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Underutilized crop diversity, seed systems, management and their implication on food security

The case of roots and tubers in South-Western Rwanda.

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Abstract

A study was carried out in the south-western Rwanda in Muganza and Karambi sectors, in order to find out the current composition of neglected yet promising underutilised indigenous crops and practices that maintained crop diversity via informal seed system in smallholder farms. The research activity is a baseline survey for future efforts in collection and conservation of agrobiodiversity.

It was found that there is a heavy dependency on own farm saved seeds. Farmers have turned to yam in replacement of taro which is nearly being wiped out by root rot diseases. The cultivation of roots and tuber crops on mounds is an ideal practice and significantly enhances the diverse use of landraces. Due to small land holding, the tendency is to intercrop hence the levelled land preparation. This practice significantly reduced the risk and/or increased resilience of the system for roots and tubers crops across the study sites.

It was also found that the price for different root crops is significantly different across the sites and the price of yam and taro is encouraging, closer to that of Irish potatoes. Rice, grown as a cash crop, is taking over through try and error method and the approaches are not scientific in all marshlands causing the shift upwards in cultivation and the loss of traditionally grown crops cultivars. It was found that crop specialisation is associated with loss in food diversity and this leads to high malnutrition.

New varieties developed by research hardly reach the end-user. The juvenile formal seed system in Rwanda, which produces less than 3% of quality seeds, will be successful only if it lays its foundation on the already established informal seed system and the private sector need to intervene through investment. The informal seed system was found to have its basis on socio-cultural believes. Crop priority settings need to be participatory to accommodate promising yet neglected crops.

A well coordinated ex-situ conservation strategy for threatened crop varieties such as finger millet, on-farm and/or in-vitro conservation of taro and yam is needed. Rwanda has to fulfil her commitment in international fora and conventions hence farmers need to be guided by research based findings to avoid the loss of time and resources but also to be facilitated in earning a living out of their long grown crops for which they constantly preserve the genetic diversity through use.

Key words: Agro biodiversity, farmers' saved seeds, food security, roots and tubers, south-western Rwanda, underutilized crop species and diversity

To Joséphine, Théo-Blaise, Théo-Bélise and Theo-Carl.

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Introduction

Research situation

The term underutilized species-referring to animals, crop plants, wild or semi-wild plants-applies to those species which appear to have considerable potential for use yet whose potential is barely exploited, if not totally neglected, in agricultural production (GTZ, 2002).

Human kind has, at one time or another used more than 7000 edible plant species. Agricultural research, however, has concentrated on a few crops and breeds. Over 50% of humankind's requirements for protein and calories are now met by just three crops (maize, wheat and rice) while 95% of the world's food energy needs are provided by just 30 plant species. The narrowing base of global food security is limiting livelihood options for the poor. The chronic food shortages present in many countries demonstrate clearly the fragility of food security based on a few staple food species. The global "opening" towards underutilized species is the result of a gradual change of attitude towards biodiversity and plant genetic resources by many countries. Instrument in this awareness raising process have been the 1992 convention on biological diversity and the FAO iv international technical conference on plant genetic resources for food and agriculture held in Germany in 1996 (cfr. Activity 12: Promoting development and commercialization of underutilized crops and species") (UNEP 1992, FAO 1996a). The Global forum on agricultural research (GFAR) in 1999 also emphasized the role of underutilized species in raising income of the rural poor (Frison *et al*., 2000, Paludosi *et al*.).

Roots and tubers form an essential component of food security for many of the poor and undernourished in the developing world, contributing a significant amount to overall caloric consumption… are most important in Sub-Saharan Africa, supplying 20 percent of all caloric consumption in the region, they also serve as an important supplemental source of carbohydrates, vitamins, and amino acids in Asia and Latin America. Famine, hunger and droughts are prevalent in Sub-Saharan African farmers, the crop's low input requirements mesh well with regional resource endowments, a shortage of chemical inputs and organic products, and limited irrigation (Scott, Rosegrant, and Ringler 2000).

About 1.1 million people in the world live of less than one US dollar per day and 325 millions are found in Sub Saharan Africa (Von Braun, J. *et al*.). In Rwanda three quarter of the population, estimated at about 9 millions today, are found

below the poverty line (national census, 2002). The world food day and TeleFood theme for 2006 called for "investing in agriculture for food security"(FAO, 2006).

The millennium development goals (MDGs) have become globally accepted benchmarks of broader progress, embraced by donors, developing countries, civil society and major development institutions alike. The MDGs can be met by 2015- but only if all involved break business as usual and dramatically accelerate and scale up action now…It will require the commitment of scientists and scientific institutions throughout the world to bring the benefits of science to all (Kofi Annan, former secretary general, United Nations).

Agenda one of the MDG is to eradicate extreme poverty and hunger and calls for halving hunger and poverty by 2015 with reference to the situation of 1990. It is achievable, "we have the opportunity in the coming decade to cut world poverty by half" (UN reports). In Rwanda, the contribution of agriculture to the growth in GDP is not enough for the country to achieve the MDG one, although the national poverty rate in 2015 will be 17 percent lower than that in 2005. Cash crop production seems to benefit less from such growth. The growth driven by productivity increases in staple crops and livestock production can reduce the poverty more than in the case where growth is driven by export crops or by non-agricultural sector. The share of agricultural spending in total government spending is required to increase from the current level of 5 percent to 10-35 percent in 2015 (Diao, et al., 2007).

Sub-Saharan Africa is a high-cost, high-risk place to do business, resulting in less investment, less employment, lower incomes, less growth and competitiveness, and higher poverty. Improving public revenue and expenditure management is on the agenda of several African countries and is also a priority of the new partnership for Africa's development (NEPAD) (World Bank, 2006). Rwanda must preserve macro stability and use resources productively to ensure sustained growth and poverty reduction. Obstacles to growth include limited and expensive electricity supply, a poor transportation network, a shallow financing system, low agricultural yields, and the high cost of doing business. The international monetary fund (IMF) is committed to working with Rwanda to realize these goals (Portugal, M., 2007).

Sub-Saharan African governments have neglected research into the challenges posed by roots and tubers production, preferring to expend scarce research dollars on cash crop production (Scott, Rosegrant, and Ringler 2000). Former political, economic and cultural processes have evolved to remain important in farmer

decisions of what crops and animals to produce; in Rwanda, white potato production is concentrated in the northwest due to an early government policy promoting commercialization of white potatoes in that area (Olson, M.J., 1994).

The Eastern Africa plant genetic resources network (EAPGREN)'s mission is "to harness, conserve, and to promote greater use of plant genetic resources (PGR) for food security, improved health, and socio-economic advancement of the rural communities of the present and future generations. It will accomplish this mission largely through capacity building and developing sustainable linkages between PGR conservation and utilization among the various stakeholders including rural farming communities, at the same time ensuring that gender considerations are internalized in the planning, implementation, monitoring and evaluation of all the network activities". Some African nations still don't have seed banks…the need for such initiatives (Adler T., 1995). CIAT's seed bank contains 300 varieties of Rwandan beans. Some of them have been grown in that country for over 400 years, (Adler T., 1995, Scowcroft). In Rwanda, the national agricultural research institution (ISAR), through the seed unit created in 2002 and crop specialized research programmes is responsible for coordinating national plant genetic resources activities. However, the institute lacks qualified personnel, material and equipment. Among other activities in Rwanda, EAPGREN propose germplasm inventories (Demissie, A., 2003).

EAPGREN using criteria set and the indicators of their importance identified 21 crops and forage species priority to the region included in the Annex I of the ITPGRFA and other non-Annex I crops of importance to the region for which the germplasn should be preserved. For Rwanda, those crops are pea, potato, beans, cowpea, yam, rice, cassava, sweet potato, finger millet, sorghum and banana. However, in evaluating accession-level of passport data available at regional level, it was reported that no assembled collections for sweet potato, Irish potato and yam; yet those crops are considered as important root crops in the region. The EAPGREN baseline survey undertaken in 2004 indicated that documentation is probably the least implemented plant genetic resources activity in the sub-region (Global crop diversity trust, 2006). Strong regional programmes can only be based on strong national programmes (Kamau, H., 2003)

Protection and conservation of crop genetic diversity entails action to conserve locally adapted varieties and genetic resources at the farm and local community level, as well as in national and regional gene banks. Robust seed supply systems depend on national and regional seed policies plus government and international support. Sound national and regional seed policies are essential (FAO, 1998). FAO

suggests that "inventory of possible seed system approaches" and "seed system profiles" for all disaster-prone countries as part of emergency preparedness be developed (May 2003). In Rwanda, after the 1994 war and genocide which resulted in the loss of germplasm, the consultative group on international agricultural research (CGIAR) centers initiated the "Seeds of hope project". It was found that; despite the conflict, farmers had been remarkably successful in preserving their bean agrobiodiversity (Sperling 1997, Sperling and Cooper 2003). Sperling and Loevinsohn (1993) found that, in Rwanda, introduced bean varieties disseminated widely from one farmer to another, having been sold initially in small quantities in local markets. However, the international plant genetic resources institute (IPGRI) and the union for the protection of plant varieties (UPOV) joint meeting argued that "it is not clear whether smallholder farmer following their traditional patterns of local exchange are engaged in private and non commercial uses" (IPGRI-UPOV, 2004).

The existence of key individuals willing to play a leading role in informal seed diffusion was an important factor in the success of informal seed diffusion mechanisms (Cromwell, 1990) and Almekinders *et al.* (1994). Given the importance of informal seed diffusion mechanisms for small grains, it is important to understand how such system operates and how they can be used more effectively (Jones *et al.*, 2001).

Seed systems studies, an under-researched area, can contribute in important ways to the formulation of more appropriate, farmer-oriented seed delivery strategies by providing detailed information on farmers' seed purchasing behaviour and seed diffusion patterns (Soniia and Sperling, 1999). Research done in seed system in Rwanda has been concentrated on beans. Farmers' seed exchange system need to be better understood and modernized in order to speed up the rate at which clean planting material of crops are exchanged so as to fight against hunger and malnutrition in the country.

In Rwanda, grown roots and tuber crops include cassava, sweet potatoes, yam, taro, *Xanthosoma* and Irish potatoes. However these starchy roots and tubers crops remain underexploited due to unavailability of seeds and the prevalence of diseases such as Cassava mosaic virus. Tolerant varieties of cassava include *Mbagarumbise* (MH 95/0414), *Ndamirabana* (TME14), *Mbakungahaze* (00063) and *Cyizere* (0057), which are being multiplied. Research has as well come up with orange fleshed varieties of sweet potatoes rich in vitamin A.

The importance of selected roots and tuber crops in the region

The Eastern Africa plant genetic resources network (EAPGREN), in its strategy plan to ex-situ conservation of plant genetic resources in Eastern Africa (Global crop diversity trust, 2006), reiterates the importance of roots and tubers crops in Africa

(i) Cassava, *Manihot esculenta* Grantz; has the ability to grow on marginal lands where cereals and other crops do not grow well; it can tolerate drought and can grow in low-nutrients soils. Cassava provides a basic daily source of dietary energy. Roots are consumed freshly boiled or raw and leaves are used as a green vegetable, which provides proteins and vitamins A and B. Cassava starch is used as a binding agent, in the production of paper and textiles, and as monosodium flavouring agent;

(ii) Sweet potato**,** *Ipomea batatas*; Africa represents a unique site of genetic diversity for sweet potato. It is a short-season crop which reliably provides food on marginal and degraded soils with little labour and few or no inputs from outside the farm. The crop is rich in carbohydrates, proteins and vitamins, and provides high cash income per unit of land and time;

(iii) Yams**,** *Dioscorea spp*.; are cultivated throughout tropical Africa. There are at least 13 species occurring in the region. Among the cultivated species, *Dioscorea bulbifera* and *D. minutiflora* are native to East Africa. Other species of edible yams cultivated in east Africa are introduced and include *D. cayenensis*, yellow Guinea yam, from West Africa and *D. alata*, white yam, from Asia.

(iv) Taro, *Colocasia esculenta (L.) Schoot*; is the fourteenth most consumed vegetable worldwide and comprises the diet of 300 million people (Singh *et al.* 2006, Bown 1998).

The problem of roots and tuber crops in Rwanda

Over the past few years, the ministry of agriculture and animal resources (MINAGRI) has made reforms aiming at transformation of agriculture from subsistence to commercial in a bid to improve the livelihood of farmers. Priority crops chosen by MINAGRI are rice, maize, beans, sorghum and Irish potatoes. However, the formal seed system provides less than 3% of national demand in quality seeds. Neglected crop species include yam and taro, finger millet, cowpea, pigeon peas, etc. and various indigenous vegetables. In the west of Rwanda, distinct farming systems have formed…There is concentration of certain uncommon crops such as millet, taro and yams (Olsom M.J., 1994). A high attack of aphids and a high sensitivity to Dasheen mosaic viral diseases was recorded for the first time in taro variety trial at ISAR Rubona in 1983 (ISAR, 1983 annual

report). Since then, no further action was taken. Currently, taro is heavily threatened and may be completely wiped out in the south-western Rwanda bordering Burundi and the Democratic Republic of Congo (DRC) due to a disease causing stunting, yellowing of the foliage and corm rot and yet it was a source of income to many households.

Research questions and objectives of the study

The formal seed system produces less than 3% in quality seeds for priority crops. All cultivated roots and tuber crops in the South-Western Rwanda are underexploited mainly due to lack of clean planting material. Colocasia Taro is heavily threatened and may be completely wiped out due to corm rot as a result of the root rot disease while cassava is severely threatened by cassava mosaic virus. Little is known about taro, yam and other neglected crops in Rwanda. Therefore, this study stands for a baseline survey for subsequent efforts for collection, characterisation, documentation and conservation of the genetic diversity of neglected crops.

Specific objectives are to get an understanding, with special reference to roots and tuber crops, on:

(i) Farmer' knowledge and practices that govern the informal seed system and a way forward for improvement.
(ii) Seed selection criteria, processing and storage/conservation of plant genetic resources.
(iii) To identify species and varieties of diverse land races/cultivars grown/conserved on farm.
(iv) To asses the richness, the degree and the trend of genetic erosion at farmer' level.

The research activity is in line with the EAPGREN's planned activities in Rwanda which include "germplasm inventories". The aim of the study is to appreciate farmers' knowledge, experience and perception on indigenous crop species, and the study examined the indigenous practices and know-how that maintained crop genetic diversity over centuries and evaluated future perspectives in preserving and sustaining the conservation of promising yet neglected crop species on which they depend on *via* informal seed system in small land holding situation.

Material and methods

Facts, issues and basic data about Rwanda

Rwanda is a landlocked country and is located between 1°04' and 2°51' south latitude and 28°45' and 31°15' east latitude. The surface area is 26330 square Km (10169 square miles) with the altitude varying from 950 to 4519m. The country is made up of multitude of hills and abrupt mountains often eroded. The relief is composed of a central plateau, the Congo Nile ridge, mountain chain (Congo and Nile river basins). Rwanda is among the poorest countries in the world with a population of approximately 8162715 (national census, 2002) and 8.6 million (UN, 2005). 77% live below the poverty line. The annual growth rate is estimated at 1.2% with a density of 400-500 inhabitants per square Km. On average the population is young, 67% of the population has less than 25 years of age. Agriculture is the backbone of the national economy, practised by more than 90% of the population and contributes for about 41% to the GDP and is characterised by small family land extremely subdivided estimated at 0.5ha (national census, 2002). Few industrial crops include coffee, tea and pyrethrum which contribute up to 93% of export earnings. Life expectancy is estimated at 42 years for male and 45 years for female. The GNI/capita is US $230 (World Bank, 2006). Prospects for revival of the rural economy are hampered by low productivity, already exhausted arable land and severe degradation of soil.

Rwanda has around 1.4 million hectare of arable land of which 60-70% is cultivated. Rwanda's climate is tropical, influenced by altitude. The average temperature in the whole country is 19°C with variation between 15 and 29°C. The altitude variation and the fragmented nature of the country result in vast agrobiodiversity. The alternation of two dry and rainy seasons allows farmers to have two harvests depending on the crop (MINAGRI, 2006).

In its "Vision 2020" as well as the poverty reduction strategy paper (PRSP), the government of Rwanda's long-term development strategy is fostering national reconciliation, good governance, security in the region, and rapid, diversified and sustainable economic growth in order to improve living conditions of the population. The medium-term strategy (2002-07) is focusing on (i) sustained macro-economic stability, (ii) rural development and agriculture transformation, (iii) good governance, (iv) human resource development, (v) economic infrastructure and (vi) institutional capacity building. In 2001, the country introduced new company and labour laws. Land titling reforms followed in 2002. In 2004 Rwanda was among the top reformers: it streamlined customs procedures,

improved credit registries, and simplified judicial procedures. Since initiating reform, Rwanda has had economic growth averaging 3.6 percent a year—among the highest for non-oil-producing states in Africa (World Bank, 2006). However, challenges are management of diversity, land ownership and reform and the reliance on external assistance (Njeuma, D., 2006)".

