Assessment of the status of Plant Genetic Resources in Kabale Highlands, Uganda; A case of cultivated crop species

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MFPED Ministry of Finance Planning and Economic Development.

PGR	Plant Genetic Resources.
FAO	Food and Agriculture Organization.
IPGRI	International Plant Genetic Resources Institute.
GPS	Geographic Position System.
SPSS	Statistical Package for Social Scientists
Ushs	Uganda Shillings.
NGOs	Non Governmental Organizations.
CBOs	Community Based Organizations.
ICRAF	International Center for Research in Agroforestry.
CIAT	Centro Internatacional de Agricultura Tropical.
KADFA	Kabale District Farmers Association.
MUARIK	Makerere University Agricultural Research Institute Kabanyolo.

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Abstract

There was lack of adequate knowledge and information on the status and risks posed to Plant genetic resources in Kabale highlands especially with cultivated crop species. Therefore, this study was to document genetic diversity and study genetic erosion in cultivated crop species so as to develop effective strategies for conservation and sustainable utilization of these resources. Data were collected from a random sample of 120 farmers in 6 parishes using a structured pretested questionnaire and analyzed by SPSS for descriptive statistics. Germplasm was collected using IPGRI germplasm collection form. The major cultivated crop species were banana/plantain *(Musa spp*), sorghum (*Sorghum bicolor.* L), peas *(Pisum sativum.* L*),* beans (*Phaseolus vulgaris* L.), potato (*Solanum tuberosum*. L) and sweet potatoes (*Ipomea batatas.* L) and 25, 10, 6, 28, 13, and 17 cultivars/varieties of these crop species, respectively were identified on the farmers' fields. Minor crops grown include Yams (*Dioscorea spp*), tobacco (*Nicotinum tabacum*), groundnuts (*Arachis hypogea*), coffee (*Coffea spp*), cassava (*Manihot esculenta*), sugar cane (*Saccharum officinarum* L), maize (*Zea mays* L), finger millet (*Eleusine corocana).* L), wheat (*Triticum aestivum*), fruits and Vegetables. Much genetic erosion had occurred to sweet potatoes, potatoes, beans and peas as many varieties were lost completely and others were on the verge of extinction. Other threatened crop species were finger millet (*Eleusine corocana.* L), wheat (*Triticum aestivum*), and pumpkins (*Cucurbita spp*). The most underlying cause of genetic erosion as mentioned by many farmers (93.7%) was introduction of new varieties. There were two main sources of farmers' seeds (formal and informal). The formal one was mainly used for new/modern varieties as many farmers (50.8%) relied on cash purchase from market and informal one for traditional varieties as many farmers (81.5%) relied of their own stock. There was a lot of seed exchange of modern varieties between the farmers. This has resulted in fast and wide spread of modern varieties and has led to the abandonment of the traditional ones. Sixty seed specimens representing four crop species (beans, sorghum, peas and maize) were collected and conserved at MUARIK, Gene Bank. The loss of traditional varieties results in reduction of the genetic base of the remaining varieties that may have a consequence upon changing environmental and ecological conditions. Therefore, the loss of landraces is a threat to national food security and future genetic improvement programs. There is therefore, an urgent need to collect, document, characterize, conserve and utilize the traditional crops and formulate policies that will protect them from further genetic erosion.

Keywords: Plant genetic resources, genetic erosion, Kabale

1.1 Background

Uganda is a land locked country, located on the East African plateau, lying between latitudes $4^{o}12'$N and $1^{o}29'$S and longitude $29^{o}34'$ E and 35^{o}E. The total land area is 236,000 Km^2 of which 33,926 Km^2 is permanent water, 7,674 Km^2 is permanent swamp and 194,000 Km^2 accounts for dry land. Of the total dry land, only 30% is under crop production represented by 4,000,000 hectares. Of the total area cultivated, 28% is under bananas, 25% cereals, 17% root crops, and the remainder under pulses, oil seeds and export crops (coffee, tea, tobacco, cotton and sugarcane). Uganda's agriculture is predominantly smallholder, representing over 90% of the total agricultural output (Mbuza *et al.,* 1996). Agriculture plays an important role in Uganda's economy by accounting for

87% of export earning and is a major source of income for most people including the rural poor (MFPED, 1997).

