with partners of the seed sub-unit,
- Ensure social and economic dimensions and environmental aspects in processes of technology development,
- Strengthen the planning and evaluation systems.

2.4 Seed storage and restoration of agricultural systems after disasters

During disasters, farmers may be forced to deplete their seed stocks, resulting in the loss of well-adapted local varieties and erosion of valuable genetic diversity that is the building block for rehabilitation and restoration of agricultural systems. Seed security is therefore an important component of food security, and needs a concerted effort strong partnership among the farmer communities, national governments, NGOs and international community. In Rwanda seeds security is being addressed by involving private sector and promoting farmer's cooperatives, and at national level, the government has procured hundreds of Cocoons of 50 and 150 metric tonnes capacity for village-level storage of maize, pulses and sorghum.



Figure 7: Some seed storing facilities, operated by MINAGRI's Postharvest Task Force

2.5 Needs and priorities for *in situ* conservation and on-farm management

Needs:

- (i). There is a need to address the existing gaps in knowledge, documentation and public awareness of PGRFA in Rwanda,
- (ii). Rwanda needs to address *in situ* conservation and on-farm management through the National policies and the National PGRFA Programme, to be able to fulfill the obligations set forth in the International Treaty and the Convention on Biological Diversity (CBD),
- (iii). It is a need to identify and address the capacity needs among national stakeholders for addressing *in situ* conservation and on-farm management,
- (iv). Appropriate activities needs to be identified and implemented to promote on-farm management in Rwanda,
- (v). There is a need to strengthen both the formal and informal seed sector in Rwanda.

Priorities:

- (i) Create or updated inventories of plant species, including crop wild relatives (CWR), wild food plants, local varieties and other underutilized species,
- (ii) More research should be done on underexploited species, including on medicinal plants and indigenous vegetables, and farmers should be supported by the National PGRFA Program to be able to conserve these species in their fields,
- (iii) A strategy has to be set-up which will enable the informal and formal seed system to cooperate and produce improved seed varieties at affordable prices, for instance with the formal seed system providing seed for multiplication and dissemination by the informal sector,
- (iv) Initiate a training system in seed production, also involving research institutions, to improve farmers' ability to produce quality seeds.

Chapter 3: The state of *ex-situ* conservation

3.1 *Ex-situ* collections in Rwanda

Rwanda Agriculture Board (RAB) is holding the National Genebank in Rwanda. As the National Genebank, located in Huye (Southern Province), is not fully operational, most of the *ex situ* collections are currently maintained through RAB's 14 crop-based programs. RAB is therefore responsible for most of the *ex situ* collections held at the genebanks, field stations, experimental/regeneration sites, herbariums and botanical gardens in the country. There are in total 1787 accessions in storage through these programmes, but the number of accessions that are actively stored in the key programmes is 814. Their location is outlined in table 4. RAB maintains these collections for research, multiplication and dissemination within projects. Targeted and planned collections are being conducted in many rural areas of the country. In terms of species collection, more efforts have been concentrated on cultivated species, but RAB also maintains an arboretum where forest indigenous and exotic species are maintained. In the field of agrostology, RAB is also maintaining a good collection of fodder plants (at least 14 species) in two stations: Karama and Rubona.

In addition to the collections maintained by RAB, germplasm is also conserved by other national stakeholders,. As an example the "Institut de la Recherche Scientifique et Technologique (IRST) is conserving one threatened species namely the finger potato, *Plectranthus esculentus* (Impombo).

Table 4: Number of accessions in active *ex situ* collections through RAB Programmes

Collection	Station/location	No. Accessions
RAB/BANANA PROGRAM	Rubona station, Southern zone	108
RAB/BEANS PROGRAM	Rubona station, (Southern Zone) Kinigi Station (Nothern Zone) and Ngoma and Nyagatare station (Eastern Zone)	208
RAB/CASSAVA PROGRAM	Rubona station, Southern zone Karama station, Eastern zone	184
RAB/COFFEE PROGRAM	Rubona station, Southern zone Karama station, Eastern zone	183
RAB/IRISH POTATO PROGRAM	Musanze station, Northern Zone	29
RAB/RICE PROGRAM	Rubona station, Southern zone	21
RAB/WHEAT PROGRAM	Musanze station, Northern Zone	81
TOTAL		814

In addition to these, the Programmes in Agroforestry, Horticulture, Sorghum, Sweet Potato and Soybeans also have stored accessions *ex situ*, which will be re-located to the National Genebank of Rwanda once this is operational.

3.2 Rwandan germplasm in *ex-situ* collections abroad

Though it is difficult to calculate the exact number of accessions that has been collected in Rwanda and are conserved abroad, Rwanda has been partaking in international cooperation and networks of germplasm exchange. As examples, there has been collaboration between the RAB Bean Program and the International Center for Tropical Agriculture (CIAT)-Columbia, the RAB Irish Potato and Sweet potato Program with the International Potato Center (CIP)-Peru, and the RAB Maize and Wheat Program and the International Maize and Wheat Improvement Center (CIMMYT) Mexico. The partnership is mainly based on germplasm exchange. There are therefore a number of accessions collected in Rwanda and stored at genebank facilities abroad. Totally 1040 accessions from 29 different species have been identified, and a complete table of these accessions can be found in Annex 3.