Small family plots, decreasing soil fertility, low use of agricultural inputs and erratic rainfall result in chronic and often acute food insecurity. About 10–12 percent of the population suffers from food insecurity every year. Rwanda is ranked 159 out of 177 countries in the United Nations development program (UNDP) human development report for 2005. Hunger is chronic and acute malnutrition prevalence in children under five is 45 percent and 19 percent respectively. Infant and under-five child mortality rates are still among the highest in the world at 110/1,000 and 195/1,000, respectively. Maternal mortality rate is among the highest in sub-Saharan Africa at 1,000/100,000 live births. In 2002, the government of Rwanda launched a poverty reduction strategy (PRS), which was replaced in 2006 by the new economic development and poverty reduction strategy (EDPRS) representing a comprehensive development agenda with a need to ensure good progress across both the productive and social sectors (World Food Programme).

Rwanda is a member of FAO since 19 November 1963 but is not part to the international treaty on plant genetic resources for food and agriculture (ITPGRFA) which came into force on 29 June 2004. By the end of 2003, Rwanda had ratified all conventions and protocols relating to the environmental protection in general and the convention on biological diversity (CBD) in particular. The ministry of environment, forestry, water and natural resources (MINITERE) is responsible for the implementation of CBD. Efforts are underway to update existing policy documents and legal texts in most cases scattered, incomplete and old. CBD gives guidelines on its articles 2, 8c, 8j on traditional knowledge, innovations and practices; 13 on provision of information, 15 on benefit sharing, 16 on technology transfer and its associated agenda 21. The agreement on trade related aspects of intellectual property rights (TRIPS 1993) of the world trade organization (WTO) requires all WTO members to introduce a minimum level of protection for intellectual property in their national laws and subsequent bilateral or multilateral trade agreements that call further strengthening of IPR regimes in developing countries (Louwaars *et a*l. 2005); in Rwanda, a seed law was published in the official gazette in 2003, to-date application ministerial decrees are not available. Plant variety protection (PVP) and phytosanitary laws do not exist. Harmonization of seed regulations and trade is spearheaded by the association for

strengthening agricultural research in east and central Africa (ASARECA) but comparatively Rwanda is lagging behind her sisters Kenya, Uganda and Tanzania.

The government has emphasised policies related to the commercialisation of agriculture, rational soil and water use and research and extension. Another policy measure in place is the stabilisation of food supplies by prioritizing and promoting the growth of food crops that have an impact on food security. These are rice, maize, beans, sorghum and potatoes. These crops have been selected on the basis of their adaptability, accessibility, nutritive value and marketability (HE, Kagame, P., FAO World summit Rome). Cash and export crops are tea, coffee and pyrethrum (MINAGRI, 2006). New crops on the rise include Macadamia nuts and extensive production of passion fruits and plums. Despite improvement in the production of commercial cash crops, food insecurity remains a real concern, and the consumption of calories per capita has not registered significant improvement in recent years… major sources of protein and nutrition remain insufficient…food insecurity is particularly pronounced in the most vulnerable groups including female-and widow-headed households (37% food insecure versus 25% for female-headed households) and elderly-headed households (35% food insecure) (CFSVA 2006)…the number of underweight children remains high…stunting, which gives and indication of chronic malnutrition due to inadequate food or recurrent illness, increased from 43% to 45% between 2000 and 2005.

Between 2001 and 2006, Rwanda's poverty rate decreased from 60.2% to 56.9% of the population… population growth in Rwanda is putting additional pressure on scarce land through over-cultivation and soil erosion… Rwanda has experienced a remarkable recovery since the 1994 genocide… since the end of the emergency period, growth rates have emerged 5.8% per annum, making Rwanda one of the top performers in Africa and an example of successful post-conflict reconstruction…Rwanda's challenge over the next decade will be to operate a successful transition from recovery and reconstruction-based growth to a broad-based and sustainable growth that will allow it to maintain past performance levels up to the year 2020 and beyond (UNDP, 2007). On its report, UNDP further highlighted a number of issues which include:

Agriculture, Millennium development goals and vision 2020

Economic growth has so far come almost exclusively from the service and manufacturing sectors, as agricultural performance has remained highly volatile and dependent on rainfall (UNDP, 2007). Agriculture employs close to 80% of the population (Rwanda-National Institute for statistics, 2006). UNDP reports that

despite a decrease in acute malnutrition among children under five, from 7% to 4%, chronic malnutrition has increased from 43% to 45% of children in the past five years. 78% of Rwandan households present some vulnerability in access to or consumption of food. 28% of Rwandan households are food insecure. Rwanda currently receives over US $30 million per year in food aid (UNDP, 2007). The comprehensive food security and vulnerability assessment (CFSA 2006) indicates that 21-25% of households are food insecure in the south-west/Cyangugu area. Between 1990 and 2005, Rwanda lost 50.2% of its own forest and woodland habitat. Since 2000, several reforestation programmes have been put in place and the number of community replanting trees has increased significantly. (UNDP, 2007).

Population challenge

Rwanda has the highest density in Africa at over 350 inhabitants per square Km, and the population is growing at 3.5% per year. The average plot size for farming is 0.81ha in Rwanda. FAO estimates that 0.9ha is required to satisfy the nutritional needs of a household. Access to safe water sources has been stagnant in the past five years in Rwanda, 95.5% of rural households still depend on firewood for cooking (UNDP, 2007)

Income distribution

The average income of the top 20% of the population has almost doubled since 1996. Rwanda's Gini Coefficient, measuring economic inequality, has almost doubled in the last 20 years, placing Rwanda among the top 15% most unequal countries in the world (UNDP, 2007)

Education sector

Net enrolment in primary schools rose from 73.3% to 85.9% between 2001 and 2005 and gender parity in enrolment has been achieved. Quality remains a challenge in primary education, however, as the pupil/teacher ratio has risen from 54 to 69 between 2001 and 2005. Secondary education enrolment remains a major challenge, with barely 10% net enrolment nationally, dropping to a mere 7.9% in rural areas (UNDP, 2007).

Health sector

Under-five mortality decreased from 196% to 152% between 2000 and 2005, thus recovering to pre-war levels. A child born into a poor (bottom quintile) family has a one in five chance of dying before reaching the age of five, twice as much as child born into a rich (top quintile) family. Malaria is the leading cause of morbidity and mortality in Rwanda. Children under the age of five account for

35% of all malaria-related deaths (UNDP, 2007). HIV/AIDS prevalence is estimated at 3% in Rwanda. Condom use remains low at 3% despite an awareness rate of 90% about HIV transmission (UNDP, 2007).

Gender equality

Rwanda enjoys the world's highest rate of female representation in parliament as 48.8% of parliamentarians are women. Rwanda has already achieved and surpassed gender equality in primary school enrolment. Rwanda ranks 119th out of 177 countries on the gender development index (UNDP, 2007). 35.2% of Rwanda households are headed by women, 56% of whom are widows (National census, 2002).

Finance

Rwanda's public revenue has already reached the 15% of GDP ceiling recommended by the IMF (UNDP, 2007).

The South-Western Rwanda

Two selected sites, (figure 1) being Karambi sector of Nyamasheke district and Muganza sector of Rusizi district; in the southern part of the Western-Province of Rwanda, former Province of *Cyangugu*; bordering Burundi in the south and DRC in the west belonging to a low and high elevated situation, respectively. The site was purposively selected basing on the fact that there is no single farm producing basic seed either government or privately owned. The highest elevation point recorded in Cyangugu area is found at Muzimu mount which is situated in Karambi sector and found in the Nyungwe national park. The two sectors or administration units were chosen from the latest map of new provinces for being in the highest and lowlands elevation and are considered as the replications in this study according to crop adaptation aptitude and production levels of food crops mainly roots and tubers. The two sites are regarded as a representative sample of the whole region (former Cyangugu Prefecture). The permission to operate was officially granted by local authorities to carry out my study. The field work was done between August 2006 and February 2007. The area has a bimodal rainfall regime with the short rain season from November to January and the long rain season from February to May. Recommended crops by MINAGRI are rice, banana, coffee, tea and passion fruits.

Karambi sector is situated in the former Gatare Commune of Cyangugu Prefecture, in the Congo Nile-Crest agro-climatic zone. Soils are of acidic formation on metamorphic rocs (gneiss, quartzite, others). Generally soils are of low fertility level on step hill sides hence risk of high soil erosion. The altitude

ranges from 1800 to above 2000mm and the rainfall ranges from 1300 to 1500m.a.s.l. In Karambi sector, there are a number of fairly shallow permanent rivers of fresh water that have a source in Nyungwe National Park and flow into Kivu Lake. Grown crops are green peas, beans, cassava, sweet potatoes, Irish potatoes, finger millet, maize, wheat, sunflower, and coffee. Interventions should be oriented towards livestock, bee keeping, new crops such as onions, passion fruits, tea, etc. with liming and application of mineral fertilizer; not forgetting resource management which is vital for environmental conservation.

Source: http://www.minaloc.gov.rw/; website last visited June 7th 2007, ©Institut National de la Statistique du Rwanda, April 2006.

Figure 1. Study site, South-Western Rwanda/Cyangugu area: Karambi sector of Nyamasheke district and Muganza sector of Rusizi district in the Western Province.

Muganza sector is situated in the former Bugarama Commune of Cyangugu Prefecture, in *Imbo* agro-climatic zone. The altitude ranges from 900 to 1400m.a.s.l, the rainfall varies from 1050 to 1500mm, and soils are of alluvial type. Grown crops include banana, cassava, beans, groundnuts, sweet potatoes, rice, sugarcane, fruits and the area is suitable for cotton production (MINAGRI). The vegetation

is composed of Cassia, Asteraceae and Mimosaceae (indigenous) families. New crops include Patchouli, Moringa tree, etc.

Basic data is not available in the new administration units and this may be a hindrance to adequate planning in Karambi as well as in Muganza sectors. Karambi sector however, lacks basic facilities and remains rural, lagging behind in terms of technology, transportation, communication, etc. unlike in Muganza sector. "Information and communication technology have the potential for reducing poverty and fostering growth in developing countries" (World Bank, 2006).

Because of the mountainous situation, the improvement of soil fertility level and soil erosion control has been given high priority. It is estimated that the amount of soil that is transported annually by soil erosion is enough to sustain the livelihood of 40000 inhabitants (Bazivamo, C., 2001).

Methods

The research activity addresses various issues ranging from the assessment of crop cultivar diversity, agricultural practices and seeds systems. It was necessary to make a combination of various techniques in order to gather as much information as possible but also to increase the validity of the findings. Each technique has its merits and weaknesses. A general questionnaire (appendix 1), edited and revised in Kinyarwanda (mother tongue) at different tiers; was addressed to community members in order to get an understanding of the local cropping pattern and the seed system, and where possible to collect quantifiable information. Visits to the selected villages were also done through transect walk for visual observation of the crops being grown so as to complement information provided by agricultural officers in the two sectors. Different farmers in possession of the same variety could have different management practices that determine how pure the variety is maintained (Chakanda R., 2000). In on-farm maize trials conducted in 1999 in the Congo-Nile crest and volcanic highlands of Rwanda, statistical analysis indicated differences between varieties and between practices but not between farmers (Ngaboyisonga, C., 2001).

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Figure 2 (a) The questionnaire was revised and edited at different levels (b) short training of enumerators for field work (c) Banana juice offered and shared during household interviews

Cultivar diversity was assessed through "participatory extent and distribution analysis also known as four-square analysis" with prior focus group discussion (FGD). Meetings with key informants were organized within the facilities of the sectors in both site's common room with writing boards at our disposal. Key informants were asked to name grown plant cultivars, then one at a time to classify if it is whether grown by many or few households on large or small areas or vice versa, then farmers were asked to broadly describe the already mentioned cultivars. A participatory rural appraisal (PRA) method was used, the procedure was first demonstrated, and then group members elected through nomination by their peers facilitated the exercise.

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Figure 2 (d) Evening recap of the day long interviews in Karambi sector (e) FGD and scoring on agricultural practices, note the facilitation of a group member (f) Viral diseased Taro plant found in a mulched coffee plantation in Karambi sector

Households were the sampling units; information was obtained through discussion with key informants in the target community as well as individual contacts and home visits. Semi-structured interviews were used during individual contacts. Male and female headed households, earlier identified at random, were interviewed with at least two days prior notice. Home visits were also made along the transect line,

by riding a motorbike and stopping at every 150 meters and entering the first household found on the right hand side, without a prior notice. Observations were made in the home garden and in the neighbourhood.

Figure 2 (g) Diversity of intercropped crop cultivars (e) stop over during transect walk, neighbours look on (f) Individual contacts, inventory in a home garden and tubers commodities sold in local markets

A total of four interviews, two in the lowlands and two in the highlands, were video recorded. The content helped to understand further and interpret some of the findings. Digital photographs were taken throughout the study period and helped to better understand the study area ad as well on the interpretation of the findings.

Field assistant for data collection throughout the study was a Teacher, Representative of Agronomists, in the local college of agriculture (*Ecole Agricole et Vétérinaire de Ntendezi*).

Key informants, in Karambi sector, were among members of the poverty reduction strategy program known as EDPRS and were drawn from a list of participants in the committee meeting that was held in the first month of my study period. Members of EDPRS committee are elected by community members and are comprised of all age brackets, literate, and gender balanced.

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Figure 2 (h) The diversity of crops species and cultivars found in a coffee plantation (i) Inyabojo yam cultivar intercropped with other crop varieties on a levelled land preparation

In Muganza sector, key informants were selected from the meeting of farmers who intend to specialize as local seed producers. The two meetings in both sectors were called respectively by the Executive Secretary of the Sector and the Officer in-charge of agriculture, animal husbandry and environment. In Karambi sector, the questionnaire was administered with the assistance of a group comprising teachers in the local primary school and students in the secondary schools on long vacation. In Muganza sector, the questionnaire was administered with the assistance of a group of native young Technicians Agronomists and Veterinarians graduates from the local college of agriculture (*Ecole Agricole et Vétérinaire de Ntendezi*).

Semi structured interviews, were conducted in Kinyarwanda (local language) spoken by all Rwandese. The research proposal was written in English for the purpose of good communication and supervision during the course work but the questionnaire was translated and administered in *Kinyarwanda* for field work. To be qualified for the interview one had to be a small-scale farmer in the study area and had to be growing root and tuber crops either in association or in pure stand in his fields. A sample of farmers falling in this category were interviewed with an effort to include all categories with regards to age, gender, group affiliations, wealth, literacy level, etc.

Local health centres, were visited to find out the status of malnutrition and the role of underutilized crops such as roots and tubers if incorporated in diet.

Local markets may indicate how much genetic diversity is being used by farmers in a certain region (GTZ). Local markets within the survey territory were visited in order to evaluate commodities and crop species on sell and at which prices through visual appreciation and conversations.

Statistical analysis was performed to test significant differences where possible using MINITAB Release 14.

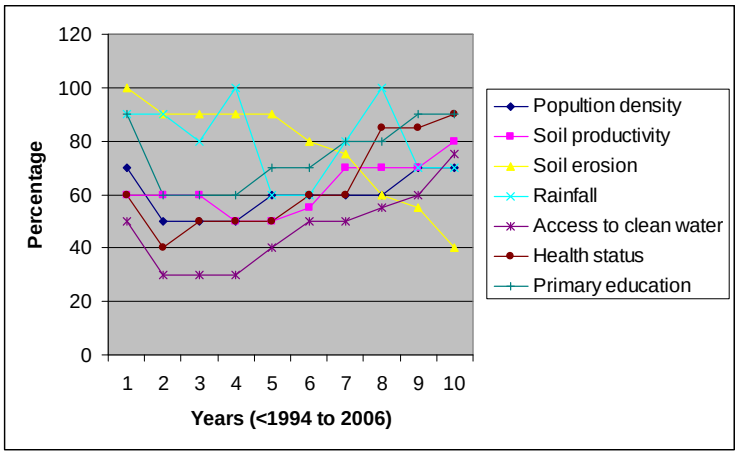
Agricultural practices were evaluated using "Evaluation of best practices for landrace conservation: farmer evaluation", a manual developed by Grum, M. *et al.*

Participatory rural appraisal tools were used with reference to the manual developed by PRA Team of Egerton University, Njoro, Kenya.

Results

Household resources and general observations along the transect

There are integrated soil erosion control measures which include trenches and progressive terraces found along the contour lines and bench terraces being formed, both techniques are accompanied by the plantation of *Setaria spp., Tripsacum spp. and Pennisetum spp.* These fodder crops are fed to domestic animals. It has been decided that domesticated animals can only be kept under zero or semi-grazing set-up. However, despites remarquable efforts in restoring soil fertility, it was noted that there are isolated cases of farmers who burn crop residues in their farms.



* Trend in some social parameters in reference to the situation before the war and genocide in 1994 (Represented as year 1).

Figure 3 Trend in social parameters in Karambi sector,

Figure 3 indicates slightly better living conditions than it was before 1994. There is a decline in soil erosion and an increase in crop production as a result of improving soil fertility measures. There is an increase in the population density and improvement in health status. This could be attributed to the newly inaugurated Karambi health centre. Each homestead is encouraged to grow vegetables in the home or kitchen garden.