1.2 Plant Genetic Resources

Plant genetic resources is that part of biodiversity which encompasses cultivated varieties (in use), newly developed varieties, farmers varieties (land races), wild and weedy species, near relatives of cultivated varieties and special stocks including elite and current breeder's lines used in agriculture, medicine, and agro-pharmaceutical industries, where great breakthroughs have been made for the benefit of mankind (Mooney, 1997; Evenson *et al*., 1998). Hammer *et al*. (1999) defines PGR as to include all species, which contribute to peoples' livelihoods by providing food, medicine, shelter, fiber, and energy. These are either cultivated by man or they are found in natural habitats as wild plants or relatives of crops.

Plant Genetic Resources (PGR) constitute an important sector of biodiversity that is crucial in attempts to feed and sustain the steadily increasing global population (Arunachalam, 1999). Advances in the science of plant breeding from the days of rediscovery of Mendelian laws of inheritance have been instrumental in utilizing PGR to develop high yielding varieties (Arunachalam, 1999). To a large extent, they are responsible for increasing productivity and food production. It has also been established that the development and sustainability of agriculture are strongly dependent on the access to plant genetic resources for food and agriculture, and as a result, the urgency to address the issues surrounding access to genetic resources has increased in the last 20 years (Correa, 2000).

The total number of plant species, which are cultivated as agricultural or horticultural crops, can be estimated to be close to 7,000 botanical species (Hammer *et al*., 1999). Nevertheless, it is often stated that only 30 species "feed the world", because the major crops are made up of a very limited number of species. The latter is also the major reason why 6 million accessions collected and conserved in genebanks belong to a very limited number of species compared to the total number of species, which contribute to food security. The most important of them are listed in Table 1. These species provide more than 90 % of calories or protein to human nutrition. Therefore, improvement by modern plant breeding and conservation of their diversity has always received attention.

Table 1: The thirty crops with the highest number of accessions represented in *ex situ* collections

Crop	Total accessions world-wide	Crop	Total accessions world-wide
Wheat	784,500	Chickpea (*Cicer)*	67,500
Barley	485,000	*Prunus*	64,500
Rice	420,500	Clover	61,500
Maize	277,000	*Capsicum*	53,500
Garden Bean	268,500	Cotton	49,000
Oat	222,500	Grape	47,000
Soybean	174,500	Triticale	40,000
Sorghum	168,500	*Medicago*	33,000
Brassica	109,000	Sweet potato	32,000
Apple	97,500	Potato	31,000
Millet *(Panicum)*	90,500	Faba bean	29,500
Cowpea (*Vigna)*	85,500	Sunflower	29,500
Groundnut (*Arachis)*	81,000	Lupin	28,500
Tomato	78,000	Cassava	28,000
Pea	72,000	Rye	27,000

Source: FAO, 1996a

1.3 Status of plant genetic resources for food and agriculture in Uganda

The main food crops grown are maize, finger millet, bananas, sorghum, sweet potatoes, cassava, beans, peas, groundnuts, potato, rice and sesame (Country report, 1996). The main traditional cash crops are coffee, cotton and tea. In addition to these, there are various arrays of introduced and native semi-wild vegetables. Most fruits grown are introduced while indigenous ones are usually collected from forests. Of the cereal crops, maize, sorghum and finger millet are the most important (Country report, 1996).

In general these crops are grown under four main farming systems; 1) coffee-banana system in the wetter areas of Southern and Eastern parts of the country. Here, the main food crop grown is banana and main cash crops are tea and coffee, 2) upland areas of Western and Eastern parts of the country. These areas have high reliable rainfall and

fertile volcanic ash. The main crops grown are exotic fruits and vegetables, bananas, and temperate crops like wheat and barley, 3) drier-Savannah areas of the North, East and Western parts of the Country. The main food crop is millet and main cash crop is cotton and 4) semi-arid rangelands of the Northeast and Southwest parts of the country. The main agricultural activity is cattle keeping in a semi-nomadic pastoral system.

According to Lingadale-Brown *et al*. (1964), there are at least 90 types of natural and semi-natural vegetation communities in Uganda, which in many cases have been modified by human activities. The plant genetic resources for food and agriculture in Uganda range from little known indigenous wild fruits and vegetables, pastures and forages, and indigenous staples like millet and sorghum to introduced crops such as maize, tobacco, cotton, and beans. There are over 1,400 species of indigenous plants in 705 genera in Uganda and of these, it is estimated that 30 species of indigenous species are endangered, 43 rare and 10 vulnerable. In addition, there are also over 230 species of exotic plants in Uganda. Surprisingly, the exotics are fast increasing due to factors related to neglect of some of the indigenous food crops, therefore, putting them at risk of genetic erosion or even extinction.