3.3 Needs and priorities for sustaining *ex situ* collections

Needs:

There are a number of constraints in sustaining *ex situ* collections in Rwanda, and the following reflect the urgent needs:

- (i) Secure funding for operation of the genebank facilities, especially the National Genebank, is needed,
- (ii) There are an urgent need for more skilled staff in the PGRFA sector, including in managing the germplasm collections,
- (iii) More equipment is needed in the storage facilities, and the facilities needs to be strengthened with mechanisms for addressing the irregular electrical supply and natural disasters (including flood, pest and diseases).
- (iv) More knowledge about the existing genetic diversity is needed, including characters' variability and their patterns of distribution,
- (v) The collaboration between scientists and policy makers at national, regional and international levels needs to be strengthened, and arrangements should be made for maintenance and duplication of samples with other genebank facilities,

Key priorities:

The following key priorities have been identified to strengthen the *ex situ* conservation of germplasm in Rwanda:

- (i). Ensure that the National Genebank gets fully operational,
- (ii). Strengthen the existing field genebanks, including building the capacity of staff,
- (iii). Support activities to strengthen the coordination and cooperation between stakeholders at national level,
- (iv). Support activities to collect, characterize and evaluate species and crop varieties, including from underutilized species and crop wild relatives (CWR),
- (v). Establish community genebanks and strengthen local communities ability to collect their material and document knowledge,

Chapter 4: The state of use

4.1 Germplasm distribution and use

Over the last decade intense efforts have been carried out to develop new varieties for priority crops particularly beans, cassava, maize and rice. Several new varieties have been developed and released, and figure 7 shows a large increase in the number of varieties released in the last decade, compared to before 2001. Research and extension services have been strengthened to carry out strong campaigns to ensure that these improved varieties are disseminated to the end users.

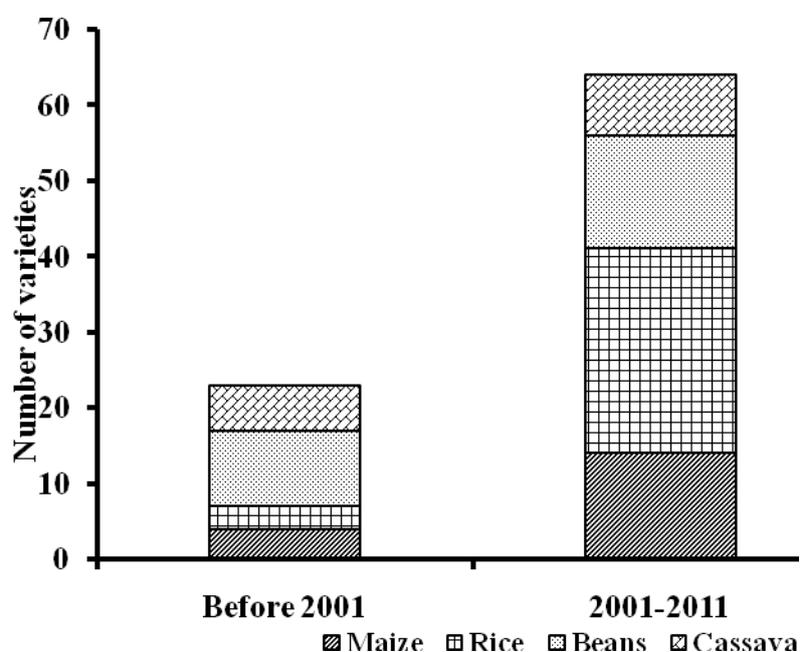


Figure 8: Comparison of Number of varieties released before 2001 to number of varieties released in the last decade (2001-2010) for four major crops

4.2 Plant breeding capacity

Plant breeders in Rwanda continue to rely on diverse plant genetic resources to facilitate the improvement of crop qualities, and research is being carried out on various crops to develop new adaptable breeds with improved qualities.

Variety development research has targeted several constraints including low yields, biotic and abiotic stress and nutrient content, but the most desirable characters for plant breeding in Rwanda are: Earliness (early maturing), resistance/tolerance to biotic and/or abiotic stresses, and superior nutritional quality, combined with productivity. Focus has been mainly put to priority crops namely maize, rice, wheat, Irish potato, beans, cassava and banana. For vegetatively propagated crops, crop improvement activities are carried for some fruits species and export crops such as apple banana, coffee, pineapple, passion fruit and tree tomato. The table below shows the number of improved varieties and breeding lines that have been tested for adaptability both on station and on-farm.

Table 5: Number of varieties and breeding lines for crop, fruit and vegetable species in Rwanda

Crop	Number of improved varieties and breeding lines
Beans	1016
Maize	854
Irish potato	12
Sweet potato	152
Cassava	83
Sorghum	160
Banana	110
Soybean	53
Wheat	53
Coffee	184
Avocado	34
Mango	10
Passion fruit	3
Apple	2
Pineapple	2
Tamarillo	2
Water melon	3
Orange	5
Lemon	2
Amaranths	58
Ethiopian mustard	9
Nightshade	14
African eggplant	3
Pumpkin	6
Cowpea	13
Tomato	31
Okra	3

Rwanda Agriculture Board is the key stakeholder involved in research activities related to plant breeding, and has in the last years has disseminated 21 varieties of beans, 7 varieties of soya beans, 1 variety of garden peas, 3 varieties of groundnuts, 6 varieties of maize, 14 varieties of sorghum, 11 varieties of wheat, 9 varieties of sweet potatoes, 6 varieties of cassava, 9 varieties of Irish potatoes, 6 varieties of coffee trees, 4 varieties of pyrethrum and 8 varieties of avocado trees. RAB (former ISAR) has also disseminated various varieties of citrus fruits, papaya trees, pineapples, apple-trees, guava trees and orange trees, several exotic and native forestry and agro-forestry species for different ecological zones and purposes in two last years. In 2011, the maize research program at RAB released 10 varieties for mid-altitudes and one for highlands, emphasis was given to development of mid altitude varieties because of the rapid expansion of crop production in these areas. These varieties included the first Quality Protein Maize (QPM) variety released in Rwanda (ISARM081) and a second variety Kigega (ZM607) which has become very popular and provides more than 60% of the national maize grain production because of its resistance to foliar diseases and high yield potential. In the case of cassava, eight new resistant varieties were released in 2009 in response to an outbreak of Cassava Mosaic Disease (CMD) which was significantly affecting cassava production. The adoption of these varieties by farmers has greatly revitalised cassava production in the country. Rice variety development efforts in Rwanda have focused on low temperature and moisture/stress tolerance for increased productivity. 15 new high yielding climbing, bush and snap varieties, developed by scientists from RAB (formerly ISAR) were released in January 2010 and have been widely adopted by farmers. The drought tolerant climbing bean varieties (MAC 49, MAC 9 and MAC 44) are the first cases of climbing beans adapted to dry mid-altitudes being developed in the world. These are expected to have a large potential to improve food security and nutrition and increase incomes for rural households.