There are various types of fruit trees mainly mango, avocado, oranges, etc., and various indicators kind of indigenous plant species, trees, shrubs, or herbs that are

purposely grown in association with crops in crop fields or in the vicinity. These species, some of them are native and others have been introduced mainly by the research institute (ISAR) and/or agricultural projects. *Eucalyptus spp.* was generally found planted on the top of each mountain but also found in crop fields as a source of firewood and for construction purposes.

Plantations of banana, the majority of which are beer type, are found concentrated around the homesteads. Several diseases had been recorded in Muganza sector but we observed for the first time cases of Banana wilt disease in the highlands in Karambi sector. Various diseases, especially viral diseases, were also observed in food crops and fruit trees. Coffee washing stations are under construction as per the national agricultural policy to add more value to export commodities. In Karambi sector, coffee is an important crop, one household grows between 2000 to 4000 plants but some may possess even up to 8000 plants. The price is 600 Frw (1.09US$) per dry kg of coffee. In many cases, coffee was found as part of the home garden and vegetables are intercropped within this cash crop. *Colocasia spp.* was also found planted in coffee plantations because their leaves are consumed as vegetables but in many instances this is practiced as a way of increasing the amount of planting material for this threatened crop. Actually, coffee plantation becomes a nursery, and any newly introduced plant material has to be tried first in a coffee plantation near the homestead. Rice, normally adapted to lowlands, is taking over in all marshlands to the extent of even being tried by farmers in the highlands, where it is not adapted.

Highlands

In Karambi sector, 12% of the respondents beside agricultural activities had a permanent employment, hence earning a monthly salary, the majority of this category are teachers in primary schools. 6% of the respondents had travelled outside their village and 12% were members of church choirs. 88% had other non farming activities such as trading in animals, and others hired outside their village as casual labourers mainly in the capital city of Kigali and Bugarama area. Some of the respondents were elected by their peers as persons of integrity commonly known as *Inyangamugayo* in traditional *Gacaca* jurisdictions. 47% of the respondents do keep local breeds of cows, goats, chicken, honey bees, etc. 82% of the respondents are permanent residents, and 18% of them have been in the village since they were borne.

Only 24% of the respondents had managed to get loans, and these credit facilities were used in various activities such as plantation of eucalyptus, establishment of small businesses, fees for distance English learning, etc. but the rest, as mentioned

by 41% of the respondents, do not know the procedure on how to get such credits, other have no interest in loans due to old age, small farm size, lack of guarantee, etc. It should be noted that there is no single bank in Karambi sector; one has to travel for a very long distance for banking operations.

47% of the respondents have not yet been visited by any extension workers/services. 12% had received training aiming at improving coffee production, how to use fertilizers and erosion control measures specifically with bench terracing. 18% have traditional knowledge in healing which is a source of income, though it fetches little money. In general 18% get money from the sell of crop produce, 35% out of selling animals and 29% from selling both crops and animals. 6% earn a living through working as casual labourer, 12% get income from various/other sources. Male parents contribute 18% to family income.

Lowlands

In Muganza sector, the majority of the respondents were males but females were represented at 19%. On average the respondents had 48 years of age. The average family size was 7 persons but 25% of the respondents had more than 10 people in their households. The majority of the respondents were married but 13% were single and 19% of the respondents were widows. The respondents included those who do not know how to read and write (13%) but 6% had completed secondary level of education and employed as civil servants. 99% of the respondents do carry out farming activities all the time despite that 25% earn a monthly salary from part time employments, 31% in addition of farming do carry out commercial activities/shop owners. There are various opportunities for off-farm employment. 24% of the respondents claimed to have knowledge in traditional medicine but it earns little money despite that it facilitates social integration. Generally, family income is from the sell of agricultural produce (50%), sell of domestic animals (6%), selling both animals and farm produce (25%) and from hiring themselves out as casual labourers (6%). As told by the respondents all family members have a contribution to household income but at different levels: husband (13%), wife (19%), both parents (63%) and all members of the household (6%). The respondents had different believes including Muslims and Christians that is Adventists, Catholics, Protestants, and Methodists churches.

A considerable number of inhabitants of Muganza sector and Bugarama plain at large are immigrants. Those that were interviewed in this study said to have settled there for more than 20 years and have got enough experience in farming activities, on average 31 years. Only 13% acknowledged to have been visited by extension workers. All the children go to school but some, from poor families, representing

19% as told by the respondents are school drop outs. Rice and tea production employ many children as casual labourers hence increasing the level of school drop outs.

In the highlands all farmers do cultivate in the hillsides but in the lowlands, Muganza sector and Bugarama area at large, the majority of the respondents own plots in the marshlands, hence are rice growers (88%) and 44% as well have plots in the hillsides. However, in both cases, the pieces of land are situated far from the homestead and the walking distance varies. Some respondents said that they have to walk up to two hours to reach some of their plots. In most instances, these pieces of land are inherited from the parents; they are of varied sizes and shapes, and the acreage is hardly known by the owner.

In the lowlands 44% have their own farm land. The cultivated land is either owned (31%), tenant (13%), tenant and owned (75%). 13% of the respondents do not have land due to extreme poverty and have no hope to own any piece in their lifetime. Like in the highlands, all the respondents have no idea on how big is the size of their farms.

The respondents said that there is shortage of land, the possible reasons include the fact that many people migrated to settle in the village. The former Cyangugu province and Bugarama area in particular is very fertile and the rice scheme is a labour intensive activity. People migrated from Gikongoro and Kibuye, neighbouring to the former Cyangugu Province, to work as casual labourers in cotton and rice production. Cotton as a cash crop was much promoted before 1960's during the colonialism time. In the subsequent years, cotton crop has gradually paved way to rice. Also, there are other employment opportunities such as the cement factory known as CIMERWA, governmental services, etc. The population is very active and ever increasing at an alarming rate due to excessive birth rate. Considerable number of inhabitants especially young ones are so much involved in trading activities with the neighbouring Burundi and DR Congo. Since there is a shortage of land, farmers do ensure that the land produces enough food for their household, they apply more than enough farm yard manure, in all fields but preference is given to pieces of land situated in the lowlands. There are few individuals who don't have/cannot manage to produce enough manure for their farmland. Few farmers use mineral fertilizers and adopted the best farming practices.

Cultivated cash crops as told by the respondents mainly include coffee (50%) and rice. 56% of the respondents do keep animals in their compound. Livestock is part

and parcel of the Rwandese home garden. There are various reasons as told by those who do not have, which include poverty and lack of grazing land or cannot afford to buy fodder crops, it was also mentioned that due to disease outbreak in the past years, there are individuals who decided to do without livestock to avoid the risk..

Animal husbandry is an important component of the farming activities in the study area as a source of manure. Only 31% of those who keep animals do practice livestock fattening practice and 13% do prepare animal feeds on their own, others do purchase ready made concentrates from Kigali or Kamembe towns since there are no local stocks. One should note that the composition of animal feeds that are locally made, e.g. mixtures of rice bran, maize bran and salt; rice bran, maize bran and soybean flour; rice bran, maize bran, soybean flour and salt, etc. do not meet all the requirements hence this kind of feeds cannot lead to the expected high level of milk production.

Farm implements include hand hoe (100%), machete (88%), knapsack sprayer (25%), wheel barrow (25%), watering cans (13%), pick (19%), scooper (31%), and hand saw (6%). Some farmers (13%) are members of farmers' common interest groups.

The majority of farmers depend on indigenous food crops for their survival. The community is organized in such a way that planting materials possessed by few individual farmers are shared through exchange by community members and with time distributed in the whole area. At harvesting time, the produce is sun dried, grains which will be used as seeds for the next cropping season are put aside and conserved in sacs or other local containers, and then the rest is sold off in local markets.

It should be noted that purchased seeds from the local market are just grains i.e. the surplus of harvests in neighbour's fields or brought in from far places by local stockists. In Muganza sector, the focused group of discussion indicated that in the whole sector a part of the produce of beans, maize, sorghum, soya beans and rice is kept by 80% of farmers for next planting i.e. farmer's self saved seeds, then exchanged at 1% for maize, sorghum, cassava and grains are purchased in local markets for sowing at the on set of the rainfall in the proportion closer to 19% for beans, soya beans, maize and rice. There is a traditional saying "Nta wimana imbuto" which literally means that every one should donate seeds or planting material to whoever is in need. In appendix 6 a summary of participatory extent

and distribution analysis on Cassava, Colocasia, Xanthosoma, Yam and sweet potato landraces in the study area is presented.

Yam crop was reported by the FGD as no longer grown in Muganza sector but it was found growing wild on a fence in one household in Muganza sector. It was reported that in the past Ibihama cultivar was only eaten by the Batwa communities, but it became common food for every one during Ruzagayura famine.

Farmers do use the compost manure that is produced in their household. Depending on the amount that is available, the priority is given to plots that are located in lowlands, with a high potential of production. The amount that is applied varies from one farmer to the other and there are those who do not use fertilizers at all (13% of the respondents). Wealthier farmers afford modern soil fertilizing methods such as the application of NPK mineral fertilizers (38%) to complement farm yard manure.

56% of the respondents said that rainfall is not reliable and sufficient for crop development (25%). There has been considerable climate change leading to an extended dry period (25% of the respondents). Sometimes it rains too late after sowing when the crops have already dried up. It was mentioned that despite the delay in the onset of the rain season, whenever it rains it is sufficient enough for producing vigorous crops and good yields, the only problem that remains is proper timing. However, this particular season, 2006/7, rainfall has been rather too much than wanted to the extent that people lost life and property by rain water and floods.

Serious incidences of pests such as rats, moles, birds, stalk borers, ants, etc.; weeds mainly couch grass, oxalis, etc.; and diseases often caused by mosaic viruses have been recorded in 63% of the respondents but 31% of the respondent mentioned not to have been affected. In Muganza sector, the respondents said that the trend of incidences is increasing (38%), decreasing (50%) and no change (6%). For those who believe that the incidence is increasing, the possible reasons that were mentioned include climatic change, declined and loss of soil fertility, some do believe that it is an indicator of the end of the world. 69% of the respondents do not know and do ignore the reasons behind. It was also mentioned by 13% of the respondents that in most instances it is due to neighbouring Burundi and DR Congo countries which have similar diseases and crop pests.

The depletion of soil fertility in the study area is said to be caused by prolonged dry period followed by excessive rainfall (25%). Prolonged dry season disturbs the

onset of the rain season (19%), the land is tired since it is cultivated all the time without a rest (13%) in fact it has become a habit, since the land is too small, and little, insufficient amounts of manure fertilizers are applied.

In their farming practices in the study area, farmers said to have aimed at and experienced the production and on-farm conservation (19%), the productivity with and without chemical fertilizer (13%), the productivity with and without manure (6%), the productivity with chemical fertilizer and manure (56%) and the productivity and resistance to disease, drought and pest of modern and landraces (13%).

44% of the respondents said that they do practice crop rotation and combinations due to the fact that crops get tired then one has to change, small land size (13%) or one wants to harvest many crops at a time. Also through try and error to find out which crop varieties are more suitable to their growing conditions, but 25% cases of the respondents do not at all practice crop rotation due to the small landholdings.

Maize and beans are cultivated all the seasons in combination with other crops but there are crops which cannot be intercropped which include rice and sweet potatoes. Rice is always grown in pure stands in the rice scheme. The reason among others is small land size. They select crops that mature at the same time, that do not compete for nutrients but also blindly because it is a habit as an ancestral practice. For some farmers the association of crops aims at harvesting many crop varieties on the same field since cultivated crops have low productivity. It was also mentioned that for farmers who don't own land, try to maximize the out put in the hired pieces of land trough combining different crop varieties.

If at all manure is to be produced, the priority is either given to plots in home garden (6%), nearby farm (31%) or in the main field (44%). In many instances despite that the amount produced is not enough; farmers do distribute the available amount to their entire land without taking into account the crop requirements. If sufficient manure is produced, the application may vary between 90 up to 120kgs (19% of the respondents) or up to 450kgs per hectare. There are those who even manage to apply up to 1 tone of manure per hectare, as told by the respondents. It was observed that manure is produced in insufficient quantity but there are few cases of households who produce manure in excess and since there is no ready market they use it any way. Chemical fertilizer, if purchased, in the first place is applied in the rice scheme for rice production (25%), then in the main field (19% of the respondents).

Preference to allocating crop varieties on the farm land is determined by the crop adaptability (25%), expected yield, the most productive plot (19%), high yielding crop variety with experience from previous cropping seasons (13%), prevalent weed species, etc. but there are farmers who do not have preferences at all. The distance from home does affect the distribution of crop varieties on the farm land. The interviewees were asked to mention the first three crops grown on farm lands nearer to the homestead. The following crops were mentioned; maize (50%), beans (44%), pumpkins (19%), vegetables mainly indigenous vegetables such as *Amaranthus sp.*, soya beans, sorghum, French beans, and fruit trees mainly papaya and oranges, sweet varieties of cassava, etc. They are early maturing (25%), needed often and all the time, do help in improving the diet and the health status, easy harvesting (25%), used immediately or soon after harvesting (19%). Sweet varieties of cassava are stolen if grown far away from the homestead. The crop varieties that are grown on distant farms include sweet potatoes, rice (56%), bitter varieties of cassava (44%), soya beans (31%), beans (38%), maize (31%), sorghum (19%) and coffee (19%). Rice has to be grown under irrigation in the rice scheme (31%), those crops and cassava in particular take long time in the field to mature (13%), are most adapted to the growing conditions hence need to be cultivated in large fields. Bitter varieties of cassava are more preferred to sweet ones because they produce quality flour for *ugali* making.

The reasons for which crops are no longer cultivated include, diseases, lack of quality seeds (31%), development and indigenous crops that became out of fashion, no interest in cultivating them (19%), there are more options for food or food items and changes in eating habits (25%), declined soil fertility (50%), lack of attention (13%), lack of market but some of the respondents do not know the reasons or simply ignore them (19%). For example, Cotton crop was much promoted during the colonialism time but later abandoned and replaced by rice. Few farmers conserved the planting material of the crop and the produce was sold in the neighbouring Burundi but today there is no marketing channel. The crop has completely disappeared.

Planting material other than own kept may be used for planting (figure 4). The germplasm is exchanged for cash or substituted for other cultivars. Wealthier farmers in the community are referred as always those that have planting materials (25%) but most importantly always have good quality (63%), farmers other than the rich people are possible sources of new germplasm as mentioned by 6% of the respondents.

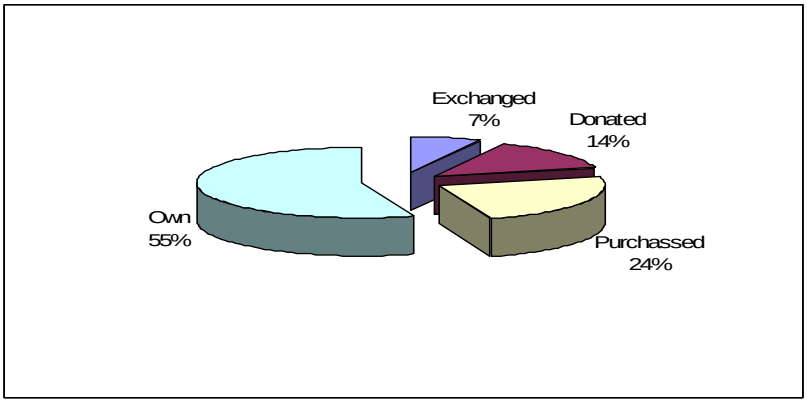


Figure 4. Proportion of seed in movement across the study area

The frequency of using planting materials from other sources greatly varies, every year (25%), only in case of calamities (100%), but also for other reasons (6%) for instance when the stored grains have been destroyed by rodents or weevils.

The reason for regularly using germplasm from other source may be due to traditional believes that for quality seeds other sources are better (25%), crop varieties change, degenerate or get tired (6%). The harvest may be sold out in years when grain price are high, eating or selling the harvest for cash needs (25%) or simply because for high yield other sources of seeds are better (3%).

The reasons for using planting material from other sources in case of calamities was said to include crop loss because of prolonged dry periods (63%), crop pests or diseases (13%), social commitments such as sickness of family members, funeral, wedding and other reasons which include poverty, etc.
In case of calamities when there is a total crop loss the source of seeds was said to be friends or relatives in the community (13%), other farmer in the community (6%), other farmers in other locations (19%), from the market (25%) or in rare cases from seed projects and/or government (13%).

In the community, one looks for who ever has the planting materials of a crop cultivar of a particular interest then proceed to request for a small amount.
Grain seeds can also be obtained through exchange, at times associations assists their members to acquire seeds for new crop varieties (13%). Seeds for new crop varieties/cultivars do penetrate in the communities through agricultural officers, seeds projects/government (31%), leaders or rich people (25%) since they travel a lot in far places and towns, on specific and rare occasions seeds are brought by

NGOs, distributed to a certain number of farmers who will then avail planting material to other members of the community in the subsequent seasons

Farmers have preferences based on characteristics associated with grown crop varieties and/or cultivars. These crop species include those which used to be grown by the respondents themselves, their neighbours, their parents, their relatives or other people in their surrounding.