1.4 Problem statement

The Kabale highlands of South Western Uganda are a component of an intensively cultivated “eco-region” found in East and Central Africa (Africare, 2001). These highlands are a source of much of the food that feeds the Country as well as the home of unique, diverse plant genetic resources (Mike, 2000). These plant genetic resources are very rich and variable as well as a potential resource for agricultural development. However, these resources have been seriously threatened through genetic erosion due to high population pressure estimated to be 370 persons per km^2, intensive land cultivation, and land degradation (Africare, 2001; Mike, 2000; Jean-Mark, 1999). Also due to socio-economic pressure, landraces are being replaced with new crop varieties thereby leading to commercialization of farming and consequently, genetic erosion (PLEC project Uganda, 2001). For example, Victoria potato variety dominates other varieties in Kabale because of its high commercial value. Erosion is also caused by other factors such as change in cultural norms, change of dietary habits, change in weather and natural calamities as reported by Nnadozie *et al*. (2003). However, there was lack of adequate knowledge and information on the status and risks posed to PGR in Kabale highlands. Therefore, acquisition of this information through base line surveys was imperative in order to develop effective strategies for conservation and sustainable utilization of these resources.

1.5 Justification of the study

Plant genetic resources are the foundation for sustainable agriculture and global food security, now and in future, whether they are used in traditional farming systems, conventional breeding or in new biotechnologies (FAO, 1998). Plant genetic resources are a reservoir of genetic adaptability, which acts as a buffer against harmful environmental changes and economic challenges (Hammer *et al*., 1999; FAO, 1999). If not well

managed, these plant genetic resources will be vulnerable to genetic erosion (FAO, 1998). The erosion of these resources results in a severe threat to the world's long-term food security (Hammer *et al*., 1999). To ensure genetic resources are continually available for sustainable food security, the need for maintaining genetic diversity in agricultural systems is widely accepted (FAO, 1999).

The practice of modern intensive plant breeding leads inevitably to a reduction in the genetic diversity of crops (Clunies-Ross, 1995; Tripp, 1996). Such erosion would have serious consequences, both on the genetic vulnerability of crops to changes in the spectrum of pests and diseases, and on their plasticity to respond to future changes in climate or in agricultural practices (Tripp, 1996; Smale, 1996; FAO, 1995; Duvick, 1984). In some cases, the loss of particular crop varieties is not *complete,* but instead reduces surviving members of a landrace to a few isolated populations. In such cases, there is significant risk of the ultimate loss of diversity, because small populations will lead to increased inbreeding which reduces the fitness of individual plants and hence may lead to extinction (Van Treuren *et al.,* 1990).

Many national programmes have not regarded quantification of genetic erosion as a high priority, as apparent from the paucity of information in the State of the World Report (FAO, 1997). The accurate documentation of the genetic diversity and genetic erosion of major agricultural crops is therefore important, both scientifically and socio-economically (Smale, 1996; FAO, 1995; Swanson, 1996; Karp *et al*., 1997). The documentation of present genetic diversity will also be used for measuring future genetic erosion and conserving the threatened crop varieties.

1.6 Objectives of the study

1. To document crop genetic diversity at inter and intra-specific levels.
2. To determine the extent and underlying causes of genetic erosion.
3. To study the farmers' seed sources and exchange systems and its impact on crop diversity.
4. To identify and document conservation practices.
5. To collect and conserve germplasm.

1.7 Expected outputs

1. Crop genetic diversity documented.
2. The extent and underlying causes of genetic erosion determined.
3. The farmers' seed sources and exchange systems identified
4. Conservation practices identified.
5. Germplasm collected and conserved.

2.0 Methodology

2.1 Description of the study area

The study was conducted in Kabale district, which lies in the South West of the Republic of Uganda between latitudes 1^{o}S and 1^{o}30'S, longitudes 29^{o}18'E and 30^{o}9'E and with altitude ranging from 1,400 - 2500 metres above sea level. It borders with districts of Kisoro in the west, Rukungiri in the North, Ntungamo in the East, and the republic of Rwanda in the South. It has a montane type of climate with a bimodal rainfall pattern. It has two main rainy seasons with March-May as the short rains and September-November as long rains. The mean annual rainfall is 1,200mm and mean annual temperature is 18^{o}C. The relative humidity ranges between 100% and 90% in the mornings and decreases to between 50% and 60% throughout the year.