As far as human capacity in plant breeding is concerned, an important achievement has been made from 1996. More employees in the country have been trained at MSc level and some are currently in training at PhD level, the majority of them being from RAB. This is a good starting point that can lead Rwanda in the developments of new varieties that are tolerant/resistant to biotic and abiotic stresses which keep changing. Other stakeholders involved in PGRFA Programme in the country focus more on the PGRFA rather than germplasm development. Other changes from 1996 that are worth mentioning include: (1) identification, collection and conservation of traditional PGRFA including finger millets, sorghum, beans as well as some indigenous vegetables (pumpkin, nightshade, spider plant,

egg plants, to just list few of them), (2) recently built genebank and its equipment which will supplement the field genebank, (3) some efforts are being made by RAB to harmonize the PGRFA management across different institutions, with the target of having all the genetic resources related activities fall under a National Genebank, (4) some regulations, namely National Seed Policy (2007) and Rwanda Biodiversity Policy (2011) have been put in place.

4.3. Needs and priorities to improve the use of PGRFA

Needs:

- (i) There is a need to strengthen the national capacities in plant breeding and variety development,
- (ii) There is an urgent need to put in place policies, strategies and protective legislation, for variety development,
- (iii) Partnership between research institutions, universities at national, regional and international levels needs to be improved,
- (iv) A stronger private sector-based seed value chain should be build to stimulate plant breeding in the country,
- (v) The existing agricultural extension system needs to be strengthened,
- (vi) More knowledge about how pre-breeding, base broadening and farmer breeding can contribute to better diversification and use of the germplasm is needed.

Priorities:

- (i) Train more research staff in plant breeding and crop improvement,
- (ii) Elaborate policies on variety development and use,
- (iii) Create a local research network linking partners that are involved in variety development,
- (iv) Create an enabling environment for private investment in national seed industry,
- (v) Training agricultural extension officers on efficient use and conservation of crop varieties.

Chapter 5: The state of the National PGRFA Programme and related legislation

5.1 The National PGRFA Programme and key stakeholders

The National PGRFA Programme in Rwanda was established in 2003 and has since then been coordinated by Rwanda Agriculture Board (RAB) (previously called Institut des Sciences Agronomiques du Rwanda (ISAR)). However, many of the core activities under the programme started in 2007, after key personnel had been trained. The main objective of National PGRFA Program is to conserve and *promote sustainable use of plant genetic resources within the country, especially those which are important for agriculture and food security*. The activities under the program are mainly focused on the conservation and sustainable use of PGRFA, including seed collection, characterization, multiplication, regeneration, evaluation, documentation and genebank management. The National PGRFA Program also operates as a centre for research and training.

The key stakeholders involved in the National PGRFA Programme are Rwanda Agriculture Board (RAB), academic institutions including National University of Rwanda (NUR) and the Higher Institute of Agriculture and Husbandry (ISAE), the Institute for Scientific and Technological Research (IRST), and Kigali Institute for Science, Technology and Management (KIST), as well as the major farmers' federations in Rwanda.

Rwanda Agriculture Board (RAB)

Rwanda Agriculture Board (RAB) was established in 2011, merging three former authorities under the Ministry of Agriculture and Animal Resources (MINAGRI), namely the Institut des Sciences Agronomiques du Rwanda (ISAR), Rwanda Agriculture Development Authority (RADA) and Rwanda Animal Resources Development Authority (RARDA). RAB's mission is *developing agriculture and animal husbandry through their reform and using modern methods in crop and animal production, research, agricultural extension, education and training of farmers in new technologies*.

RAB has fourteen Programs, located at twelve different research and experimental stations across the four agricultural zones in the country: Southern, Northern, Eastern and Western. The research stations cover a total area of 4,664 ha of experimental fields, and each station

focuses the research on specific crops grown in those regions. In addition to research and conservation of material (see Chapter 3), the programs provide farmers and NGO's involved in agricultural sector with seeds and planting material, and train them on seed production, processing and drying, packing and marketing of their products.

Some of the current priorities for RAB's research programmes, are to introduce improved genetic material and transfer appropriate technologies for a variety of traits, including root disease control in beans, production of vitamin A- and iron-rich crops, production of high quality fodder and pastures, high yielding and disease resistant/tolerant varieties of cassava, nutritionally superior sweet potato (orange and yellow fleshed varieties) and quality protein varieties of maize. Moreover, RAB continuously contributes to work on the improvement and management of soil fertility through transfer of technologies for production of diversified species of trees to counter the shortage of mulching material and firewood, prevent erosion and improve soil fertility. Other future priorities consist of the improvement of crops and stockbreeding by reducing the constraints facing the agricultural sector (see chapter 1). Efforts will include strengthening of the national research system, controlling genetic manipulation, introduce *in vitro* techniques and biotechnology. RAB will therefore need to strengthen the collaboration with international agricultural and technological research institutes, Universities, NGOs and MINAGRI's agricultural programmes.

National University of Rwanda (NUR)

Established in 1963, the National University of Rwanda (NUR) has the mandate to *provide higher education, conduct research, and offer services to the community*. It is located in the Southern Province, 150 km south of the capital city of Kigali. With regard to the conservation and rational use of biological diversity, the Faculty of Agriculture at the NUR provides high level training to forthcoming professional Agriculturists, and offer undergraduate programmes for instance in crop science. The role of NUR in the preservation of biological resources includes training of students and senior staff and creates awareness of issues related to management of biodiversity and assist in developing a collective responsibility and commitment towards resources management. NUR also contributes to strengthening the role of scientists and researchers in natural science, conservation and sustainable use of biological diversity.

Institute for Scientific and Technological Research (IRST)

The Institute for Scientific and Technological Research (IRST) was established in 1989, replacing the National Institute for Scientific Research (INRS). Its mission is to *carry out scientific and technological research related activities in direct relationship with the country's socio-economic development*. It is involved in environmental protection and conservation and contains a Research Centre involved in research and conservation of useful herbs in the Herbarium. Moreover, ISRT has a *Pharmacopeae* and Traditional Medicine Centre (CURPHAMETRA) which is responsible for the development of medicinal plants. It manufactures curative plant-based drugs such as ointments, tablets, disinfectants and syrups from local plants that are also used by the local population in their traditional medicine (Rwangabo, 1993). These efforts are important with regards to *in situ* and on-farm management of local plant diversity.