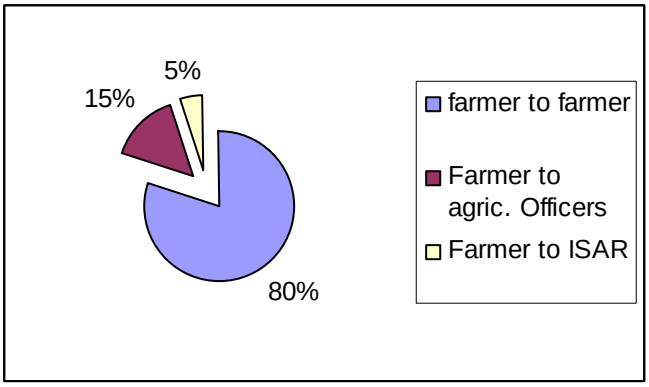


Figure 5. The kind of established linkages for seed exchange.

Figure 5 indicates that 5% of the respondents mainly from the lowlands in Muganza sector, at least at any one time have donated germplasm to the national agricultural research institute which also serves as the national genebank. Further information indicated that the least collection made in 2004 was on indigenous vegetables which were later sent to AVRDC in Arusha and there is no indication that this material transfer followed the protocol on benefit sharing in vigour.

Landraces are maintained by farmers themselves and a cultivar of particular interest may be brought from local or distant market if there is a chance to get them. The germplasm of particular interest is hardly found in the market (13%). The harvested grains are conserved in bags (19%) with an application of insecticidal chemicals if affordable or displayed on the top of a simple kind of shelves, or hung on smoke on the roof of houses. Landraces are maintained because they have a good taste. Only 25% of the respondents said to be aware of any newly introduced/cultivated crops in their environment.

The introduction of new crop cultivars, as told by the respondents, aims at obtaining higher income from farming activities. They help many farmers in

poverty reduction but they require good fertile soil to be able to give the good expected yield (19%). Agriculture is ever improving; there is a constant development (13%). Landraces have disappeared at it is normal since even in well taken care off crops such as rice, farmers have noticed that varieties get tired and degenerate.

However, the introduction of new germplasm is received with fear, community members do not know the side effect *i.e.* health hazards if eaten, noting that farmers eat grains bought from the market ignoring the source, do not know the reason why they have been brought in the village. New planting material may fail to produce if cultivated. For instance a maize variety was brought in Muganza sector and failed to produce any cobs. Also, there is a variety of rice that was introduced and it became difficulty for threshing. In small scale rice growing, the threshing methods consist on hitting bundles of rice to stones and this resulted in the breaking of grains since they were very difficult to remove from the stalk.

As told by the respondents, some landraces have vanished and/or on the way to vanish as a result of introduced equivalent planting material. There is no difference, in the use of crop residue of landraces and improved varieties and they are commonly used as mulch in coffee plantations as well as in feeding animals.

The respondents said to have faced with complete crop failure due to drought, pests and diseases at least one time in their farming experience mainly with beans and cassava crops and several times in the past 5 to 8 years especially due to drought. Following the 1994 war and genocide, all the crops that were on the field mainly beans, maize, rice and banana got lost, as told by the respondents. For those who completely lost seeds for local crops reconstituted their seed stock through requesting planting material from friends, relatives or other farmers in far places, buying from the market, then saving little by little on the harvest until their seed stock was reconstituted but in the community, there are those who managed to harvest as usual and they are the ones who donated initial planting material to their fellow farmers.

19% of the respondents think that production practices of landraces such as land preparation, planting, threshing, and harvesting as compared to improved varieties is discouraging. Too much fertilization is required, they require special attention, and they take time to rich the right harvesting stage, etc. and the market price of local varieties is lower than that of improved crop varieties.

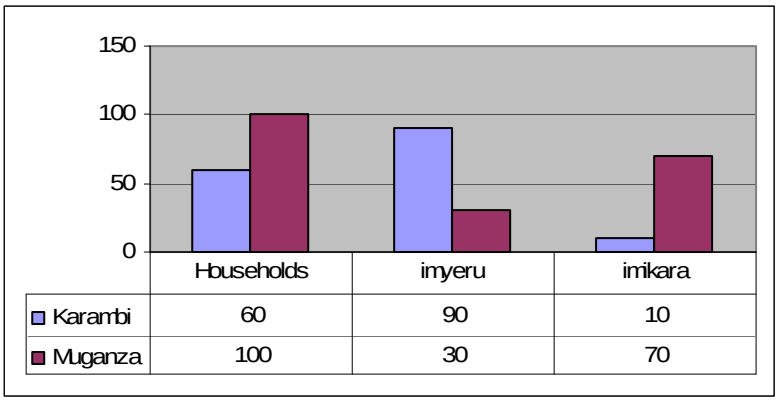


Figure 6. Trend in *Colocasia taro* grown in the study area (estimated % of households)

From figure 6, it is seen that *Colocasia spp.* are still grown in the study area in considerable number of households. Through visual appreciation of the crop plants that are found scattered in the field and in association with other crops especially in the highlands, are more of weeds than crops.

Seed selection is practiced by 38% of the respondents, the rest instead use left over for next planting season. Those who do select seeds mainly do it by removal of diseased and bad looking grains. Farmers believe that without selection high yield cannot be achieved. All members in the household are responsible for seed selection being the husband (44%), the wife (75%) and the children (6%), as told by the respondents. The selection practice is deliberate in 88% of the respondents. In 19% of the cases, they do practice pre-harvest seed selection method, which include pure selection (25%) and mass selection (75%). Special activities carried out in the field during seed selection for selecting a plant or part of the crop include the removal of diseased and damaged plants, removal of weeds, selection of a particular plant of interest and cleaning the field.

The seed selection techniques/knowledge is transmitted from parents to children. Children learn from parents (44%) through learning by doing. First of all they learn how to appreciate quality seeds through seed sorting by removal of bad, diseased seeds and unfit grain, and then they practice plant selection through doing it together with the parents.

Table 1. The price of Cassava products (Frw)*

Cassava products	Gashonga	Nkanka	Bushenge	Nyakabuye	kanjongo	Giheke	Mean± SE
Unprocessed	100	±120	±90	80	80	±60	88.33±8.33
Dry	200	250	±220	150	120	80	170±26.3
*Imivunde***	250	180	±160	150	200	100	173.3±20.6
Flour	120	±120	150	150	100	120	126.67±8.03

* One US $= 550 Frw

** Approximately fermented cassava product free from cyanide acid

The prices of different cassava products (table 1) are significantly different (Kruskal-Wallis test, H=11.1; p=0.011) across the sites.

The majority of the respondents store their farm produce. The respondents do not know really how long it takes to conserve viable seeds with their techniques, but as told by the respondents, the maximum time can go up to four years. Different respondents said to frequently stored grains for five months up to one year and the maximum time of storage period so far tried was up to two years. Special conservation treatments that are used before storage include the application of chemicals if affordable (13%), sun drying (100%), smoking, and removal of diseased grains, the use of ash and the use of herbs. These are ancestral, easy and cheap practices. Traditional methods are more preferred since chemicals are very expensive. Storage problem that are encountered include the failure of grains to germinate, when there is excessive rainfall grains go rotting (25%) or if attacked by weevils (19%).

Table 2. The price of root and tuber crops in the study area (Frw)*

Cassava products	Gashonga	Nkanka	Bushenge	Nyakabuye	kanjongo	Giheke	Mean± SE
Cassava	100	±120	±90	80	80	±60	88.33±8.33
S.potato	70	70	90	85	50	±60	70.33±6.11
Taro	80	80	100	80	80	80	83.33±3.33
Yam	100	±80	90	80	100	100	91.67±4.01
I.potato	130	100	100	180	90	100	116.7±13.8

* One US $= 550 Frw

The price for different root crops (table 2) is significantly different (Kruskal-Wallis test, H=13.16; p=0.01). The price of yam and taro is closer to that of Irish potatoes.

The preparation of grain seeds for storage include washing, drying, threshing, etc. and farmers apply simple techniques to test if grain seeds are dry enough for

storage. In Muganza sector, naturally hot, farmers do not worry much about the drying and the moisture content before storage unlike in Karambi sector, humid area. However, a simple cracking of grains under the teeth for an experience person helps to judge the level of moisture and a decision is made if it is the right time for storage or not. The other method is through rolling grains between fingers to estimate through feeling, the level of moisture content. Generally little amount may be dried at a time depending on the size of the free space available in the compound, but for rice production there are common cemented drying grounds and it is possible to dry 5-10T at once. Depending on the crop type, some are completely dry after the harvesting while for others one has to wait for two to five or six months before long term storage can be made. However, seed viability tests *i.e.* germination test, are never carried out by farmers. They make sure that the harvest is clean enough through threshing before storage and grain sorting through removal of diseased, insect damaged, etc. is carried out shortly before sowing.

The decision on the number of landraces to be grown is usually made by women (50%), men (6%) or both (44%). The allocation for each particular farmland is made by women (25%), men (19%) and by both in 44% of the respondents. Farmers (75% of the respondents) do selectively allocate different parcels/plots of land for different cultivars but others do not (19% of the respondents). Such allocation is based on

(i) crop adaptability, cultivars that performed well in the past
(ii) location, soil type and fertility level; and
(iii) availability of manure.

The fractions of grains which will be used for food is separated from that of grains which will be used for planting purposes and separately from other types of grain crops as told by 63% respondents.

31% of the respondents had at least at one time practiced the mixing of grain of different landraces either at planting or when storing, but 63% had not because each crop variety is stored separately. The reason behind this separation is because the grains for different types of crop get attacked by weevils if stored for a given period of time. Normally, the mixing is made just before sowing and it is best suited for their small land holding and also favoured by the lack of storage facilities. The decision on the kind of mixtures is made either by female (19%), male (6%) or both (13%).

All the respondents said that women have access to land ownership either through land distribution or inheritance but do not in 13% of respondents. The reason is simply because women are naturally weak, hence cannot be trusted.

Women play an important role in seed selection during pre-, post-harvest and storage because in many instances men are occupied by off-farm activities. Women have the responsibility to take care of crops and cultivars. There is a traditional division of labour such that the man is responsible for clearing the land and the threshing falls under woman' responsibility. The hiring of male or female in casual labour is also based on kind of activity to be performed. The majority of the respondents especially for rice production do use external labour and women do accompany and supervise the hired casual labour since men are most of the time committed else where, in social or in better paying occupations.

The maintenance of crop diversity and the contribution of agricultural practices to basic livelihood strategies in the study area were found to be much anchored in the culture.

Table 3. The effect of cultivating root and tuber crops on mounds across sites*

Strategy	Enhance diverse uses of farmers' varieties					Optimize the use of diverse on-farm resources					Increase resilience of the system and/or reduce risk					Mean ± SE
Site	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Cassava	4	5	4	4	4	3	5	5	4	4	4	4	4	4	4	4.133±0.133
Taro	4	2	1	4	4	3	2	4	3	3	4	3	2	3	4	3.000±0.239
Yam	5	5	5	5	5	3	4	2	4	4	4	3	1	4	4	3.867±0.307
S.potato	5	4	4	5	4	3	4	3	3	4	5	5	2	5	4	4.000±0.239

* Scale one to five where 1 = lowest and 5 = highest scores

The cultivation of roots and tuber crops on mounds significantly enhances the diverse use of cultivars (table 3) across different locations (Kruskal-Wallis test $H=11$; $p=0.008$). There was a tendency for the practice to significantly increase resilience of the system or reduce the risk between the crops (Kruskal-Wallis test $H=6.57$; $p=0.087$). The cultivation on mounds is mandatory for Imburamuzi cassava cultivar (appendix 4)

Table 4. The effect of flat land preparation on root and tuber crops across sites*

Strategy	Enhance diverse uses of farmers' varieties					Optimize the use of diverse on-farm resources					Increase resilience of the system and/or reduce risk					Mean ± SE
Site	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Cassava	2	1	3	1	1	1	2	4	1	4	1	1	0	0	1	1.533±0.322
Yam	1	2	3	2	0	5	4	4	4	4	1	2	2	1	3	2.533±0.376
S.potato	2	3	2	2	4	2	1	3	1	2	3	3	4	4	4	2.667±0.270

* Scale one to five where 1 = lowest and 5 = highest scores

It was observed that the cultivation on mounds is often practised in pure stand, but due to small land holding, the tendency is to grow many crops in association hence the flat land preparation (table 4). Statistical analysis shows that levelled land preparation significantly reduces the risk or increase resilience of the system for roots and tubers crops across the sites (Kruskal-Wallis test H=11.24; p=0.004).

Table 5. The effect of on-field conservation of root and tuber crops across sites*

Strategy	Enhance diverse uses of farmers' varieties					Optimize the use of diverse on-farm resources					Increase resilience of the system and/or reduce risk					Mean ± SE
Site	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Cassava	2	2	3	1	2	1	2	1	2	1	4	4	4	4	4	2.467±0.322
Taro	4	3	3	4	4	4	4	4	4	4	4	3	4	4	4	3.800±0.107
Yam	3	4	2	4	5	4	5	3	4	4	2	1	4	2	2	3.267±0.0316
S.potato	5	5	5	5	4	4	3	2	4	4	4	4	2	3	3	3.800±0.262

* Scale one to five where 1 = lowest and 5 = highest scores

On-field conservation of the crop produced through harvesting the small amount that is of direct use either for home consumption or for sale in local markets, had a significant effect (table 5) in enhancing the diverse use of landraces (Kruskal-Wallis test H=13.01; p=0.005) and a significant difference in optimizing the use of diverse on-farm resources (Kruskal-Wallis test H=13.33; p=0.004). The practice also had a tendency to increase resilience of the system and/or reduce the risk (Kruskal-Wallis H=9.55; p=0.023).

Culture is made up of believes, dos and don't. In the study areas, as told by the respondents, it is believed that:

(i) One shall not drink milk if s/he has eaten meat products, yam and/or Irish potatoes;

(ii) Yam crop cannot be grown on the roadside; it has to be hidden some where in the farmland otherwise passers-by may contaminate the field. To prevent this contamination, *Ephorbia tirucalli* or *Synadenium grantii*

plant species are planted at the same time with the crop to be protected, in many instances groundnuts and yam crops;

(iii) It is also believed that yam produce, at the harvest, cannot be transported across the river otherwise it will not taste good, it will not be fully cooked;

(iv) One shall not tress pass the place at which roots of yam have been washed;

(v) Grain covers of ground nuts are pored between two ways so as to protect the crop against unknown diseases;

(vi) The first harvest, *umuganura*, has to be served to the husband in the family, but if his parents are alive they are the ones to bless the harvest. In the same idea, at planting time, when the first rains drop, the children reassemble in their parents' field to sow seeds. No body is allowed to sow seeds on the owned field before sowing for the parents "in-laws";

(vii) When there is a new born in the family, there will be a ceremony known as *Nyabwerera, ubunnyano*, to give him/her a family name. On this occasion other children in the nearby will be invited, served food, in many instances beans boiled together with bitter banana cultivar. Each child in the group will suggest a name after which all of the children will go to cultivate using a piece of wood. Water will be pored on them "blessing", assuming that it has rained to make an end to the ceremony;

(viii) Sowing seeds of cucurbitaceous is made immediately at the onset of the rain season. Young children in the family will wake up very early in the morning, before washing their faces or showering and proceed to sow seeds. It is believed that whoever will be lucky in future will be the person whose seeds will produce a better crop and high yield;

(ix) It is not allowed to point fingers at a flower or a fruit in formation, other wise they go rotting;

(x) Seeds for cucurbitaceous family will be sown on the sand left after burning crop residues, *ikiyorero*;

(xi) When earth quake takes place, cassava, sweet potatoes and groundnuts will rot. To prevent the rotting, farmers will uproot plants situated at the beginning of the field to rescue the rest of the crop;

(xii) Women are not allowed to harvest bananas other than the cooking type;

(xiii) One cannot make fire from where pounded cassava leaves, *isombe*, is being cooked otherwise the taste will be bad, it will not be fully cooked;

(xiv) Bean leaves known as *umushogoro,* cannot be harvested after it has rained;

(xv) The first harvest of maize should be roasted on bean's crop residues so that beans and maize shall always mature at the same time.

Cultural believes

Cultural mentalities influences seed systems positively and negatively. Those mentalities help in conservation of crop genetic resources because of the great importance and respect attributed to indigenous crops. For instance not planting yams near to the public way may assist in keeping quality crops and selection of germplasm, neither stolen nor contaminated. Thieves normally chose the best looking, healthy plants. It is believed that seeds of African cucurbitaceous crops *i.e.* cucumber, gourds, pumpkins, etc. should be sown on ash left after burning crop residues. Obviously, the practice will help to obtain a good crop stand because of mineral elements directly transformed and available to the plant. Seed quality can be improved. However, one should not ignore the side effect of this burning of crop residues.