The average land area for agriculture is 2.06 hectares or 5.08 acres per household. The District is mountainous and has undulating hills with steep convex slopes of 10-60^{o} and gentle slopes of 5-10^{o} nearer the swampy valleys formerly occupied by papyrus swamps (Lindblade *et al*., 1996). Important crops grown include: sorghum, beans, peas, potatoes, sweet potatoes and bananas. The District is divided into three Counties and one municipality. The Counties include; Rukiga, Ndorwa and Rubanda.

The soils are mainly volcanic, ferralitic and peat soils. The volcanic soils are mainly found in Muko sub-county. The ferralitic soils are the most widespread in the district. The peat soils are mainly found in papyrus swamps and produce the rich organic soils for agriculture, which dominate the valleys of Kabale District.

2.2 Sampling method and sample size

Random sampling was used throughout the study, covering the three counties, one sub-county per county, and two parishes per sub-county to give a total of six parishes in the whole study area (Table 2). Sampling was restricted to parish level as the villages were very compacted and thus could not capture the whole crop diversity in the area. From a list of 100 farmers provided by each parish chief, 20 farmers per parish were randomly selected to make a total of 120 farmers in the whole study area.

Table 2: Selected study sites

County	Rukiga		Ndorwa		Rubanda	
Sub-County	Bukinda		Buhara		Muko	
Parish	Nyakisiru	Karorwa	Bugarama	Rwene	Ikamiro	Butare

2.3 Data collection

Data were collected using both open- and close-ended structured questionnaire that was pre-tested before the actual survey (Appendix I). The questionnaire was administered to individual farmers but group discussions and field observations were also done. Altitude was measured using geographic position system (GPS). To assess yields, plots currently being harvested were measured and a 2 x 2 meter representative section was harvested within each plot. In some cases, some plots had been harvested, so recall information was considered reliable.

For bananas, the land area for each cultivar was measured as follows:

$$\frac{\textit{Number of stumps for each cultivar}}{\textit{Total number of stumps for all the cultivars}} \quad X \quad \textit{Total area for all the cultivars}$$

For other crops that were grown as a mixture especially beans, the land area and production for each variety were obtained by measuring a 2x2 meter representative section and extrapolating proportions of each variety to the whole plot. This was on the assumption that all the varieties were evenly distributed with in the plot.

2.4 Germplasm collection

The standard universally accepted IPGRI germplasm collection form was used (Appendix II). Individuals were sampled at random at the collecting sites. Equal number of seeds were collected from each plant sampled.

2.5 Data analysis

Data were coded, entered, and analyzed using a SPSS program Version 10.0 for Windows for descriptive statistics. Percentages and cross tabulations techniques were used to examine the associations between investigated factors.

3.0 Results and discussion

3.1 Socio-economic characteristics

Majority of farmers interviewed (38.4%) were between 41 and 50 years of age (Table 3). Others were aged 20-30 (4.2%), 31-40 (25.8%), 51-60 (20.8%) and >60 (10.8%). This shows that the young generation (<30 years) was less involved in agriculture because some were still attending schools while others had migrated to towns to look for better paying jobs. The old generation (>60 years) was also less involved because they were very weak and could not afford agricultural activities.

More females (82.2%) were interviewed than males (17.8%). The reason for choosing more females than males was because the former do most of agricultural work (59%), while men only contribute 30% and children 11%. Therefore, women were more equipped with indigenous knowledge of various crops than men and were very useful in this study.

Most farmers had a family size of 6-10 persons (47.5%), 1-5 persons (30.8%) and >10 persons (21.7%). The large number of persons per family is an indicative of the high population pressure and land fragmentation in the area.

Most farmers had attained primary school level (51.2%), others secondary (23.3%), tertiary (13.3%) and 12.2% did not attend any formal education. This shows that people who were much involved in agricultural activities either did not attend any formal education or stopped at lower levels (primary and secondary levels). Those who attained higher levels were on other better paying jobs in towns.