Kigali Institute for Science, Technology and Management (KIST)

The mission of the Kigali Institute for Science, Technology and Management is to *train senior technicians in the field of science, technology and management*. The faculty of technology has numerous researchers in the field of environmental science.

Higher Institute of Agriculture and Animal Husbandry (ISAE)

ISAE has been established in 1989 and its role of ISAE is to train technicians and professionals in different agricultural fields at advanced diploma and bachelor's levels. Through its departments of Crop Production and Forestry and Nature Conservation, ISAE scientists run research programs on crop improvement and forestry management. Regarding Crop Improvement, ISAE conducts breeding activities for climbing bean, potato, rice, apples, grapes and tree tomato. They have in their germplasm collection about 9 climbing bean varieties, 6 potato varieties, 11 rice varieties, 2 apple and grape varieties used as parental lines in breeding programs. The tree tomato planting material is multiplied using tissue culture methods.

Regarding forestry and agroforestry programs, a tree nursery has been established to produce different forestry and agroforestry species for afforestation and collection park and some grass and legumes species for livestock are maintained in the field as germplasm collection.

Rwanda Farmers Federation (IMBARAGA)

Rwanda Farmers Federation-Imbaraga has been founded in 1992 with the mission of organizing and coordinating Rwandan farmers' activities and strengthening their productive capacity for agricultural development. Its interventions cover the whole country and its responsibilities are:

- To advocate for farmers rights and place in the area of Economic Development,
 - To deliver to farmers necessary agricultural advisory services, including technical trainings, technical support and/or financial assistance,
 - To assist farmers on agribusiness activities, including in seed production, inputs sales, food storage, processing and sales,
 - To develop partnership with different development partners in Agricultural Sector,
 - To disseminate varieties among farmers for food and agriculture purpose through seed production and marketing and working closely with Rwanda Agricultural Board (RAB) in participatory breeding programs and on-farm variety development trials.
- The major crops targeted by the Federation are maize, bean, cassava, Irish potato, rice, banana, pineapple and passion fruit. Regarding germplasm conservation, the Federation took the initiative of collecting and maintaining about 17 different varieties of local indigenous vegetables that are more nutritious than exotic ones and this initiative has been supported by RAB.

Syndicat INGABO

Syndicat Ingabo is an association of farmers' cooperatives operating in Southern Province of Rwanda and has been also created in 1992. The association assists farmers involved in cassava, maize, coffee, soybean and pineapple value chains. The agricultural advisory services are provided to farmers in collaboration with RAB to increase crop production, seed production for seed producers and adding value for agro-processors.

The association also trains farmers in cooperative organization and management and links producers to markets.

Syndicat INGABO has a good experience in cassava and maize participatory variety selection and dissemination in Southern Province in collaboration with RAB research programs.

Cooperative des Agriculteurs de Mais dans la region des Volcans (COAMV)

COAMV Cooperative is based at Gahunga, Burera District in Northern Province of Rwanda. It has been created in 2002 to promote the maize value chain in northern volcanic regions of Rwanda. The cooperative provides farmers with technical assistance to increase maize production and owns a maize mill to process maize flour for the local and regional markets.

The cooperative works with RAB in participatory variety selection for maize, bean and potato crops and helps in variety dissemination. It is also certified and has facilities to produce and conserve maize, bean and potato seed for farmers. The seed production is supported through training and assisting seed producers in seed production techniques and seed quality control.

5.2 International conventions and legislation related to PGRFA

Various conventions relevant to conservation and sustainable use of PGRFA have been signed by Rwanda, including the RAMSAR convention (Convention on Wetlands) in 1971, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1973, the United Nations framework Convention on Climate Change (UNFCCC) in 1992 and the Cartagena protocol in 2000. Rwanda also ratified the Convention on Biological Diversity (CBD) in March 1995 and became party to the convention in May 1996. Subsequent to the ratification of the convention, Rwanda has developed its first National Strategy and Action Plan for the Conservation of Biodiversity (2003) and has submitted four national reports to the convention. A National Seed Policy and a National Forest Policy is also in place, and the Ministry of Lands, Resettlement and Environment has furthermore developed a *Rwanda Biodiversity Atlas Information System*.

Specifically related to plant genetic resources, Rwanda became contracting party to the International Treaty on Plant Genetic Resources for Food and Agriculture (International Treaty) in October, 2010. Rwanda also signed the Nagoya protocol in February 2011, as the first Sub-Saharan country. Both these developments are expected to facilitate the conservation and sustainable use of plant genetic resources, and through this contribute to food security. There are currently no legal regulations specifically relative to PGRFA in Rwanda, but the Government has requested assistance to develop a National PGRFA Strategy to further facilitate the conservation and management of PGRFA.

The National Focal Point for the International Treaty and the Nagoya protocol is associated with RAB. Additionally, a taskforce containing several stakeholder institutions has been put in place to oversee the implementation of these two instruments. This task force consists of scientists with backgrounds in genetic resources management as well as legal specialists.

5.3 Needs and priorities with regards to the National PGRFA Programme

Needs:

- (i) The taskforce overseeing the implementation of the International Treaty and the Nagoya protocol needs to be strengthened in order to carry out its mission,
- (ii) Mechanisms to support the National PGRFA Programme should be put in place, for instance including a National PGRFA Strategy,
- (iii) The Linkages between local research institutions and universities need to be Set for the efficient implementation of PGRFA Programme,
- (iv) Partnership with regional and international research institutions needs to be strengthened for financial support and expertise exchange.

Key Priorities:

- (i) A National PGRFA Strategy should be developed and implemented,
- (ii) Financial support and staff should be provided to support the National PGRFA Programme,
- (iii) A Steering Committee overseeing the implementation of the National PGRFA Programme activities should be put in place,
- (iv) An operational local research network should be established, and collaboration with regional international research institutions enhanced.