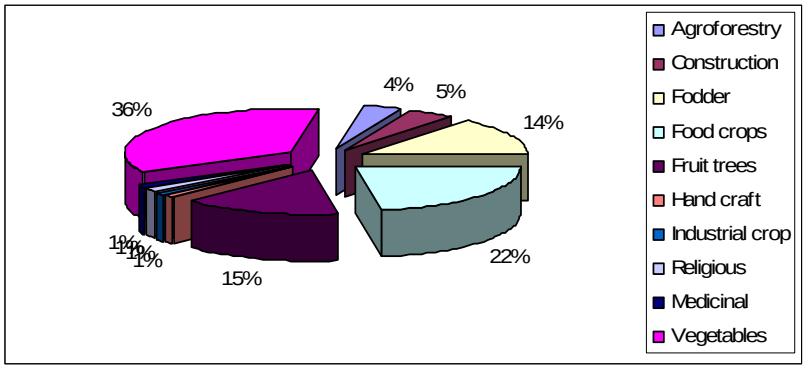


Figure 7. Proportion of species found in home gardens in Karambi sector.

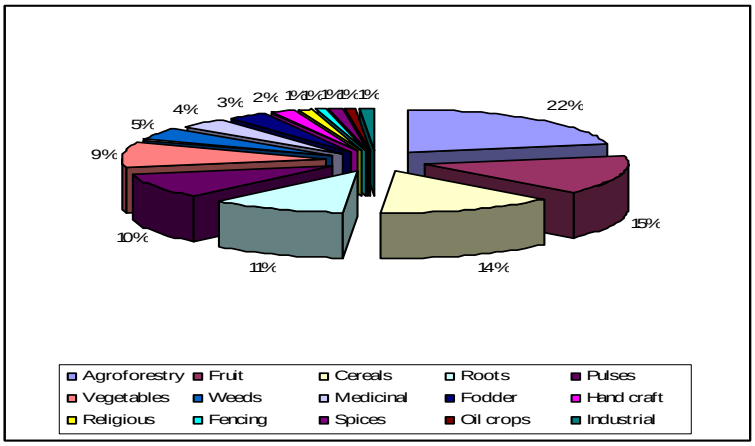


Figure 8. Proportion of species found in home gardens in Muganza sector

From figures 7 and 8, it was observed that there is a high proportion of species in the home gardens of Muganza than in Karambi sector. In the two sites it was found that coffee is part of the home garden which makes it to be of high value in terms of income but also it has an added advantage in conservation and production of various types of vegetables. There was no clear boundary between home garden and field for main crops, there is an intermixture of various kinds of crops around the homestead and even in the compound.

Shift in kind of grown crops and their effect on food security

The shift in crops upwards in elevation (figure 9) has driven sweet potatoes to now being grown in the hillsides, but also this goes together with market price and the tendency in increased soils erosion. It was found that the expansion of rice is through try and error and farmers should be guided by research based findings to avoid the loss of time and resources.

Figure 9. Shift in crops upwards in the study area

Yam crop has also shifted and is found more concentrated towards Nyungwe national park. It was noted that *Inyabojo,* and cultivars possessing thorns, are more grown in the highlands while the cultivars without thorns, *Ibikoro by'inka, Ibirundi*; are more found in the lowlands. However, with the expansion of tea plantations in the highlands and particularly in the buffer zone to Nyungwe national park and the surrounding, tea growing is likely not only to affect yam growing but also all the food crops in general *vis* climbing beans, Irish potatoes, cassava, banana, etc. and the risk of loosing finger millet cultivars, will be much felt in the highlands, in Karambi sector. Hence the urgent need for collection and ex-situ preservation of the crops and varietals diversity at risk for the benefit of crop improvement and future generations. However, it is clear that the national agricultural research institute alone cannot manage this task with regard to the danger at hand especially with the rate at which landraces are likely to disappear.

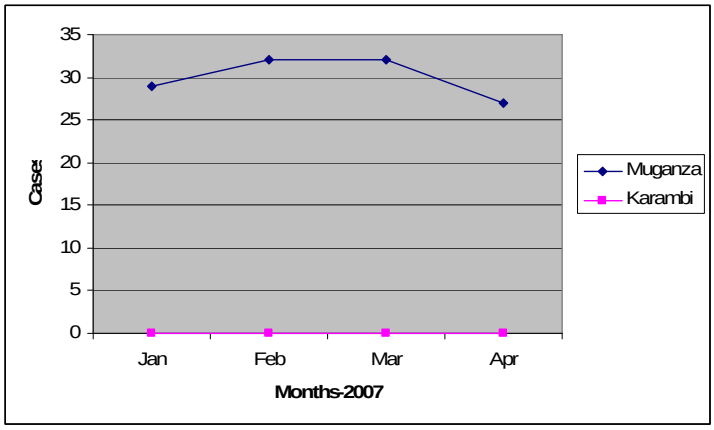
Food diversity, a health status

Major factors affecting access to food are prices and incomes. It was noted that some modern restaurants in Kigali are getting specialized in traditional foods such as yam and *Solanum melongena* was found as a special preparation alongside vegetables (figure 10). Irish potatoes are roasted in nearly all bars. So, value addition or simple promotion of indigenous crops such as taro and yam may make wonders in improving the livelihood of rural people. It was found that some crop varieties are of more value to specific community groups. The current situation of food security in Rwanda is alarming. There is a shortage of food both in quantity and quality with regards to major nutrients.

(a) Sweet potatoes with β-carotene (b) Taro and beans (c) *Ugali* and vegetables (d) Yam (e) Roasted potatoes and meat

Figure 10. A sample of root and tuber based dishes in the study area

In the lower elevation in Muganza sector with expanding rice scheme, cassava and maize specialization, indigenous vegetables being replaced by cabbage and tomatoes as cash crops unlike in the high elevation rural area in Karambi sector where agriculture remains traditional, kitchen garden composed of indigenous vegetables and wild food collected from all over, severe cases of malnutrition (figure 11) have been recorded by Muganza health centre. It should be noted that only reported figures are from those who visited the health centres, in acute and severe level that needed urgent attention, the situation on ground may reflect a worse picture.



* Bugarama rice scheme is part of Muganza health centre

Figure 11. Cases of malnutrition recorded by health centres in the study area

There are a number of wild foods for human beings, animals and birds found in the study area. Wild food diversity in the study area includes indigenous vegetables, mushrooms, wild fruits, insects, birds and animals such as moles, honey, etc. They are sources of traditional medicine and food for all the categories of peoples, the rich as well the poor, adult and young regardless of the social groups. They are always available whenever there is sufficient rainfall, and the

surplus may be sold earn some income, as told by the respondents, they are normally sold in local markets. Several species of edible wild plants have high concentrations of pro-vitamin A carotenoids, folate and some minerals (Ogle, M.B., 2001).

Leaves of cassava when pounded will be eaten as vegetable locally known as *isombe*. Roots of cassava are turned into flour then a traditional meal in form of cake known as *ugali* is made. It can be served together with beans, meat, indigenous vegetables as well as with *isombe*. *Isombe* is recommended for breastfeeding mothers. *Isombe* as well as leaves of Colocasia taro and Xanthosoma could as well play a major role in the nutrition of malnourished and people with poor health status such as those with HIV/AIDS infection. However, it was found that not all cultivars are suitable for leaves harvesting. *Maryohe* or *Gacacana* cultivars normally have few leaves and leaf harvesting in *Imitarina* cultivar will lead to rotting of tubers.

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(a) Cassava planting material has become a scarce commodity (b) Taro cultivars ready for harvesting in a typical combination of crops and livestock in rural households in Muganza sector

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(c) Cooked taro (Amaganda cultivar boiled in water) being sold along the road side in Muganza sector, in front of a primary school at US$ 0,10 for 4 pieces (d) Taro , Amazungu cultivars being sold in local market in a basket. The presence of Imyeru cultivar can also be easily noticed..

Figure12 a-d. Different aspects of commodity chain in the study area

In Rwanda, copping strategies to food security among other things include "one cow one family programme" through which few households get animals from the government then their offspring are exchanged among community members. The programme has just kicked off but its sustainability is questionable. In the study area, a number of rivers were found but do not have fish. Fish ponds are alternative source of proteins as it was observed in Muganza sector, fish ponds belonging to a scout unit were found besides the rice scheme. However, the scaling up is needed.

Discussion

The government of national unity in Rwanda is geared towards decentralisation of services and good governance. There are participatory annual work plans, *imihigo*, right from the grass root level, and planned activities are carried out through communal activities known as *umuganda*. The role of community member is commendable in solving problems at community level, in meetings organized to this effect. In the study area, as well as at national level, throughout the period in which the study was carried out, local population was performing traditional *gacaca* jurisdictions to try community members presumed to have participated in the 1994 genocide. The inhabitants are recovering from the shock and there is an improvement in social cohabitation and cohesion. Community members assist one another for instance when it comes to carrying a diseased person to the nearest hospital. Families are being encouraged to voluntarily produce few children that they can provide basic needs for instance feeding and education.

In the past decade, Rwanda has made significant progress in almost every aspect of its development, from health to poverty reduction, which has enabled it to regain or surpass pre-1994 levels in many key development indicators (UNDP, 2007).

Despite that there are tremendous efforts in soil erosion control and in restoration of soil fertility, some households still have the awkward mentality of burning weeds and crops residues. This practice is not only a waste of resources but destroys soil structure, texture and also soils micro organisms.

The social networking helps in agricultural activities and genetic resource management in the study area, in the sense that farmers' associations do assist their members in acquiring soft loans in form of farm inputs basically seeds, fertilizers and pesticides for rice production, which are reimbursed at the harvesting time. There are cases of farmers who, due to insufficient production do eat every thing that was harvested then rely on friends or on the market to get seeds for the next planting seasons. "A significant proportion of farmers in Rwanda, Burundi, and DRC, and a small percentage of farmers in Uganda, are chronically short of seeds and obtain all of their seeds from off-farm sources every season" (Sonia D. and Sperling L., 1999).

It was reported that for cassava due to heavy infestation of cassava mosaic virus, planting material for the first time in Muganza sector is being stolen from the field and/or sold at the price varying between 500 to 700 Frw *i.e* between 1 and 1.3 US$ per bundle, weighing approximately 30kgs. In the southern part of Rwanda, "in

the early 1990's, pre-war, it was not too unusual to hear of someone being beaten to death by neighbours for stealing some cassava roots" (Sperling, L.).

There are many households growing bitter cassava cultivars on large fields in Muganza sector unlike in Karambi sector where sweet cultivars are predominant. This could imply that cassava which is grown in Muganza sector is market oriented i.e. generation of income while in Karambisector, it is geared towards home consumption i.e. food security.

Simply by looking at the stem, leaf colour or shape and/or roots and if need be, the confirmation is done through lipping the tip end of a cassava root; farmers are able to tell whether a cultivar is sweet or bitter. Cultivated Cassava cultivars fall into two groupings and are classified as either *Maryohe* or *imiribwa* and *Marure* literally meaning sweet cultivar that can be cooked and bitter ones, respectively. Bitter cultivars need to be processed to reduce the level of cyanide acid before they can be cooked dry boiled together with beans or processed into cassava flour. The local classification of Cassava plants into cultivars with local names thus reflects a skilful morphological recognition of several locally preferred genotypes (Mkumbira, J., 2002, Chiwona-Karltun, L. et *al.*, 2000). 'Cool' and 'bitter' cultivars constitute two different crops with different roles in farming and food systems (Mkumbira, J., 2000).

The white cultivars, *imyeru*, of Colocasia taro are more profound in the highlands while the reddish type, *imikara*, is predominant in the low lands. Further investigations are needed to find out the relationship between this crop adaptability and the taro disease at hand. "Corm yield as well as taro leaf blight resistance, disease caused by *Phytophthora colocasiae*, is highly influenced by genotype, environment and their interaction" (Sigh *et al.*, 1995). "Cooler temperatures may have some effect on the poor or low expression of resistance genes" (Sigh *et al.* 2006). On the other hand, this crop adaptability may be linked with disease resistance. A study done in Ethiopia shows that in Barley, early maturing varieties were found to be more scald susceptible than late flowering ones (Leur Van A.G.J. and Gebre H., 2003).

It should be concluded that taro crop has been lost. However, for the purpose of crop improvement, those few remnant plants, probably have resistant genes to the disease that has devastated taro crop in the south-western Rwanda, hence need to be preserved. On the other hand, these plants may be constituting a reservoir of the disease and a total fields clean up may be needed. Further research need to be carried out. Options for long term control of taro diseases should include (i) the

use media such as radio, television, newspapers, etc. to advise farmers about the problem, what they should do about field sanitation, etc. (ii) the identification of disease free areas and isolate them (iii) the prevention from the spread of the disease via sales of cassava products in markets (iv) the soil application of Ridomil ®EC and calcium hypochloride to sterilize areas around taro plots but also foliar sprays using copper oxychloride and manzate so as to control leaf blight have shown good results in the American Samoa.

When farmer gets new germplasm, s/he multiplies it in the home garden in order to get enough planting material but also experiments it by making keen observations and comparisons with existing crop cultivars and by the same time makes own selections. In Kenya, farmers adopted NPP 670 variety of *Cajanus cajan* from observing it growing in the field and factors favouring the diffusion included its attractiveness as a cash crop, the ease with which it could be distinguished from other varieties, the low seed rate, and the relative ease with which growers were able to maintain seed purity (Jones R.B. *et al*., 2001). From similar findings, "it is well-known that Rwandan women take nearly exclusive responsibility for the bean crop: variety seed selection, weeding, sowing, and harvesting" (CIAT, 1995).

Rainfall is not reliable in the study area but at times destroys and leads to death of residents. "Sub-Saharan Africa has the highest proportion of people living in extreme poverty and the extreme climate events, such as drought and floods continue to threaten the livelihoods of the poor. Climate change thus presents a serious risk, to livelihoods as well as the national economies. The International Research Institute for climate and society (IRI) calls for an integrated and participatory approach that incorporates climate science into multidisciplinary development planning" (ASARECA, 2007).

Indigenous crops are good, needed all the time, eaten on daily basis but are on the decline and there is risk for hunger in the near future. These crops are low yielding but they give good yield if well taken care of and have good taste. They fetch high price in the market but not always available. Planting material remains a serious problem and for taro and cassava in particular, the crop is being wiped out by diseases. Crops such as sugar cane, tomatoes, etc. do not earn much income to farmers by the fact that they lack marketing strategies, cannot be stored for long term and there are no transformation units in the nearby.

In the study area, it was said that seed is very expensive; the price varies depending on the situation in the market. There are various constraints in accessing quality seeds. For instance, when there is hunger farmers feed on every thing that was

harvested. Comes the sowing seasons, prices are too high. One has to travel for long distances, in difficult conditions, to purchase grains which will be sown as seeds but at an exorbitant price. It is difficult for one to get what s/he wants from the local open markets.

There are no such activities in seed production being carried out in the study area but the research institute (ISAR), Ntendezi research stations, situated in between the study sites approximately 5 hours drive from Karambi and one hours drive from Muganza sectors, does seed multiplication in insufficient quantity for selected priority food crops and for research purposes. Located at Ntendezi, Nyamasheke district, at 1600m above sea level on acidic soils; its land size is only 50ha out of which 20 ha are for grazing animals and crops are grown on approximately 10ha per season. The station also supervises other two experimental sites (i) Mwito, 7.1ha out of which coffee occupies 3.1ha and *Themeda sp., Tripsacum sp. and Pennisetum sp.* which are used for mulch are grown on 2ha, and (ii) Bugarama, a 0.6ha plot used for maintaining collection of banana cultivars, additional 2ha have been acquired for experimentation on rice. Basically, Ntendezi research station has got no capacity for seed production.

Genetic erosion has taken place. Some crop varieties that existed in the past have disappeared and currently have been replaced by others. The production of landraces is decreasing (31%). The main reasons are low disease resistance and high bird attack. Things have changed these crops have become out of fashion and hence have disappeared and the remaining ones are cultivated in small acreage, it is difficult to get the planting material, the land is cultivated throughout the year. Declining soil fertility and climate change have also proven to lead to inadaptability of crops and cultivars of particular interest, hence the loss of diversity and crops have become more vulnerable, as told by the respondents. 31% of the respondents said that landraces are much important to them.

The number of species and varieties grown over the last 10 to 20 years or so are declining as told by 81% of the respondents. The effect is much felt in crops such as cassava. Indigenous crop varieties are in decline but varieties for crops such as rice are ever increasing due to success in research activities. Other reasons include the small landholdings, the fact that those crops take long time to mature, much attacked by diseases, declined yield and the lack of seeds (25% of the respondents). It was also mentioned that indigenous crops and existing crop cultivars become out of fashion due to the introduction of new planting material.

Considerable numbers of wild animals and bird species that existed have disappeared, as told by the respondents, due to lack of living conditions *i.e.* food shortage, destruction of habitants as a result of expanding agricultural activities, bush clearing and fire, cleared forests, hunting, toxic chemicals such as acaricides, insecticides, etc, and the loss of economic value. Crops that were grown among others in the past 15 to 20 years or so are crops that are no longer cultivated. As told by the respondents, they include different types of vegetables, fruits, fodder species, cereals, medicinal plants, spices, nuts, etc. It was noted and this confirms earlier observations that a farmer may loose a crop variety but the same crop or that particular variety may be found else where with other farmers in the vicinity or far away in the same sector. "Rwandans…they harvest roughly 500 types of beans, 50 varieties of sorghum, 10 to 12 kinds of maize, and 8 or 9 different sweet potatoes" (Adler, T., 1995).
It should be noted that in the study area, it is unusual to travel in far places; community members live and stay around their villages or in the vicinity.