Table 3. Socio-economic characteristics of the respondents

Characteristic	%
Age	
20-30	4.2
31-40	25.8
41-50	38.4
51-60	20.8
>60 years	10.8
Sex	
Male	17.8
Female	82.2
Marital status	
Married	75.0
Single	14.4
Widowed	5.6
Separated	5.0
Family size	
1-5	30.8
6-10	47.5
>10	21.7
Education level	
None	12.2
Primary	51.2
Secondary	23.3
Tertiary	13.3
Length of residence	
1-10	8.3
11-20	15.1
21-30	20.8
>30 years	55.8
Ethnic group	
Bakiga	67.8
Bafumbira	16.7
Banyarwanda	13.3
Banyankole	2.2
Land tenure	
Customary	97.5
Mailo	0
Lease	0
Freehold	2.5

A big number of the farmers (55.8%) had lived in their areas for > 30 years, while others had lived there for 1-10 years (8.3%), 11-20 years (15.1%) and 21-30 years (20.8%).

Most farmers were Bakiga by tribe (67.8%), while a few were bafumbira (16.7%), Banyarwanda (13.3%) and Banyankole (2.2%). The higher percentage of Bakiga tribe was because this area is traditionally for Bakiga but some other tribes have migrated from neighboring areas including Kisoro district, Rwanda and Ankole region.

Many farmers (97.5%) owned their land customarily. This is official recognition of the Uganda nationals who by birth have the right to own land without necessarily having it registered with the Registrar of Titles. Minority (2.5%) owned their land by freehold. This is tenancy where land is surveyed and registered with the Registrar of Titles and the proprietor has it in perpetuity.

3.2 Crop genetic diversity at inter and intra-specific levels

3.2.1 Bananas and plantains (*Musa spp*)

Twenty five banana/plantain cultivars were found grown by the farmers interviewed. Among them, 14 were cooking type, 5 were plantains and 6 were beer type (Table 4). The most widely grown banana cultivar among the cooking type was Mbwazirume, with percentage (78.3%), land area (1.87 Ha) and production (10.56 Tones/year) (Table 4). The second most widely grown cultivar was Enyamwonyo endingwa with percentage (63.5%), land area (0.85 Ha) and production (7.01 Tones/year). These two cultivars were most grown mainly due to their big bunch size and marketability. On average, each bunch of Mbwazirume and Enyamwonyo endingwa weighed 28kgs and 25kgs respectively. The price per bunch ranged from 1,500-3,000Ushs and 1,500-4,000Ushs, respectively, depending on the season (1US$ = 1930 Ushs). They were estimated to yield up to 7 and 6 tones per hectare per year respectively compared to others, which were estimated to yield 3 – 5 tones per hectare per year.

The least grown banana cultivar among the cooking type was Tibihira only in terms of percentage (24.6%). But in terms of land area and production, cultivar Mabeere/Kitika was the least (0.23 Ha and 1.64 Tones/year, respectively) (Table 4). The reason for this is that cultivar Tibihira was a new variety and had not reached many farmers, but its bunch was bigger (average 23kgs) than that of Mabeere/Kitika (average 18kgs). The latter also did not have good taste and a high market value but was only grown because since it is not susceptible to lodging as it is short, no stakes are necessary to support it.

Table 4. Banana/plantain cultivars grown, their percentages, land area and production

Cultivar	%	Area (Ha)	Production (Tones/year)
Mbwazirume (C)	78.3	1.87	10.56
Enyamwonyo endingwa (C)	63.5	0.85	7.01
Mijuba (C)	56.4	0.54	4.04
Nyakyetengwa (C)	54.8	0.65	6.37
Nyinaruhuna (C)	52.6	0.48	4.49
Kibuzi (C)	51.4	0.31	3.05
Enjagata (C)	48.2	0.64	6.55
Enyanshenyi (C)	48.1	0.37	3.39
Enzirabahima (C)	45.1	0.48	4.59
Rwamigongo (C)	43.3	0.52	3.45
Enzirabushera (C)	41.9	0.38	3.13
Ensika (B)	40.5	0.37	2.34
Enyabururu (C)	38.7	0.28	2.06
Enkara (B)	37.6	0.24	1.87
Kabalagala (P)	35.1	0.11	0.86
Mabeere/Kitika (C)	33.4	0.23	1.64
Kayinja (P)	33.3	0.19	1.28
Rwabuganga (B)	32.8	0.18	1.23
Kisubi (P)	30.2	0.06	1.52
Engoote (B)	29.9	0.12	0.98
Ensa (B)	26.7	0.13	1.47
Tibihira (C)	24.6	0.27	2.47
Bogoya (P)	20.4	0.16	1.24
Entundu (B)	19.5	0.06	0.81
Gonja (P)	7.7	0.04	0.25

C = Cooking type, P= Plantains, B= Beer type

The most widely grown banana cultivar (brewing type) was Ensika, with percentage (40.5%), land area (0.37Ha) and production (2.34Tones/year). The least grown banana cultivar (brewing type) was Entundu, with percentage (19.5%), land area (0.06Ha) and production (0.81Tones/year). Cultivar Ensika was most grown because of its good concentrated juice for brewing while cultivar Entundu was reported to give dilute juice.