Chapter 6: The state of Regional and International collaboration

6.1 Regional and international collaboration

Overall, there has been an increase in international activities since the last country report was written, and participation in regional programmes activities under the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA) has particularly benefited the research programmes in the country as Rwanda is founding member of the organisation. The ASARECA programmes were created before the last report and are about 7: Staple Crops, High Value Non-staple Crops, Livestock and Fisheries, Agro-Biodiversity and Biotechnology, Natural Resources Management and Biodiversity, Policy Analysis and Advocacy and Knowledge Management and Up-scaling programmes. The partnership is particularly involving germplasm exchange, sharing of experiences and success stories, capacity building (human and infrastructures) and research funding. Many joint studies with regard to socio-economic analysis (for beneficiaries and/or crop commodities), seed systems, value chains, agronomic and breeding trials have been conducted. The ASARECA supports local research institutions (RAB and Universities), Private Companies and Farmers' Associations.

Partly due to the adoption of the Crop Intensification Program, Rwanda's partnership with the Consultative Group on International Agricultural Research (CGIAR) centers such as CIP, CIAT and CIMMYT through ASARECA has also improved.

6.2. Needs and priorities for increasing the regional and international collaboration

Needs:

- (i). Staffing and the capacity of staff working with PGRFA management in the country is a challenge and needs to be addressed through recruitment and training,
- (ii). The National genebank needs to be made fully functional, in order to efficiently collaborate with regional and international institutions,
- (iii). The Multilateral System (MLS) for access and benefit sharing needs to be established and applied,
- (iv). There is a need to build on regional and international collaboration and networks, to more efficiently share knowledge, experience, technologies and germplasm, including among researchers, policy makers, extension officers and farmers,
- (v). A strong national, regional and international seed commercialization channel should be promoted, for instance through national and regional seed selling points.

Key priorities:

- (i). Intensify recruitment and training of staff for the national PGRFA programme,
- (ii). Equip the National Genebank with adequate and sufficient facilities for PGR collection, evaluation and conservation,
- (iii). Linking the National Genebank to other regional and international Genebanks for germplasm and information sharing using existing information technologies,
- (iv). Enhance the partnerships with existing and new regional and international agricultural research institutions for knowledge sharing, germplasm exchange and staff training,
- (v). Support technically actors of seed industry (value chain) and improve local and regional seed market linkages.

Chapter 7: Access to PGRFA, sharing of benefits and Farmers Rights

7.1 The state of access to PGRFA

Access and benefit-sharing (ABS) is a key element of both the CBD and the International Treaty. In a world where countries are dependent on each other for PGRFA to sustain food production and meet the increasing challenges of disease and climate change, Rwanda wish to both be able to contribute to and benefit from the opportunities that lies in shared access to these resources.

For a long time Rwanda has been a beneficiary of the activities of Bioversity International, other CGIAR centers and the International Food Policy Research Institute (IFPRI), and the access to PGRFA has improved greatly in the country. Today, Rwanda is receiving germplasm accessions used for research and breeding purposes from a number of institutions abroad. The CGIAR centers, including International Maize and Wheat Improvement Center (CIMMYT), International Rice Research Institute (IRRI), International Center for Tropical Agriculture (CIAT), World Agroforestry Centre (known as the International Centre for Research in Agroforestry, ICRAF before 2002), Center for International Forestry Research (CIFOR), International Potato Center (CIP), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Institute of Tropical Agriculture (IITA) , and International Livestock Research Institute (ILRI) have all been actively involved in training and exchange of germplasm through international nurseries and regional networks. This includes wheat and maize from CIMMYT, sweet potato from CIP, rice from IRRI and sorghum from ICRISAT. Currently there is no well planned system of tracking the number of germplasm introduced in Rwanda or exchanged with other partners and this is the area where emphasize should put it on. All accessions are obtained responding to priorities of Rwandan government. New varieties have been released based on materials received from these centers particularly of maize, beans, sorghum, wheat and rice. Many other materials have been used in breeding programmes as sources of genes or as reference varieties. Since the last County Report (1995), Rwanda has not developed any national policy or legislation to ensure appropriate access and benefit-sharing related to the conservation and use of plant genetic resources in the country. However, with the implementation of the National PGRFA

Programme and development of national conservation facilities, the collection of germplasm is becoming a country-driven process based on national priorities.

Even though many PGR were received from CGIAR centers, Rwanda has got in the past various genetic material from foreign countries through bilateral cooperation and assistance. Some rice varieties like zong ngeng, yun yin and yun keng were from People's Republic of China, Taiwan and North Korea. The Belgian Colonial Power and the Catholic Church of Rwanda introduced export crops varieties like coffee and tea and many horticultural and vegetable crops such as orange, lemon, tree tomato, mango, spinach, cabbage, eggplants, carrot, onion and others.

Except from with the CGIAR centers, Rwanda has not undertaken any action to enhance the access to other genetic material located outside the country. Therefore, the access to PGRFA is generally unsatisfactory and should be increased. There is a plan to put the materials in the genebanks under the MLS.

7.2 Fair and equitable sharing of the benefits of PGRFA

Breeding of new varieties are currently under Rwanda Agriculture Board mandate, hence varieties developed are first benefited by Rwandan farmers and those varieties can be shared by other research institution or CGIAR centers. Crop varieties introduced or developed by RAB are distributed to farmers through partnerships with non-governmental and governmental development projects, and farmers' associations working in rural areas. The agricultural extension services helped in training farmers on how to grow those crop varieties by the application of improved cultivation techniques to increase yields and consequently crop production.

With regards to Farmer's Rights, as specified in Article 9 in the International Treaty, governments are to support farmers in maintaining and developing crop genetic resources and recognizing and rewarding them for the contribution to the global pool of genetic resources. Measures may include the protection of traditional knowledge, equitable benefit sharing, participation in decision-making, and the right to save, use, exchange and sell farm-saved seeds and propagating material. With regards to Farmer's Rights in Rwanda, there are plans to put in place strategies to implement Farmer's Rights.