There are negative influences associated with traditional believes. Seed exchange and crop improvement can be hindered for instance by the fact that yam cannot be taken across the river. Timely sowing is a very important determinant factor of good crop stand and good yield. However, the fact that one has to first sow seed for the mother in-law before sowing own crops, may bring delays in planting hence resulting in poor crop stand and harvest. In the same sense, the planting of cucumber and similar crops may be delayed if one has to wait for a certain period to have all the children in the family together, because they hold the responsibility of sowing this particular seed. Some crop variety seeds may not be accepted in particular households because of their associated cultural obligations. A household headed by a woman may not adopt beer making types of bananas. In households that keep domestic animals particularly cows, will probably not be interested in growing crops such as Irish potatoes and yams, hence hindering crop diversity in a given area. Crop diversity and seed availability for roots and tubers such as cassava will always be on the lower side in areas where earthquake is likely to be prevalent.

It should be noted that Colocasia taro has almost disappeared in some parts of the south-western Rwanda but it was found grown in all households in Muganza sector, at least a few plants per household. It was also highlighted by the FGD that seed availability for taro is increasing with time, and no longer a big problem in Muganza sector. This needs to be verified. However, it could partly be attributed to the neighbourliness with Burundi which is a potential source of planting material, then farmers' practice of exchanging seeds may be contributing to reverse the situation of taro seeds crisis. However, the free movement of planting material

across borders needs to be looked at with caution. Because of the war and after effects, coffee plantations and food crops in these fertile plots were neglected, that were free of diseases, hence the multiplication a variety of fairly clean planting material of colocasia taro. Like wise, in Nicaragua, cocoyam production has relied on the use and re-use of vegetatively propagated material without any process of sanitation or reinvigoration. When harvests started to decline, farmers moved to new areas in an attempt to increase the yield, but since they were using already infected planting material the disease was instead spread. The use of disease-free planting material is therefore of utmost importance as a way to prevent the spreading of the disease to new areas in the region and to other regions in the country (Ryes Gastro, G. 2006).

The shifting in cultivation zones, crop movement across borders and crop adaptability in addition to climatic changes have to be seriously addressed. This requires the participation of all stakeholders, probably special projects have to be designed. The highest ever recorded yield in Xanthosoma *X.sagittofolium*, variety trial at ISAR was 36T/ha with the cultivar Kamembe (ISAR, 1983 annual report). As implied by the name, the material originated from south-western Rwanda. However, as some crop varieties/cultivars disappear as diseases spread out, we loose out potential genes for crop genetic improvement and food for tomorrow.

Lack of information may also be a hindrance to proper feeding. The preparation of cassava leaves (*isombe*), and guidance on eating it the Rwandan way, apart from radio and TV programmes may be found on the web, last visited 29 May 2007: http://www.cp-pc.ca/english/rwanda/eating.html

In Rwanda, MINAGRI's crop forecast surveys for 2007- short rainy season, meant a 4 percent decline in crop production as compared to the 2006 season. This is attributed to roots and tuber crops. The decline for roots and tubers is attributable to lower harvest of Irish and sweet potatoes due to a reduced cultivation area as a move to rice planting and less cassava due to the cassava mosaic disease but also too late rains followed by too much rains. It is a government policy to increase the production of rice as a cash crop (Ministry of finance and economic planning, 2007). Efforts are being made to multiply clean planting material of cassava but taro remains at risk; yam so far remains undisturbed.

It was observed that all agricultural practices are important to the conservation of landraces (appendix 1). The cultivation on mounds is mandatory for *imburamuzi* cassava cultivar. This explains why the cultivar is no longer grown as the land became scarce and crop combination is more practiced on a levelled land

preparation. Weeding is not compulsory in potato growing. In fact potato weeding is perceived by farmers as a waste of time. In Colocasia taro it must be done as well as in cassava. But in Xanthosoma, weeding is not observed because the crop in many instances is intercropped with mulched coffee plantations. The fact that coffee as a cash crop is part of the home garden, makes it more valuable in south-western Rwanda. Due to poor storage at harvest, farmers practice staggered harvesting on small amounts, which is of direct use for home consumption or sale in local markets. But for *Kanyoma* cultivar of sweet potato, it should be harvested as soon as it attain physiological maturity otherwise it rots. *Amazungu*, is the only cultivar that has shown suitability for prolonged storage in a pit, the rest will sprout.
For other root crops prolonged storage can only be done with prior transformation of the produce. Post-harvest technology was also found practices through sun drying of cassava and Xanthosoma leaves. There is need of scaling up simple existing technologies to assist farmers.

In Muganza sector, there is a cooperative that produces liming material. It is a great opportunity for inhabitants of Karambi sector and many other places in south-western Rwanda since it solves problems of soil acidity. However, this comparative advantage is less exploited in the region. Farming is a business not just a means of survival. What you put in the soil bring about what you get out. This requires proper planning on how much seed, fertilizers, expected out put, etc. Farmers need to be trained. Extension services need to be improved, farmers need to be guided and provided with relevant information.

There are few farmers who prepare themselves animal feeds. This entrepreneurship needs to be supported, the raw material such as rice bran is readily available but wasted. There is need for farmers to be facilitated in acquiring loans and credit facilities. Special credit schemes have proven to be useful if community members are working together in associations.

There is need for early warning and preparedness strategies to famines indicators. A high attack of aphids and a high sensitivity to viral diseases, Dasheen mosaic, was recorded for the first time in Taro (*Colocasia esculenta*) variety trial at ISAR Rubona in 1983 (ISAR annual report) and no action was taken. To date the crop has been wiped out in south-western Rwanda. Banana wilt disease was observed in Karambi sector, other crops and fruit trees are being threatened by various kinds of diseases mainly viral diseases; that need urgent attention.

There is an urgent need to have a national genebank which properly serves the purpose. With the current structure at MINAGRI (i) administratively, the genebank should be a unit within RADA (ii) but for the time being it is housed within ISAR facilities and among other duties should supervise the management of plant genetic resources and advise on the movement of plant genetic resources across national boundaries. At ISAR, (i) research programmes should concentrate their efforts toward breeding and creating much superior crop varieties (ii) The seed unit at ISAR needs to be reorganized and coordinated in different research stations to ensure not only quality seed produced but also crop diversity given proper attention in a decentralized framework and above all maintain genetic purity of the crop seeds (iii) Attention needs to be made towards staffing, training and retaining of qualified personnel.

It was found out that there is a high dependency, above 80%, on farm saved seeds. There is need for balancing between food security and genetic diversity with the need of increased yields. The current crop priority setting needs to be revised and needs to be participatory. It is not fair to generalise since even within an agroecological zone there are micro climate suitable to particular crops. It was surprising to find that finger millet is grown by a conservative farmer in the lowlands, in Muganza sector. Crops such as yam and taro play a major role in the study area, being for home consumption, income generation and animal feeding, which are associated with cultural beliefs. It was also found that finger millet growing is a speciality of aged women. So, with the current population structure with the majority being young, there is a risk of loosing landraces in the near future.

Rice, cash crop and priority crop at national level, is becoming important in the study area and in Rwanda at large to the extent of even being tried else where, where it was not adapted before, in the highlands as it was observed in Karambi sector. Rice is an important cereal crop in developing countries. It is adapted to hot and humid regions in the lowlands. In Rwanda, before 1994, the total land size was nearly 3000ha with a production approaching 10000T/year, to date the rice schemes covers about 5000ha (MINAGRI, 2004) but the objective is to achieve at least 40000ha in the year 2010. Rwanda's 165000 hectares are said to be wetlands, out of which 92000 hectares are already being cultivated (MINAGRI, 2007). Rice requires good, fertile, irrigated soils, fertilizers and chemicals. Hence, due to its expansion rate it is replacing long grown indigenous food crops, vegetables as well as medicinal plants locally adapted on small scale farming set up. Landraces are likely to face the same fate as cotton.

Micronutrient malnutrition, primarily the result of diets poor in bioavailable vitamins and minerals, affects more than half of the world's population, especially women and preschool children (CIAT-IFPRI, 2002). New orange fleshed sweet potato varieties, rich in β-carotene converted by the body into vitamin A, have been developed by international research institutions and currently available in Rwanda. Some evaluation trials have been conducted in south-western Rwanda. They may be found in few homesteads. However, crop specialization tends to results in poor nutrition and health status.

With the revival of the great lakes community (CEPGL), efforts need to be pulled together to control common diseases and pests. Research activities that had been put to a stand still at the regional agricultural and animal husbandry research institute (IRAZ), located at Gitega in Burundi should be resumed and especially existing research findings for crops like taro should be immediately disseminated to rescue farmers in the south-western Rwanda who have lost this much appreciated crop but also to the benefit of the region as a whole through trade. "Hunger is a political creation which must be ended by political means" (Clover J., 2003, Morris, J.). Taro is currently being imported from DR Congo into Rwanda. There is need for ISAR to resume research activities in taro and yam. For instance, this could be achieved through regional collaborative projects under the umbrella of ASARECA

The current seed law that was enacted in 2003 to date has got little meaning without its application ministerial decrees. It remains unknown and public awareness is badly needed. In the same way the country needs to develop appropriate plant variety protection (PVP) and phytosanitary laws. However, the PVP will be meaning less if there are no new varieties to be released, hence breeders being private or from public institutions should constantly produce new and superior varieties. Also the public funds invested in research should only be justified if the end-user enjoys the outcome.

The major problem remains on how informal seed sector can produce quality seeds of a certain acceptable level. The first step should be to train farmers on how to produce quality seeds through their own means. Training in techniques, should be accompanied by setting up of demonstration sites. No way can food security be attained with the current rate of 3% production in quality seeds if more than 90% of inhabitants depend on agricultural activities for their survival. The private sector needs to be convinced and be called upon to venture in the seed industry. Taking into consideration the reality in my study area, the majority of farmers are living in extreme poverty and yet any quality seed that is produced is sold at expensive

prices. The ministry of agriculture has no single seed producing farm or seed shop in the study area and near by suburbs.

Among other things;

(i) for effectiveness in management and better services, the government owned seed producing farms should gradually be privatized
(ii) the priority in research activities carried out at Ntendezi research station should be based on local needs and translated into solutions to local agricultural problems
(iii) there are farmers who are willing to specialize in seed production despite the small land holding that make it difficult to respect the required norms such as isolation due to the distances between plots of the same cop variety, training should start off to curb this and
(iv) households need to be guided to get organized into cooperatives to cater for their common interests.

Now that the problem of land and land tenure in particular in Rwanda is being addressed by the new land bill, farmers can pool together their pieces of land to form estates, the main problem remains access to credit and agricultural inputs. Farmers should have access to quality seeds and extension services should help do advise farmers in proper land management with the use of modern agricultural practices. There are various cheap technologies that simply need adoption and appropriation. I believe that much effort should be invested in training farmers, local seed producers, as the first step towards graduating informal seed production into a kind of strong seed system that perfectly fits into the small land holding situation in south-western Rwanda and the whole country at large.

In order to achieve vision 2020, UNDP suggests that Rwanda must invest 79.6% of its labour force who are currently employed in agriculture, to enable them became engines of small and medium enterprise development, investment and economic growth (UNDP, 2007).

Conclusion

In the study area, rural people depend solely on farming activities for their survival. There are few opportunities for off-farm employment. Farmers have turned to yam in replacement of taro which has been wiped out by diseases. The expansion of rice as a cash crop in the study area is through try and error and farmers need to be guided by research based findings to avoid the loss of time and resources. The cultivation of roots and tubers crops on mounds significantly enhance diverse use of landraces across different locations (Kruskal-Wallis test H = 11.00; P = 0.008). However, due to small land holding, the tendency is to grow many crop in association hence the flat land preparation. The practice significantly reduce the risk or increase resilience of the system for roots and tubers crops across the sites (Kruskal-Wallis H = 11.24; p= 0,004).

Crop specialisation brings about less diversity in food leading to malnutrition. New varieties developed by research do not effectively reach the end-user probably due to lack of effective distribution channels by the formal seed sector. The juvenile formal seed system in Rwanda will be successful only if it lays its foundation on the already established informal sector. A well organized informal seed system was found to have its basis on socio-cultural believes, though with positive and negative influences to the conservation and use of crop genetic resources. It was found that some community members are willing to specialise as seed producers. Some crop cultivars are of more value to specific community groups.

The fact that farmers are gradually changing from free access of planting material through donations to grain seeds for cash and ready to pay for seeds in cash or in kind, it is a foundation for successful seed industry. Seed sales from specific farmers who specialize can be a source of income. The prices of different cassava products are significantly different (Kruskal-Wallis test, H=11.1; p=0.011) across the sites. Taro and yam are marketable crops, and there is a growing demand. It was also found that the price for different root crops is significantly different (Kruskal-Wallis test, H= 13.16; p= 0.010). The price of yam and taro is closer to that of Irish potatoes which shows how important yam and taro crops are to the region. However, it was reported that farmers fill safer by having food crops in their fields rather than having cash in hand. On-field conservation of the produce by harvesting the small amount that is of direct use either for home consumption or for sale in local markets, had a significant effect in enhancing the diverse use of landraces (Kruskal-Wallis test H = 13.01; p= 0.005) and a significant difference in optimizing the use of diverse on-farm resources (Kruskal-Wallis test H = 13.33;

p= 0.004) and also the practice had a tendency to increase the resilience of the system and/or reduce risk (Kruskal-Wallis H = 9.55; p= 0.023).

The government should create incentive for farmers to conserve crop genetic resources and/or specialize in seed industry. There should be pragmatic strategies and practices to be used to contribute to the conservation of those crops grown since time immemorial, to make sure that future generation will use them.

The possible solutions to overcome seed crisis in the study area, as told by the respondents, are based on a special assistance from the government:

(i) There is an urgent need for ex-situ conservation of threatened crop varieties such as finger millet and the on-farm and/or *in-vitro* conservation of taro, yam and if need be some varieties of cassava. The collection strategy shall involve the full participation of all stakeholders.

(ii) Farmers need to be assisted in the establishment of community genebanks.

(iii) There is need for ISAR to resume research activities in taro and yam. Research should provide disease resistant varieties. There should be more effort in research for disease control so as to effectively assist and advise farmers in appropriate control measures or how to deal with new disease outbreak.

(iv) There is need to establish a specialized unit and projects which will develop strategies and guidance to conserve indigenous crops so that who ever needs seeds can be able to get them.

(v) Farmers need to be assisted in their self seed saving strategy.

(vi) The government should assist in acquiring or provide modern seed storage facilities.

(vii) Crop specialists are expected to do their best to assist farmers and the extension services should be closer as much as possible to farmers and efforts should be made to avail farm inputs. However, extension services currently under the ministry of local government needs to be properly organized in order to accommodate and translate policies from the ministries of agriculture and animal resources as well as from the ministry of land, natural resources and forestry into actions.

(viii) The government should provide land for the multiplication of landraces, but interested private sector should be called upon to venture in this area.

(ix) The government should assist in acquiring quality seeds and at an affordable price.

(x) Special intervention in seeds aid should be well taught off as disaster preparedness measure. However, the dependence on free seed distribution should be discouraged. Farmers are willing to purchase seeds, it is a good foundation to build a strong seed industry.
(xi) Reduction of the current excessive birth rates and land subdivision need to be put to a halt.

This study provides basic elements towards the collection and conservation of agrobiodiversity *in-situ* and/or on-station. However, care should be taken for collection of germplasm and only approaches that fully involve participation of all stakeholders *vis* local farmers, agronomists, local leaders, researchers, NGOs, etc.; should be used.

Further research need to be carried out to investigate in depth:
(i) Agricultural practices that keep landraces on-farm.
(ii) If remnant plants of Colocasia taro found on-farm possess resistant genes hence worthy conservation or if are reservoirs to the disease that devastated the crop then fields clean up need to be organized.
(iii) Due to food preferences and habit, Colocasia taro imported from DRC is found sold in local markets. There are mushrooming modern restaurants in the capital city of Kigali that specialize in traditional food. This opens up endless opportunity for the promotion of indigenous crops and if well organized it can make wonders in improving the livelihood of rural peoples. Further research in this area is needed.
(iv) The white cultivars, *imyeru*, of Colocasia taro are more found in the highlands while the reddish type, *imikara*, is predominant in the low lands. Further investigations are needed to find out the relationship between this crop adaptability and the taro disease at hand.
(v) Due to the expansion of rice, the shift in crops upwards in elevation has driven sweet potatoes to now being grown in the hillsides, but also goes together with the increase in market price. Deep research is needed.
(vi) Molecular marker technique should be used to clearly distinguish locally grown cultivars that currently are classified into either bitter or sweet cassava varieties by farmers.
(vii) The study was carried out in south-western Rwanda, hence the findings are location specific. However, despite that they show the trend, there is need to carry out a country wide study. It is clear that

there is need to re-orient the national research strategy on roots and tuber crops.