Among the plantains, Kabalagala was the most grown only in terms of percentage (35.1%), but Kayinja was most grown both in terms of land area (0.19 Ha) and production

(1.28 Tones/year) (Table 4). Kayinja is used mainly to supplement the beer cultivars and also to make more juice and was grown on much bigger area than kabalagala. The least grown cultivar among plantains was Gonja. This was in terms of percentage (7.7%), land area (0.08Ha) and production (0.53Tones/year). The second least grown plantain was Bogoya with percentage (20.4%%), land area (0.16Ha) and production (1.24Tones/year).

But in general, banana/plantain yields were low mainly due to poor agronomic practices, diseases, particularly bacterial wilt (causal agent *Pseudomonus solanacearum*) and weevils (*Cosmopolites sordidus*). The recommended spacing of 3m X 3m was not followed. The plants were closely spaced and the reason was that due to steep slopes, the plants were liable to lodging. By reducing on the spacing, they reduce the chances of lodging.

Bananas and plantains were widely grown in areas with low altitude and gentle slopes and least grown in areas with high altitude and steep slopes. Nyakisiru and Karorwa Parishes were much more involved in banana and plantain production than other areas mainly due to gentle slopes and low altitudinal ranges (1778-1848 and 1835-1864 m.a.s.l, respectively). Temperatures in these areas are warm and favorable for banana and plantain production. Also with relatively gentle slopes, plants are not susceptible to lodging and do not need many stakes, which is a big problem in Kabale. Ikamiro parish was least involved in banana and plantain production and Butare parish was hardly involved. These areas have steep slopes and high altitudinal ranges (1985-2120 and 2130-2417 m.a.s.l, respectively). The temperatures in these parishes are very cool and not favorable for banana and plantain production. Only two farmers were trying out cultivar Mabeere/Kitika in Butare parish on small scale but the yields were not promising.

3.2.2 Sorghum (*Sorghum bicolor.* L)

Ten sorghum varieties were found on farmers' fields (Table 5). The most widely grown variety among them was Kyatanombe, with percentage (73.6%), land area (2.23Ha) and production (5.61Tones/season) (Table 5). This variety was favoured most because of its high yield (average 3.9 tones/ha), high price (200-250 Ushs/kg), and good culinary quality at making porridge and local brew (Omuramba). The only problem with it was its height (tall), hence its susceptibility to lodging.

Table 5. Sorghum varieties grown, their percentages, land area and production

Local variety name	%	Area (Ha)	Production (Tones/season)
Kyatanombe	73.6	2.23	5.61
Rwemereza	51.4	1.63	3.64
Kigufu	44.1	0.89	1.87
Ruyanga	34.1	0.69	1.26
Buhuri	28.8	0.48	0.65
Munyarwanda	18.5	0.33	0.86
Shokanyi	17.3	0.54	0.91
Kabusiba	13.0	0.21	0.44
Mabeere	8.7	0.08	0.17
Magune	3.4	0.01	0.02

The second most grown variety was Rwemereza with percentage (51.4%), land area (1.63) and production (3.64 Tones/season). This variety was also most liked and widely grown mainly due to its high yield (average 3.2 tones/ha), big grain size and its height (medium height thus not very susceptible lodging).

The least grown sorghum variety was Amagune, with percentage (3.4%), land area (0.01Ha) and production (0.02 Tones/season). This variety is facing genetic erosion as many farmers have abandoned it. It is white in color, very sweet and most liked by birds

and when grown alone, the yields are reduced by bird attack. The few who are still growing it mix it with other varieties. Another variety called Mabeere is also facing genetic erosion mainly due to its poor culinary quality as porridge and low yield (average 1.7 tones/ha).