7.3. Needs and priorities for increasing the access and benefit sharing

Needs:

- (i) There is a need to build the capacity to develop, implement and enforce domestic legislative, administrative or policy measures on access and benefit-sharing, thereby contributing to the conservation of biological diversity and sustainable use of its components are needed, including through:
 - Identification of relevant actors and existing legal and institutional expertise for the implementation of the Nagoya Protocol;
 - Taking stock of domestic measures relevant to ABS in light of the obligations of the Nagoya Protocol; Development and/or amendment of access and benefit-sharing legislative, administrative or policy measures with a view to implementing their obligations under the Nagoya Protocol;
 - Establishment of ways to address trans boundary issues;
 - Establishment of institutional arrangements and administrative systems to provide access to genetic resources, ensure benefit-sharing, support compliance with prior informed consent and mutually agreed terms and monitor the utilization of genetic resources and traditional knowledge associated with genetic resources, including support for the establishment of check points.
- (ii) Building the capacity of Parties to negotiate mutually agreed terms to promote equity and fairness in negotiations in the development and implementation of access and benefit-sharing agreements, including through enhanced understanding of business models and intellectual property rights,
- (iii) Building the capacity of Parties to develop their endogenous research capabilities to add value to their own genetic resources and traditional knowledge associated with genetic resources through, inter alia, technology transfer; bio prospecting and associated research and taxonomic studies; and the development and use of valuation methods,
- (iv) Addressing the capacity needs and priorities of indigenous and local communities and relevant stakeholders; in particular, projects that would:
 - Encourage their participation in legal, policy and decision-making processes; and
 - Assist in building their capacity related to genetic resources and traditional knowledge associated with genetic resources, such as through the development of

community protocols, model contractual clauses and minimum requirements for mutually agreed terms to secure the fair and equitable sharing of benefits.

- (v) There is a need to raise awareness of the importance of genetic resources and traditional knowledge associated with genetic resources, and related access and benefit-sharing issues, notably through the development and implementation of national and regional awareness-raising strategies,
- (vi) Since the plant genetic resources in the country are scattered in different stations, institutions and farmers' homes, there is a need to have duplicates within the National Genebank for conservation and easy access,
- (vii) At regional and international levels, some local PGR stored in CGIAR genebanks have not duplicates available in the country, there is a need to create duplicates and make exchange,
- (viii) Some local research institutions such as universities do not have framework to access PGR for research purposes. There is a need to establish a formal framework to access germplasm from local, regional or international genebanks,
- (ix) Farmers need assistance for the management of traditional and landrace varieties at their disposal and this will enable exchange with research institutions,
- (x) There is a need for strong collaboration with the Management of Parks and Natural Reserves to preserve and use of CWR for food and agricultural research purposes.

Key priorities:

- (i) Do a National inventory of PGR in Rwanda, and collect samples to keep in the National Genebank,
- (ii) Link with regional and international genebanks, exchange material,
- (iii) Set up a collaboration framework to give local research institutions and universities access to national and international germplasm for research purposes,
- (iv) Train and assist farmers in use and conservation of PGRFA locally,
- (v) Set up a collaboration framework between National Genebank and the Management of Parks and Natural Reserves for the conservation and use of CWRs in agricultural research.

Chapter 8: Contribution of PGRFA management to food security and sustainable development

Sustainable agriculture refers to the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the natural resource base and avoiding environmental degradation (Cohen *et al.*, 1991). It stresses greater efficiency of resource use and a balance with prevalent environment to achieve sustainability. It aims at the optimum use of our total resource base so that the maximum possible production could be harnessed without jeopardizing the long-term capacity of the valuable resources.

8.1 Contribution of PGRFA to agricultural sustainability

At the core of sustainable agriculture is conservation and utilization of plant genetic resources for food and agriculture (PGRFA), ensuring that farmers have access to a genetically diverse portfolio, suited to a range of agro-ecosystems and farming practices, and resilient to climate change. With a reservoir of alternative traits and characteristics, PGRFA can allow us to diversify crops, foods and farming methods, and provide material for targeted plant breeding. This would contribute positively to agricultural sustainability, food security and economic development. In Rwanda, PGRFA materials contributed a lot to the development of a wide range of crop varieties from the high yielding, disease-resistant, drought-resistant and market quality varieties. These crop varieties developed are from different species such as maize, bean, rice, soybean, cassava, Irish potato, sweet potato, banana and vegetables. They enabled diversification in agriculture and mitigated major disease outbreaks and climate change effects and so making agriculture more sustainable.

8.2 Contribution of PGRFA to food security, economic development and poverty alleviation

PGRFA comprises the diversity of genetic material contained in traditional varieties, modern cultivars, crop wild relatives and other wild species. It is this genetic diversity that provides farmers and plant breeders with options to develop, through selection and breeding, new, unique and more productive crops, that are resistant to virulent pests and diseases and adapted to changing ecological conditions – which are essential for ensuring food security. In

Rwanda, the most important contribution to food security has been through the Crop Intensification Programme. In the CIP implementation, different crop varieties developed from PGRFA materials enabled the achievement of food security and diversification in recent years. Yields and productions of staple crops like maize, bean, cassava, wheat, irish potato and rice showed tremendous increases which made positive impact on living conditions of the population. Beside the increase of the number of rural households that became food secure, farmers obtained enough crop products to sell on the local and regional markets and increased their incomes consequently poverty has been significantly reduced especially in rural areas with significant positive impact on economic development (NISR, 2012).

To augment increase in productivity of these crops, CIP imported improved seeds from the neighboring countries such as Kenya and Tanzania in the region. In 2008, 765 tons of seeds of maize and wheat were imported for cultivation in season A. The amount gradually increased from 1200 t in 2009A to 3512 t in 2011 A. In addition, improved planting materials (cuttings) of cassava and potato were also distributed to farmers.