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Appendix 1 Extended glossary

Neglected and under-utilized crop species (NUS) are defined by the international plant genetic resources institute (IPGRI) as those that have been overlooked by scientific research and by development workers, and yet play a crucial role in the food security, income generation and food culture of the rural poor. "Underutilized crops", referred to also as minor, orphan, neglected, underexploited, underdeveloped, lost, new, novel, promising, alternative, local, traditional, niche crops (Paludosi, *et al.*, 2000 and 1999), are those crops with a potential, not yet fully exploited, to contribute to food security and poverty alleviation. These crops tend to be neglected by research, extension services, farmers, policy and decision makers, donors, technology providers, consumers and socio-cultural practices" (FAO).

Lost species are those species used in the past but not existing any more to the best knowledge of the community and where planting materials are not available in the community. Threatened are species which still exist in the community but at low frequency of occurrence (Grum, M. *et al.*).

Informal seed system or "**farmers' seed system**" is a system in which farmers produce seeds while at the same time practicing a form of crop development and maintain crop genetic diversity *in situ* (Louwaars, 2002). The word "**variety**" as used by farmers genetically stands for "cultivar" and "seed" refers to grain or planting material produced by farmers and may be exchanged or informally traded.

Seed security is defined as access by farming households to adequate quantities of quality seeds and plant materials of adapted crop varieties at all times. **"Access"** implies that the source of these seeds should be within an acceptable distance, and supplies delivered in a timely manner and at affordable prices. **"At all times"** refers to the availability of appropriate seed stocks in time for each and every growing season, and in rapid response to natural or man-made calamities (FAO, 1998).

Food security has been defined by different authors as: "access by all people at all times to enough food for an active, healthy life"(World Bank), "all people at all times have both physical and economic access to the basic food they need"(FAO committee on world food security), "access by all people at all times to sufficient food and nutrition for a healthy and productive life"(the agricultural trade development and assistance United States of America's Act of 1990{P.L.480}), "when all people at all times have access to sufficient food to meet their dietary

needs for a productive and healthy life"(USAID Bureau of Africa, 1986). In the 1996 Rome declaration on world food security, food security is defined as food that is available at all times, to which all persons have means of access that is nutritionally adequate in terms of quantity, quality and variety, and is acceptable within the given culture (Clover, J., 2003). FAO defines food security as "physical and economic access, at all times, to sufficient, safe and nutritious food to meet dietary needs and food preferences for an active and healthy life"(FAO, 2005). Food is a fundamental human right (FAO).

The right to food is defined as "the right of every man, woman and child alone and in community with others to have physical and economic access at all times to adequate food or means for its procurement in ways consistent with human dignity" (UN, committee on economic, social and cultural rights). "The right of every one to have access to safe and nutritious food, consistent with the right to adequate food and the fundamental right of every one to be free from hunger" (1996 World Food Summit). The right to food is one of the most consistently mentioned in international human right documents but is the frequently violated in recent times (Clover, J., 2003).

Appendix 2 List of abbreviations

CBD	Convention on Biological Diversity
EDPRS	Economic Development and Poverty Reduction Strategy
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
MINITERE	Ministry of land, water and natural resources, Rwanda
TRIPS	Trade Related Aspects on Intellectual Property
WTO	World Trade Organization
PVP	Plant Variety Protection
ASARECA	Association for Strengthening Agricultural Research in East and Central Africa
UNDP	United Nations Development Programme
FAO	Food and Agricultural Organization
EAPGREN	East African Plant Genetic Resources Network
MDG	Millennium Development Goals
DRC	Democratic Republic of the Congo
ISAR	Institut des Sciences Agronomiques du Rwanda
CIAT	International Centre for Tropical Agriculture
UPOV	International Union for plants protection
CGIAR	Consultative Group on International Agricultural Research
IPGRI	International Plant Genetic Resources Institute
UNEP	United Nations Environment Programme
FGD	Focussed Group of Discussion
PRA	Participatory Rural Appraisal
GTZ	German Technical Cooperation Agency
MINAGRI	Ministry of Agriculture and Animal Resources-Rwanda
AVRDC	The World Vegetable Center
NGO	Non Governmental Organization
IFPRI	International Food Policy Research Institute
CBM	Swedish Biodiversity Centre
CEPGL	Communauté Economique des Pays des Grand Lacs

Appendix 3 Questionnaire

Questionnaire on underutilized-indigenous crop genetic resources, utilisation, seed systems, management and their implication on food security in the south-western Rwanda*

* Questionnaire adapted from similar activities in Ethiopia and IPGRI Nairobi

I. Area description and general information

District
sector
Cell
Name of the respondent (optional)
Occupation
Date

II. Household information

1.Sex: (a) male, (b)female; 2.Marital status: (a) single, (b) married, (c) divorced, (d) widowed, (e)Children-Head of the family; 3.Education: (a) can not read and write, (b) can read and write, (c) formal education in years, (d) church school, (e) Attended specialized training (please specify); 4. Religion: (a) Christian (please specify) (b) Muslim (c) other (please specify) 5. Involvement in farming: (a) full time, (b) part-time
6. Other experiences (specify) e.g. employment, travelling, member of an association or choir, exhibition, business, etc.
7. Number of children going to school?
8. Number of children not attending school?
9. Are you permanent resident of this village? (a)Yes, since when? (b) No, when did you arrive in this village?
10. For how many years have you been farming?
11. Are there any activities other than farming you have been mostly engaged in? (a)Yes, please list them (b) No
12. Do you have access to credit for your livelihood activities? (a)Yes, what do you use it for? (b)No, what is the reason?
13. Do you get extension services? (a)Yes (b) No
14. Have you attended any farmers training programme in relation to crops production? (a)Yes, what was the training all about? (b) No
15. Do you have additional skill other than farming (e.g. traditional healing, physiotherapy)? (a)Yes, how do you use this skill to support your life? (b)No
16. What advantage did you get from the training for your livelihood activities?
17. What are the sources of your overall household income? (a)Crop sale (b) Livestock sale (c) Both crop and livestock sale (d) Casual labour (e) Remittance (f) other (please specify)
18. Who is contributing to the household income? (a) Husband (b) Wife (c) Children (d) Parents (e) All members of the household

III. Household resources

1. Where do you cultivate and estimate the walking distance from the household (a) Hills side (b) Low land (c) Marshland
2. Do you have your own farm land? (a) Yes, ownership (i) owner (ii) tenant (iii) tenant/ owner; what is the size of your farm in hectares (ha)? (b) No, what is the reason?
3. Do you feel that there is shortage of land in the village? (a)Yes, what could be the possible reason?

(b) No
4. If you have shortage of land, how do you ensure that your land produces enough food for your household?
5. What cash crops do you cultivate?
6. Do you own livestock? (a) Yes, can you mention the number of livestock you have? (b)No
7. Do you practice livestock fattening practice? (a) Yes, how do you do it? (b) No
8. What are your farm implements?
9. How the social networking does help in agricultural activities and genetic resource management in this area?

IV. Cropping system

1. How crop fields are possessed by farmers and distributed in this area?
2. What are the soil fertilizing methods in this area?
3. Is there reliability in precipitation and is it sufficient for crop development?
4. Do you have incidence of pests and diseases? (a) Yes (b) No
5. What kind of crop pests, weeds, diseases and climatic problems are prevalent? What control measures do you use?
6. How is the trend of this incidence? (a) Increasing (b) Decreasing (c) no change
7. If it is increasing, what do you think has led to the increase in pest and disease incidence?
8. What causes depletion of soil fertility in this area?
9. Which one of the following farmer-based research/evaluation do you practice?
(a) production and on-farm conservation (b) productivity with and with out chemical fertilizer (c) productivity with and with out manure (d) productivity with chemical fertilizer and manure (e) productivity and resistance (disease, drought and pest) of modern and landraces (farmers' varieties)
10. Do you practice crop rotation, (a) Yes, what is the reason? (b)No, which is the reason?
11. Which crops grow in association and on which farm land? (a) home garden (b) nearby farm (c) main field. Please give reasons or uses of intercropping
12. If there is any plant species (tree, shrub, or herb) purposely grown in association with crops in crop fields or in vicinity, give the name of these species grown with the associated crops and their use.
13. If you use manure, (a) for which farm? (i) home garden (ii) nearby farm (iii) main field (b) How much do you use for one hectare?
14. If you use chemical fertilizer, for which farm? Which are the factors that determine the distribution of crops/varieties on the farm land?
15. Does distance from the home affect the distribution of crops/varieties on the farm land? (a) Yes, list the first three crops grown on farm lands nearer to the home. Why do you grow the above mentioned crops on nearer farms? (b) No
16. Which crop/varieties are grown on distant farms? Why?

V. Crops/varieties grown on household farms

1. Which are the major crops and plant varieties grown in all households?
2. When the crop or plant variety was first introduced in the village where it came from?
3. Over the last 15-20 years or so, have there been changes in species or crop variety grown?
4. Do you think these species are (a) increasing (b) decreasing (c) neither increasing nor decreasing and which are the reasons?
5. What practices should be used to contribute to conservation of crop species you mentioned so that future generations can use them?
6. From your personal experience, which are the positive and negative traits of the crops/varieties?
7. Among the crops that you grew in the past 15-20 years or so, are there crops which are no longer cultivated? If yes, in your opinion, for which reasons are no longer cultivated? Which year they were last grown (approximately)
8. For the crops you have grown during the last three years what is the yield kg/ha and utilization? How many varieties of each crop do you grow?
9. Tell me the crops/varieties grown on your farm during the last 3 years.
10. Do you know any wild relatives of crops in your area? If yes can you tell me local names of those?

11. Type of animal species that exist/existed in the area (wild and domesticated) Reason of disappearance*?*

VI. Seed exchange

1. Do you use seed other than your own for planting?
2. State the source of seed for planting for particular crop? (a) own saved (b)exchange with other farmers (sharing between and among farmers (c) donated (e) purchased (f) other source
3. For what purpose do you exchange seed? (a) Cash (b) Substituting for seed/grain of other variety (c) Labour (d) Share crop (e) Other reason (please specify)
4. Which farmers are recognized as seed farmers in the community? (a) Rich because always has seed (b) Rich because has good quality (c) Poor because always has the variety (d) Poor has good quality (e) Other reasons (please specify)
5. How frequent do you use seed from other sources? (a) Every year (b) Only in case of calamities (c) Other (please specify)
6. Which are the reasons for regularly using seed from other sources: (a) for seed quality other sources are better (b) Variety changes, degenerates, get tired (c) Sold out in years when grain price are high (d) Eating or selling the seed for cash needs (e) for yield other source are better
7. In cases of calamities, what are the reasons for using seed from other sources? (a) Crop loss because of climate (e.g. drought) (b) Crop loss because of crop pest or disease (c) Crop loss because of sickness family members/funeral/weeding/other social commitments (d) other reasons (please specify)
8. When there is total crop loss in case of calamities, which is the source of seeds? (a) Friends or relatives in the community (b) Other farmer in the community (c) Other farmer in other location (d) Market (e) Seed project/government (f) Other reasons (please specify)
9. How new variety does diffuses among the people in this area?
10. What linkage is established for seed exchange? (a) farmer to farmer (b) farmer to agricultural officers and extension services (c) farmer to research and conservation institute, ISAR.

VII. Knowledge on crop plant species or grown varieties

1.The questions concern your recollection of the different desirable and undesirable characteristics associated with crop varieties you used, used by your neighbours, your parents, your relatives or other people in the surrounding (a) crop species/varieties (b) desirable characteristics (c) undesirable characteristics (d) use value (e) other characteristics.
2. Where do you get seeds of landrace varieties during sowing?
3. How do you maintain landrace varieties?
4. Why do you maintain landraces?
5. Do you know any newly introduced/cultivated crop varieties in this area? (a) crop/variety name (b) seed source or origin (c) year introduced (d) brought by (e) reason for introduction
6. What factors cause the introduction of new varieties?
7. How and by whom new varieties are introduced for the first time in this area?
8. Have you encountered any problem following the introduction of new varieties? If yes, which ones? (Please specify).
9. Which local varieties/species of crop have vanished and on the way to vanish as the result of introduced equivalent new varieties?
10. How do you compare the use of crop residue of local varieties and improved varieties?
11. Which are the criteria for seed selection for the next planting season?
12. What can you say about the cost of seeds in this area (price per Kg seed or per cutting)?
13. What are the constraints in accessing quality seeds?
14. What are the possible solutions to overcome seed crisis in this area?
15. Are activities in seed production-multiplication been carried out in this area? If yes who is involved?
16. Do you use farm inputs such as mineral fertilizers, pesticides, etc. and where do you get them from?
17. Are there specific activities for soil erosion control and improvement of soil fertility in this area?

VIII. Genetic erosion

1. Do you know any crop/varieties that existed in the past but have disappeared or replaced by other varieties? If yes can you list them and specify the reason and time it was lost?
2. Is the production of local varieties is increasing or decreasing? (a) increasing (b)decreasing (c) no change. Please justify your response.
3. How do you see in terms of diversity and vulnerability?
4. Do you think landraces are important to you and do you share the concern for their disappearance? (a) Yes (b) No
5. What do you suggest about the conservation or maintenance of local varieties of crops?
6. How many times have you faced with complete crop failure due to drought/pests and diseases in your farming experience? When was this?
7. Have you lost any variety following the 1994 war and genocide? If yes list them
8. During those days how did you manage to conserve crop seeds from disappearance?
9. If you lost completely seeds local crops from where do you get them?
10. Do you think production practices of local varieties (such as land preparation, planting, threshing, and harvesting) compared to improved varieties is discouraging? Please justify your response.
11. Do you think market price of local varieties is lower than market prices of improved varieties? (a)Yes (b) No

IX. Seed selection

1. Do you practice seed selection or use left over seeds for next planting season? (a)Yes, I do select. Please justify your response (b) No I use left over seed
2. Who is responsible for seed selection? (a) husband (b)wife (c)children
3. Is the selection practice deliberate? (a)Yes (b)No
4. For which crop do you apply seed selection and when? Give reasons (a) pre-harvest (b) post-harvest (c) storage
5. Do you multiply seeds for the selected seed? (a)Yes (b) No
6. For pre-harvest seed selection which selection method do you apply? (a) pure selection (b)mass selection
7. Which are special activities that you carry out in the field during seed selection for selecting a plant or part of your crop?
8. How is the seed selection techniques/knowledge pass from parents to children?

X. Seed storage

1. Do you store seed? If yes (a) for which crops (b) how many varieties (c) the source of seeds (d) which species do you judge more interesting to conserve? (e) how and where do you store seed?
2. What special conservation treatments do you use before storage? (a) applying chemical (b) drying (c) smoking (d) removing diseased seed (e) using ash (f) using herbs (g) exposure to light (h) others (please specify) (i) Why do you practice this treatment?
3. What storage problem do you encounter?
4. How do you prepare your seeds for storage (washing, drying, threshing, etc. and how do you know that seeds are dry enough for storage).
5. To which level and on basis of which criteria do you dry seeds?
6. How much seeds can you dry at once?
7. How long does it take do dry seeds enough for storage*?*
8. How do you conserve your seeds?
9. For how long can your technique conserve viable seeds?
10. Which is the longest period of time for which you can conserve seeds?
11. Do you control pathogens/diseases/rodents?
12. Which control measures? Chemical, natural-plants, etc. (detailed explanation)
Can you explain how the procedure - treatment techniques for each species? /
13. Do you test the quality and seed viability before storage?
14. At which period and which methods?

15. Do you test seed viability and at which intervals during the storage period?
16. Cheap seed storage techniques?
17. Do you know any other seed storage techniques? If yes describe them.
18. Do you have any suggestions on how farmers in this community can be assisted through use of such cheap storage techniques?
19. Any other comment/suggestion?

XI. Gender and division of labour

1. What is the major occupation of household members? (a) husband (b) wife (c)children (d)parents (e) whole family
2. Who makes decision on the number of varieties/landraces to be planted?
3. Who makes decisions about which landrace to plant in each farmland?
4. Do you allocate different parcels/plots of land for different varieties? (a)Yes, what criteria do you use for such allocation? (b) No
5. Who makes decision for seed selection/seeds of varieties preferred for planting?
6. Do you store seeds of different landraces separately from food grain/other types of seed? (a) Yes, who makes decision? (b) No
7. Do you have practice of mixing seeds of different landraces either at planting or when storing? (a)Yes, who makes the decision for this? (b) No. Please justify your answer?
8. Do women have access to land either through land distribution or inheritance? (a)Yes (b) No, why?
9. Can you mention the role of women in seed selection during pre-, post-harvest and storage?

XII. Culture, songs, sayings, myths, etc.

1. What cultural significance do you know of landraces in this area?
2. Is there any songs and sayings you know in connection with crops/landraces in this area (a) crop type/variety (b) songs, sayings (c) implied meaning
3. Can you tell me any rituals in relation to crops/landraces in this area?
4. How do you celebrate it and what is its interpretation all about?