3.2.3 Peas *(Pisum sativum.* L*)*

Six pea varieties were identified from the farmers' fields (Table 6). Among them, the most liked and widely grown variety was Meisho, with percentage (69.2%), land area (2.23Ha) and production (5.97 Tones/season).This was mainly because of its color (white), big seed size, high yield (average 3.8 tones/ha), high price (300-500 Ushs/kg) and good culinary quality . The second most grown variety was Rwemereza mainly because of its color (white), medium seed size (slightly smaller that Meisho), high yield (average 3.5 tones/ha) and good market (300-455 Ushs/kg).

Table 6. Pea varieties grown, their percentages, land area and production

Local variety name	%	Area (Ha)	Production (Tones/season)
Meisho	69.2	1.89	5.97
Rwemereza	57.7	1.15	3.92
Kiyundo	38.6	0.59	1.84
Mitabiro	18.2	0.21	0.63
Misere	7.0	0.07	0.21
Amaharare	2.4	0.02	0.06

The least grown pea variety was Amaharare with percentage (2.4%), land area (0.02Ha) and production (0.06 Tones/season). This variety was not liked mainly due to its color (greenish-black) and low price (150-200 Ushs/kg). The second pea variety facing genetic erosion was Misere mainly due to its color (greenish-black), small seed size, poor culinary quality, and low market value.

3.2.4 Beans (*Phaseolus vulgaris* L.)

Twenty seven bean varieties were grown by farmers interviewed, 18 of them were bush type and 9 climbing type (Table 7). Among the bush type, the most widely grown variety was Kachwekano (K20), with percentage (73.4%), land area (1.15 Ha) and production (2.15 Tones/season) (Table 7). This was because of its high yield (average 2.2 tones/Ha) and market (200-300 Ushs/kg). This has also been reported by Grisley (1994). The only problem was its susceptibility to the common bean disease, fusarium wilt (Causal agent: *Fusarium oxysporum*, f.sp. *phaseoli*). The second most widely grown bean variety (bush type) was K132, with percentage (61.6%), land area (0.88 Ha) and production (1.63 Tones/season). This variety was also most widely grown because of its high yield and marketability. K132 resembles variety Kachwekano (K20) and farmers always confuse these varieties for one another. The least grown bean variety (bush type) was Kijunde, with percentage (5.6%), land area (0.02Ha) and production (0.03 Tones/season). This was

mainly because of lack of market, and rotting in the field. Another bean variety (bush type) facing genetic erosion was Mwonyogwembeba because it was very popular with wild rats.

Table 7. Bean varieties grown, their percentages, land area and production

Local variety name	%	Area (Ha)	Production (Tones/season)
Kachwekano (K20) (B)	73.4	1.15	2.15
K132 (B)	61.6	0.88	1.63
Rushare(B)	56.8	0.74	1.16
Kahura(B)	53.4	0.67	1.25
Gisenyi (C)	43.9	0.63	1.23
K131(B)	42.5	0.41	0.71
Bwiseri(B)	42.7	0.57	0.88
Ngwinurare(C)	38.3	0.37	0.69
Bwanalesi(B)	38.1	0.39	0.69
Umubano(C)	34.0	0.42	0.88
Vuninkingi(C)	27.4	0.16	0.29
Kankuryembarukye(B)	26.3	0.22	0.36
Kashogashoga(B)	24.5	0.24	0.44
Kahura(C)	19.0	0.05	0.09
Bwanalesi(C)	19.7	0.07	0.13
Kabanda(B)	18.1	0.31	0.52
Shoronga(B)	14.6	0.23	0.39
Ruhendamagari(B)	13.0	0.14	0.25
Bikanja(B)	13.2	0.19	0.31
Bwiseri(C)	10.4	0.03	0.05
Matafu(B)	10.0	0.09	0.14
Kikoti(B)	9.9	0.05	0.08
Kabenga(B)	9.2	0.08	0.13
Mwonyogwembeba(B)	8.5	0.04	0.05
Kijunde(B)	5.6	0.02	0.03
Nyinacanada(C)	5.0	0.02	0.04
Rusavinyanza(C)	4.1	0.01	0.02

B = Bush beans C = Climbing beans

Among the climbing type of beans, locally called ‘Musingiriro’, the most widely grown variety was Gisenyi, with percentage (43%), land area (0.63 Ha) and production (1.23 Tones/season) (Table 7). Other most widely grown bean varieties (climbing type) were Ngwinurare, Umubano and Vuninkingi. These varieties have also been reported by Sperling (1995) and Mugisa-Mutetikka (1997) to be the most grown and highly adopted.