Table 6: Distribution of improved seed (in tons) and planting materials (Units) under CIP

Crop	2008A	2009A	2009B	2010A	Total
Maize	520	893	179.58	1,417	3,009.58
Wheat	60	327	300.85	181	687.85
Cassava	42,932,600	95,987,000	0	0	138,919,600
Beans	0	32	28	0	60
Potato	400	0	0	0	400

Under CIP, the use of improved seeds by farmers has risen from 3% to 40%. By encouraging farmers to use improved seeds, CIP have substantially increased the local demand and the capacity for seed production. With the exception of hybrid seeds, the open pollinated varieties of maize and self pollinated varieties of wheat, rice and beans are multiplied by public (RAB) and entrepreneurial farmers in the country (Kathiresan, 2011).

Agriculture represents the major share of GDP (31 %) and provides livelihood more than 80 % of population living in rural areas (MINAGRI, 2011). Since vast majority of the population depends on agriculture for their livelihood. Plant genetic resources in Rwanda are the driving

force to alleviate the poverty. For instance, PGRFA constitute 84 % of agriculture GDP, or approximately 30 percent of the overall GDP.

8.3 Needs and priorities for improving the contribution of PGRFA to food security and sustainable development

PGR are a strategic resource and lie at the heart of sustainable agriculture. The link between genetic diversity and sustainability has two main dimensions: firstly the deployment of different crops and varieties and the use of genetically heterogeneous varieties and populations can be adopted as a mechanism to reduce risk and increase overall production stability; and secondly, genetic diversity is the basis for breeding new crop varieties to meet a variety of challenges.

Needs:

- (i) Even though agriculture is considered as the backbone of the national economy, much efforts are needed to increase its budget support and funding of agricultural research for development in particular,
- (ii) Agricultural research capacities in terms of human resources and infrastructures are still insufficient, there is a need to continue their improvement and development,
- (iii) There is a need to build a competitive national seed industry and strengthening the agricultural extension services and their collaboration with agricultural research institutions.

Priorities:

- (i) Increase budget and support to agricultural sector and agricultural research in particular,
- (ii) Provide the agricultural research with sufficient and skilled staff, and with adequate facilities for the management and optimum use of PGRFA,
- (iii) Set up an enabling environment for private sector investment in seed industry,
- (iv) Set up and strengthen linkages between agricultural research, extension services and farmers for optimum adoption and use of improved varieties-based innovations.

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Annex 1: Crop Production in Rwanda, Annual Total (Tones)

	2005	2006	2007	2008	2009	2010	2011
Total Crops	7,290,502	7,178,575	7,074,813	8,234,188	9,254,763	10,139,259	11,212,264
Cereals	409,358	363,466	352,057	461,163	615,059	738,080	848,658
Sorghum	227,972	187,380	164,406	144,418	174,553	161,229	151,754
Maize	97,251	96,662	101,659	166,853	286,946	432,404	525,679
Wheat	21,942	18,978	24,195	67,869	72,479	77,193	90,684
Paddy	62,193	60,446	61,797	82,025	81,081	67,253	80,541
Pulses	252,303	352,166	402,346	392,305	431,139	436,954	421,257
Beans	199,648	296,724	328,811	308,563	327,728	327,497	331,166
Groundnuts	15,105	9,020	9,921	11,122	15,353	14,369	14,756
Soybeans	16,335	28,779	44,163	50,931	54,203	57,089	37,426
Peas	21,195	17,643	19,450	21,689	33,855	37,999	37,909
Roots & Tubers	3,118,050	2,946,900	2,738,133	3,815,126	4,264,961	5,192,652	5,783,263
Irish Potatoes	1,314,051	1,275,586	967,283	1,161,943	1,289,623	1,789,404	2,171,517
Sweetpotatoes	885,467	776,640	841,079	826,440	803,228	840,072	845,099
Taro	136,894	129,275	150,356	144,919	152,369	185,964	187,248
Cassava	781,637	765,199	779,414	1,681,823	2,019,741	2,377,213	2,579,399
Bananas	2,593,083	2,658,232	2,686,198	2,603,949	2,993,482	2,749,152	3,036,273
Vegetables & Fruits	917,709	858,010	896,080	961,643	950,122	1,022,421	1,122,814

Source: MINAGRI, 2012

Annex 2: Germplasm collected and stored in Rwanda

Crops	Species	Germplasm Type	Number of Varieties	Location	Source
CEREALS	-Rice	-Seed	21	RAB	Introduction
	-Maize	-seed	456	RAB	Introduction
	-Wheat	-seed	81	RAB	Introduction
	-Sorghum	-seed	34	RAB	Introduction
	-Millet	-seed	3	FARMS	Local
LEGUMES	-Beans	-seed	208	RAB	Introduction
	-Peas	-seed	4	RAB/FARMS	Introduction
	-Cajanus	-seed	2	FARMS	Local
	-Lentille	-seed	2	FARMS	Local
ROOTS AND TUBERS	-Irish potato	-Field, <i>in vitro</i>	29	RAB	Introduction
	-Sweet potato	-Field, <i>in vitro</i>	257	RAB/FARMS	Introduction
	-Cassava	-Field		RAB/FARMS	
	-Colocase	-Field	184	FARMS	Introduction
	-Yam	-Field	2	FARMS	Local
	-Dioscora		2	FARMS/IRST	Local
	-Finger potato		2		Local
OIL SEEDS	-Soyabean	-seed	51	RAB	Introduction
	-Arachide	-seed	2	FARMS/RAB	Local
	-Tournesol	-seed	2	FARMS	Local
HORTICULTURES	-Fruits	Seeds, field, <i>in vitro</i>	7	RAB	Introduction Introduction
	-Vegetables	Seeds, field	4	RAB/FARMS	Introduction/
	-Flowers and ornamental trees	Seeds, field	23	RAB/FARMS	Local
CASH CROPS	-Tea	Field	34	RAB	Introduction
	-Coffee	Field	183	RAB	Introduction

	-Pyrethrum - <i>Morus alba</i> -Tobacco	Field, <i>in vitro</i> Field Field	3 12 3	RAB/SOPYRW A RAB FARMS	Introduction Introduction Local
FORAGE	Pulses & cereals	Field, seeds Field, seeds		RAB RAB	Introduction Introduction
FIBERS	Sisal Papyrus	Field Field	1 1	Farms Farms	Local Local
TREE AND WOOD	Agroforestry	Seeds, field		RAB/FARMS	Introduction Local
SUGAR	Sugar cane	Field	1	FARMS KABUYE	Local/introdu ction
MEDICINAL PLANTS	Tree and plants	Field		IRST/FARMS	Local, introduction