XII. Dietary assessment

1. Food group, frequency, mean intake per day
2. What are the wild foods found in this area (fruits, vegetables, others - specify)?
(a)What roles do they play and for whom? (b) Are they important? If so where and when (which period of the year) and why? (c) Are fishing activities practiced here? Where?
(d) How about hunting activities and for which types of animals? (e) Which edible insects are found here, in this area? (f) Where do you get/collect wild food from? (g) Why do you (people) use wild foods (vegetables, fruits, etc?) (h) Which are multipurpose wild foods plants (food, feed, and medicine)? (i) How are wild food species perceived in this area?

THANK YOU FOR SHARING YOUR TIME FOR THIS INTERVIEW!

Appendix 4 Conservation practices and their relationship with grown crop cultivars

Table 6 Conservation practices and their relationship with grown crop cultivars*

Crop	Practice	Varieties for which the practice is of high importance	Varieties for which the practice is of normal importance	Varieties for which the practice is of low importance
Cassava				*Gacacana* ou *Maryohe* (normally grown in associations)
	Land preparation on mounds	*Imburamuzi* (Always)	All varieties/ cultivars	
	Propagation by cuttings		All varieties/ cultivars	
	Picking leaves as vegetables	*Ibicucu* (isombe)	*Ibicucu , Imburamuzi, Gitaminsi*	*Gacacana ou Maryohe* (No enough leaves), *Imitalina* (roots will rot)
	Flat land preparation	*Gacacana*		*Imburamuzi*
	Sun drying	*Imburamuzi*	*Gitaminsi*	*Gacacana* (Direct home consumption)
	On-field conservation (delayed harvesting)	*Gitaminsi*	All varieties/ cultivars	*Imburamuzi , Gacacana*
	Fermentation-removal of acid	*Imburamuzi*	*Gitaminsi*	*Gacacana*
	Soaking in water	*Gitaminsi*	*Imburamuzi*	*Gacacana*
	Prolonged storage (sun dried)	*Gitaminsi, Imburamuzi*		*Gacacana*
	Skin removal (*Gukobora*)[1]	*Gitaminsi*	*Imburamuzi*	*Gacacana*
	Pounding & sieving-for flour	*Gitaminsi, Imburamuzi*		*Gacacana*
	Own saved seed-storage	All varieties/ cultivars		
Colocasia				
	Cultivation on mounds	All varieties/ cultivars		*Amanyarwanda* (grown in mulched coffee plantations)
	Weeding	*Amazungu, Imyeru*	*Amazungu, Amarundi*	*Amanyarwanda*
	Adding soil	*Amazungu, Imyeru*	*Amarundi*	*Amanyarwanda*
	On-field conservation (Staggered harvesting)	*Amazungu, Imyeru*	*Amazungu, Amarundi*	*Amanyarwanda*
	Conservation of the harvest (in a pit)	*Amazungu (Imikara* only) other will sprout		
	Loosening of soil +weeding	*Amazungu, Amarundi*	*Amanyarwanda*	
	Peeling off-before cooking	*Imikara, Imyeru*		*Amanyarwanda*
	Cultivation on pure stand	*Imikara, Imyeru*		
	Harvesting of leaves as	*Amanyarwanda,*	*Amazungu*	*Amanyarwanda,*

[1] The practice consists with removal of the periderm or the bark of cassava root. Normally peeling cassava consists of removal of the bark, sclerenchyma, cortical parenchyma and the phloem just to remain with the cambrium.

	vegetables	*Imikara, Imyeru*		*Amarundi*
	Sun drying leaves before cooking them	*Amanyarwanda*[2]		*Amazungu*
Yam			All varieties / cultivars	
	Cultivation on mounds		All varieties/ cultivars	
	Staking	*Ibihama*	All varieties/ cultivars	
	Sawing in other crops after yam has germinated	*Ibihama*	All varieties/ cultivars	
	Progressive harvesting by cutting tubers every 3 months	*Ibihama*	All varieties/ cultivars	
	Sun drying of the harvest	*Ibihama*	All varieties/ cultivars	
	Cooked boiled with other food items	*Ibihama*	All varieties/ cultivars	
	Storage	*Ibihama*	All varieties/ cultivars	
	Planting the apical part-tuber	*Ibihama*	All varieties/ cultivars	
	Trapping moles		All varieties/ cultivars	
	Cultural believes[3]		All varieties/ cultivars	
Sweet potato			All varieties/ cultivars in large scale plantation	All varieties/ cultivars
	Cultivation on mounds	All varieties / cultivars	All varieties/ cultivars in the dry season	
	Seed multiplication [4]			
	Weeding	Only if associated with other crops (*Amahunge*)	All varieties/ cultivars	Not done at all in all varieties/ cultivars due to culture
	On-field conservation (Staggered harvesting)[5]		Other varieties except *Kanyoma*	*Kanyoma*[6]
	Sun drying to improve the taste (sweet taste)	*Karoti, Kanyoma, Nsengumugabo*		*Mugande*[7]
	Washing before cooking[8]		All varieties/ cultivars in rainy seasons	Not compulsory in dry seasons

* As told by the focussed groups of discussion

[2] Since they are harvested in large quantity at the same time, leaves are sun dried then cooked as needed

[3] An Ephorbiaceous must me planted together with the yam and groundnuts crops

[4] Small plots are planted in the marshlands where there is enough moisture so as to conserve seeds during the dry season until rain falls for the next cropping season

[5] Harvesting the small amount that is required for immediate cooking or selling due to poor storage facilities

[6] It should be harvested soon after maturity otherwise it will be wasted due to rotting

[7] Usually has a sugary taste

[8] Not necessary in dry periods

Appendix 5

Table 7a. The situation of crop varieties/cultivars grown in the study area*

Crops	Muganza sector (low lands)					Karambi sector (high lands)				
	Many household Large area	Many household Small area	Few household Large area	Few household Small area**	No longer grown	Many household Large area	Many household Small area	Few household Large area	Few household Small area**	No longer grown
Cassava	*Nyirakarasi "50" Kirisa Mugabomuremure*	*Maryohe Gitamisi*	*Imihonge*	*Igisurupiya (imifobe)*	*Pfukamabere*	*Imitarina Mavuta Nyirakanya munyu*			*Bukarasi Munyegereze Gitamisi N.kaganda N.kumbati*	*Imihonyi N.gacyacyari*
Taro				*Amaganda Amanyarwanda Amaswage Ameru (Rweru) Amazungu (Kizungu)*					*Imyeru Imikara Amanyarwanda (Amarera) Amanyangwe*	
Yam				*Ibikoro by'inka Ibihonge*	*Ibinyabojo Ibirundi Ibihama*			*Inyabojo*	*Ibiriga Iibigeja*	*Ibihama*
Sweet potatoes		*Bugande Hiningi*		*Nsenge Nsasagatebo Murungu*		*Kijyambere (Project) Badada*	*Mugororo Makara Rukocoka (Magabari)*		*Kigingo Ndamirabana*	*Karucurira Senge,Rukocoka(Magabari),Nyirabusegenya*
Irish potatoes							*Cruza,Sangema,Mabondo Mugogo (Gisenyi)*		*Sangema Cruza Mabondo,Kinigi*	
Finger millet					*Njagari Nyirakagwi, Rutare*				*N.mabuye Kirima, Bambu Ibamba*	*Nyiramujaga Rutare*
Indigenous Vegetables	*Isombe "Irara" (Cassava species)*	*Imbogeri Ibisusa, Imbwija*			*Isogi, Isogo, Isaga Dodo*					
Cucurbitacea				*Ibihaza/imyungu, Amadegede,Amafinga, Amakuta,Chayotte, Ibicuma (ibisabo)*						

* As told by the focussed groups of discussion

** Cultivars at risk of disappearance that require an urgent attention

Table 7b. The situation of crop varieties/cultivars grown in the study area (cont.)*

Crops	Muganza sector (low lands)					Karambi sector (high lands)				
	Many household Large area	Many household Small area	Few household Large area	Few household Small area**	No longer grown	Many household Large area	Many household Small area	Few household Large area	Few household Small area**	No longer grown
Vigna unguiculata Ground nuts				*"big"and "small" (Grains size) Marango, Agahusa Akanyarwanda*						
Soybeans	*Kijyambere"short" andlong"plants*									
Beans	*Magabari Rwandarugali Gasosera, Minwari Mukwararaye*	*Mpemberwa*				*Mukwararye Ibijagasha Ubukara,Ndamirabana, Mbagarumbise*				
Maize	*Bambu (Ibirayi) Nyirakagoli Kanjegeri*			*Katumani Mamesa Pool 9a*[9]					*Kijigo, Baya Nyirakagori Bambu Gishambara*	
Chilli pepper				*Uburende Urusenda (Bushali, Pilipili)*						
Solanum melongena		*Umweru*		*Igitagarasorya*			*Bushari Umweru*			
Sorghum		*Umukara Urutenderi Urubuye Amakoma*		*Mugabo Impingwarimwe*						
Wheat									*Kirima Nyiramabuye Kinigi, Siko Project (Gishenzi)*	
Rice					*Marigashe, Nyirabihogo, Matwi, Sifara, 6000, 44*					
Banana	*Gisubi Karengera Mazizi*	*Barabeshya Inyamunyu*		*Ishumbu, Kanuka, Intuntu,Icyungurube, Icyungurube Kamaramasenge*		*Kayinja,Gros michel,Barabeshya,Inzirabahima*				*Mazizi(umukara)lost due to ndergound Rotting*

* As told by the focussed groups of discussion ** Cultivars at risk of disappearance that require an urgent attention

[9] Newly introduced variety

Table 8. Description of grown cultivars for selected crops in the study area*

Crop/ Cultivar	Farmers' description
Xanthosoma	
Amaganda	The taste is not that bitter. Cooked boiled together with beans. If harvested at full maturity they can be stored. The corm can also be cooked.
Amanyarwanda (Amakwana):4type -butimbo,-amarera,-amagoyi, amarundi(Bwayisi)	Indigenous, grows naturally (like weed), Have good and characteristic odour, good taste, culture attached to it, harvested once per year (July). Many clustered corms in forms of fingers loosely attached to the plant. Low yield, has to be cooked overnight (much firewood needed). Lost around 1970 in Muganza sector. Leaves are edible (vegetables). Was much adapted to slash and burn cultivation. If available in the market the price is the same as that of Irish potatoes. *Amarundi (Bwayisi*) are reddish, good taste, cooked like *amazungu* (*imyeru, imikara*).
Colocasia	
Amazungu:Imyeru, Imikara	High yield, eaten roasted or boiled together with beans. Currently there is a serious problem of getting seeds due to disease outbreak, requires fertile land. It is found grown in coffee plantations as a way of conserving seeds. *Imyeru*, introduced around 1970 from Zaire (DRC). *Imikara* type is said to have been introduced from Uganda in 1963.
Yam	
Ibikoro by`inka	Whitish flesh, high yield
Ibinyabojo (ibirebahejuru)	Indigenous or may have originated from Zaire (currently DRC). Bitter taste (slightly) but better than Irish potatoes, reddish flesh, many tubers with hairs per plant but slightly small (±60cm diameter) but can grow big if fertilizer applied. Small vine. Adapted to high density cultivation. Has many tubers per plants then due to the competition for space they push upwards hence the meaning of the name ibirebahejuru. Ururenda imbere+Ifufu
Ibihonge	Yellowish flesh, high yield. Should be harvested soon after maturity otherwise will rot. Low market price.
Ibikoro by`i Burundi (ibirundi)	Adapted to cold environment, bitter taste, looks like *Ibihama*. Big sized vine. Only one big tuber per plant (one is just enough to feed 3 peoples) or can be divided into 4-5 pieces for seed production.
Ibihama (Amatuga)	Aerial tubers. Reported by FGD that it is usually eaten by the *Batwa* community but it was food for every body between 1930 and 1946 during *Ruzagayura* famine.
Ibiriga	Plant has thorns, good taste, high yield (where adapted), 3-4 hairy tubers per plant (not that big),white flesh, staggered harvesting every 3 months and the proper harvesting done one year in dry period (the harvest will be kept as seeds). Roasted. Requires heavy washing (too much ururenda)+amafufu
Ibigeja	God taste, normally eaten roasted. Can also be boiled with beans. Ancestral crop. Gives high production in bench terraces with good fertilization.
N.busegenya	Small sized long vines, adapted to forest zones, bad taste
Finger millet	
Njagari	Finger millet is said to have been introduced from Gikongoro in 1980's. Planting in December and harvesting in June. Only one farmer is growing the crop in Muganza sector. The crop has disappeared in Muganza sector since 1993. Gives good (taste) porridge and the crop gives good yield if fertilization applied, 1.5kg seeds will produce 36Kgs/are. *Njagari* cultivar is characterized by loose head
Nyirakagwi	Compact head
Rutare	Compact head, black grains, lost about 20 years ago due to variety degenerescence, low yielding
Nyiramabuye	Early maturing, good taste. Looks like Kirima, small sized grains, black coloured, few shoots, early maturing as compared to other grown varieties but is low yielding. Good for *ugali*. It was the first variety to be grown in the area but almost disappearing only grown in mixture with other varieties not in pure stand. Sensitive to diseases in rain season.
Bambu	Looks like *Kirima.* Late maturing, does not change colour looks like sorghum, still can germinate if stored up to 3 years.
Kirima	Looks more or less like *Nyiramabuye*. Comparatively early maturing, high yield, whitish grains with the size slightly bigger than that of *Nyiramabuye*. Good for *ugali*. Originated from *Gikongoro*. Resistant to diseases.
Nyiramujaga	Had loose fingers, low yield, and sensitive to diseases in rain season, almost disappearing.
Ibamba	Has many shoots, big grains, loose head, and whitish colour, late maturing variety, high yielding, good taste. Good for preparing local drinks (porridge, *ikigage /amarwa*) hence replacing sorghum in the highlands.

* As told by the focussed groups of discussion

Appendix 6 A summary of participatory extent and distribution analysis on Cassava, *Colocasia*, *Xanthosoma*, Yam and sweet potato landraces in the study area

Table 9. Summary of participatory extent and distribution analysis on Cassava landraces in the study area

Cultivar	Classification	Muganza sector*	Karambi sector*
Nyirakarasi	Bitter	4	0
Senkanti "50"	Bitter	4	0
Kirisa	Bitter	4	0
Mugabomuremure	Bitter	4	0
Maryohe (Gacacana)	Sweet	2	0
Gitamisi	Bitter	2	1
Imihonge	Sweet	3	0
Igisurupiya (Imifobe)	Sweet	1	0
Imitarina	Bitter	0	4
Mavuta	Bitter	0	4
Nyirakanyamunyu	Bitter	0	4
Bukarasi	Bitter	0	1
Munyegereze	Bitter	0	1
Nyirakaganda	Bitter	0	1
Nyirakumbati	Bitter	0	1
Ibicucu (Isombe)	**	2	2
Total cultivars grown		9	9

* 4= Many households growing landraces on large fields, 3 = Few households growing on large fields, 2 = Many households growing landraces on small fields, 1 = few households growing landraces on small fields, 0 = landraces not grown in the village. No longer grown cultivars in both sites include *Pfukamabere, Imihonyi, Nyiragacyacyari*, and *Imburamuzi*;
** only leaves are harvested and eaten as vegetables. Often grown on fences, may stay in the field for several years.

Table 10. Summary of participatory extent and distribution analysis on *Colocasia* and *Xanthosoma* landraces in the study area

Cultivar	Muganza sector*	Karambi sector*
Amaganda	1	0
Amanyarwanda	1	1
Amaswage	1	0
Imyeru (Ameru, Rweru)	1	1
Amazungu (Imikara, Kizungu)	1	1
Amarera	0	1
Amanyangwe	0	1
Total cultivars grown	5	5

* 4= Many households growing landraces on large fields, 3 = Few households growing on large fields, 2 = Many households growing landraces on small fields, 1 = few households growing landraces on small fields, 0 = landraces not grown in the village.

Table 11. Summary of participatory extent and distribution analysis on Yam landraces

Cultivar	Muganza sector*	Karambi sector*
Ibikoro by'inka	1	0
Ibihonge	1	0
Ibiriga	0	1
Ibigeja	0	1
Inyabojo	0	3
Total cultivars grown	2	2

* 4= Many households growing landraces on large fields, 3 = Few households growing on large fields, 2 = Many households growing landraces on small fields, 1 = few households growing landraces on small fields, 0 = landraces not grown in the village.

Table 12. Summary of participatory extent and distribution analysis on Sweet potato landraces

Cultivar	Muganza sector*	Karambi sector*
Bugande	2	0
Hiningi	2	0
Nsenge	1	0
Nsasagatebo	1	0
Murungu	1	0
Kijyambere (Project)	0	4
Badada	0	4
Mugororo	0	2
Makara	0	2
Rukocoka (Magabari)	0	2
Kigingo	0	1
Ndamirabana	0	1
Total cultivars grown	5	7

* 4= Many households growing landraces on large fields, 3 = Few households growing on large fields, 2 = Many households growing landraces on small fields, 1 = few households growing landraces on small fields, 0 = landraces not grown in the village. No longer grown cultivars are *Karucurira* and *Nyirabusegenya*.