Annex 3: Germplasm collected in Rwanda and stored in *ex situ* collections abroad

INSTITUTE / TAXON	ACCESSION NUMBER
National Botanic Garden of Belgium (BEL014)	
<i>Dolichos sericeus</i>	1
<i>Lablab purpureus</i>	1
<i>Macrotyloma africanum</i>	3
<i>Phaseolus coccineus</i>	2
<i>Phaseolus lunatus</i>	1
<i>Phaseolus vulgaris</i>	4
<i>Vigna ambacensis</i>	1
<i>Vigna frutescens</i>	1
<i>Vigna hosei</i>	1
<i>Vigna luteola</i>	3
<i>Vigna oblongifolia</i>	2
<i>Vigna umbellata</i>	1
<i>Vigna vexillata</i>	2
Africa Rice (CIV033)	
<i>Oryza sativa</i>	3
CIAT (COL003)	
<i>Brachiaria brizantha</i>	7
<i>Brachiaria decumbens</i>	18
<i>Brachiaria humidicola</i>	1
<i>Brachiaria jubata</i>	4
<i>Brachiaria platynota</i>	5
<i>Brachiaria ruziziensis</i>	4
<i>Chloris virgata</i>	1
<i>Dunbaria sp.</i>	1
<i>Eragrostis curvula</i>	1
<i>Macrotyloma axillare</i>	1
<i>Neonotonia wightii</i>	2
<i>Panicum maximum</i>	1
<i>Phaseolus coccineus</i>	2
<i>Phaseolus lunatus</i>	1
<i>Phaseolus vulgaris</i>	403
<i>Rhynchosia minima</i>	1
<i>Sesbania sesban</i>	2
<i>Stylosanthes fruticosa</i>	1
AGRITEC (CZE090)	
<i>Phaseolus vulgaris</i>	1
IPK (DEU146)	
<i>Amaranthus cruentus</i>	2
<i>Amaranthus dubius</i>	1
<i>Amaranthus lividus</i>	2
<i>Amaranthus powellii</i>	1
<i>Chenopodium ugandae</i>	1
<i>Physalis peruviana</i>	1

INSTITUTE / TAXON	ACCESSION NUMBER
IPK (DEU159)	
<i>Solanum spegazzinii</i>	1
ILRI-Ethiopia (ETH013)	
<i>Brachiaria bovonei</i>	5
<i>Brachiaria brizantha</i>	10
<i>Brachiaria decumbens</i>	25
<i>Brachiaria humidicola</i>	5
<i>Brachiaria jubata</i>	6
<i>Brachiaria platynota</i>	15
<i>Brachiaria ruziziensis</i>	3
<i>Chloris gayana</i>	3
<i>Digitaria diagonalis</i>	2
<i>Digitaria ternata</i>	1
<i>Hyparrhenia filipendula</i>	1
<i>Hyparrhenia sp.</i>	1
<i>Macrotyloma africanum</i>	2
<i>Macrotyloma axillare</i>	1
<i>Neonotonia wightii</i>	2
<i>Panicum maximum</i>	2
<i>Sesbania macrantha</i>	1
<i>Sesbania sesban</i>	2
<i>Setaria sphacelata</i>	1
<i>Stylosanthes fruticosa</i>	1
<i>Teramnus sp.</i>	1
<i>Trifolium pseudostriatum</i>	2
<i>Trifolium purseglovei</i>	2
<i>Trifolium tembense</i>	1
<i>Trifolium usambarense</i>	3
<i>Zornia setosa</i>	1
RBG (GBR004)	
<i>Chloris gayana</i>	3
<i>Digitaria diagonalis</i>	1
<i>Loudetia kagerensis</i>	1
<i>Macrotyloma africanum</i>	2
<i>Macrotyloma axillare</i>	1
<i>Neonotonia wightii</i>	2
<i>Panicum maximum</i>	2
<i>Sesbania macrantha</i>	1
<i>Setaria sphacelata</i>	1
<i>Trifolium pseudostriatum</i>	2
<i>Trifolium purseglovei</i>	2
<i>Trifolium tembense</i>	1
<i>Trifolium usambarense</i>	3

INSTITUTE / TAXON	ACCESSION NUMBER
ICRISAT (IND002)	
<i>Arachis hypogaea</i>	1
<i>Cajanus cajan</i>	5
<i>Sorghum bicolor</i>	291
IITA (NGA039)	
<i>Glycine max</i>	1
<i>Manihot esculenta</i>	2
<i>Vigna ambacensis</i>	1
<i>Vigna gracilis</i>	1
<i>Vigna hosei</i>	1
<i>Vigna oblongifolia</i>	2
<i>Vigna vexillata</i>	2
CIP (PER001)	
<i>Ipomoea batatas</i>	4
<i>Solanum sp.</i>	2
IRRI (PHL001)	
<i>Oryza sativa</i>	2
PPRI (SVK001)	
<i>Phaseolus vulgaris</i>	1
ICARDA (SYR002)	
<i>Pisum sativum</i>	1
<i>Triticum aestivum</i>	2
USDA-ARS (USA005)	
<i>Tephrosia heckmanniana</i>	1
USDA-ARS (USA016)	
<i>Sorghum bicolor</i>	86
<i>Vigna unguiculata</i>	3
<i>Vigna vexillata</i>	2
<i>Zornia setosa</i>	1
USDA-ARS (USA020)	
<i>Amaranthus cruentus</i>	1
<i>Amaranthus hybridus</i>	1
<i>Amaranthus powellii</i>	1
USDA-ARS (USA022)	
<i>Phaseolus coccineus</i>	2
<i>Phaseolus vulgaris</i>	4
<i>Pisum sativum</i>	1
USDA-ARS (USA029)	
<i>Oryza sativa</i>	2
UCR (USA200)	
<i>Phoenix reclinata</i>	1
USDA-ARS (USA970)	
<i>Oryza sativa</i>	2
Total	1040