These are improved varieties that have recently been introduced in the area and spreading very fast thus replacing the traditional varieties. These varieties are mostly grown because of their high yields (2.0-2.5 tones/ha) and are not very susceptible to the common bean disease fusarium wilt (Causal agent: *Fusarium oxysporum*, f.sp. *phaseoli*) which is the main problem with bush type of beans. The least grown bean variety (climbing type) was Rusavinyanza, with percentage (4.1%), land area (0.01 Ha) and production (0.02 Tones/season). This was followed by Nyinacanada and Bwiseri, which are also climbing type. These varieties were low yielding due to susceptibility to the common bean disease, fusarium wilt.

However, many farmers were willing to plant the new varieties of climbing beans but the only problem was lack of wood stakes. The major woods used by farmers as staking materials were *Eucalyptus spp*. This was also the major tree species used as staking materials by farmers in Rwanda as reported by Sperling (1995).

3.2.5 Potatoes (*Solanum tuberosum*. L)

Twelve potato varieties were grown by the farmers interviewed (Table 8). Among them, Victoria was the most widely grown potato variety, with percentage (71.6%), land area (1.54 Ha) and total production (17.81 Tones/season) (Table 8). This variety was most liked because of its high yield (10-20 tones/Ha), high price (150-250 Ushs/kg) and its good culinary quality as chips. This has also been reported by Low (1997). This is a new variety recently introduced in the area. However, this variety was said to be more susceptible to the late blight (Causal agent: *Phytophthora infestans*) than other varieties. Therefore, use of fungicides was imperative.

Table 8. Potato varieties grown, their percentages, land area and production

Local variety name	%	Area (Ha)	Production (Tones/season)
Victoria	71.6	1.54	17.81
Rutuku/Rusina	64.9	0.84	9.53
Sangema	51.2	0.38	4.23
Cruza	44.4	0.25	3.46
Bumbamagara	39.1	0.31	2.24
Kimuli/Rwamatiya	35.6	0.35	2.65
Rwamgume	24.2	0.16	2.02
Rwanshaki	22.3	0.18	1.76
BR	14.1	0.11	1.26
Katikamwe	10.6	0.05	0.36
Kisoro	8.4	0.06	0.63
Malierahinda	5.8	0.02	0.13
Kabeera	4.5	0.01	0.07

The second most widely grown potato variety was Rutuku/Rusina, with percentage (64.9%), land area (0.84 Ha) and total production (17.81 Tones/season). This is also more widely grown due to its high yield (10-15tones/Ha) and market (100-200 Ushs/kg) as well as suitability for making chips. It was also susceptible to the late blight and use of fungicides was necessary especially during heavy rains.

Varieties Bumbamagara and Kimuli/Rwamatiya were mainly grown for home consumption on small plots and in most cases, they were grown on their own as volunteers in either banana plantation or other fields. These varieties are resistant to late blight and do not need herbicides like other varieties. However, they are low yielding (6-7tones/Ha) and do not have a ready market. Varieties Rwangume, Rwanshaki and BR are new and have not reached many farmers.

The least grown potato variety was Kabeera, with percentage (4.5%), land area (0.01Ha) and production (0.07 Tones/season). This is because this variety is the most susceptible to diseases mainly late blight and has no market. Other varieties facing genetic erosion were Malierahinda, Kisoro and Katikamwe mainly because of lack of market, susceptibility to late blight and poor yields.

In general, potato was more widely cultivated in Butare Parish than in other parishes. This is probably because of its close proximity to Kalengyere Highland Crops Research Center and farmers have easy access to planting materials and new varieties. A lot of potato diversity was found in this area. In addition, this area has a high altitude (2130–417 m.a.s.l) and cool temperatures favorable for potato production as reported by Low, (1997). A number of new potato varieties (Rwangume, Rwanshaki and BR) were mainly grown in this area.

3.2.6 Sweet potatoes (*Ipomea batatas.* L)

Seventeen sweet potato varieties were found grown by farmers interviewed (Table 9). Among them, variety Mushemeza/Musanyusa was the most widely grown only in terms percentage (69.2%) (Table 9). However, in terms of land area and production, variety Mukono was leading (1.43 Ha and 14.06 Tones/season, respectively). These two varieties

(Mushemeza/Musanyusa and Mukono) were most liked and widely grown because of high market value (100-150Ushs/kg) and high yield (9-18 tones/ha). They also have a smooth skin hence easy to peel and were mostly sold to schools and vendors for selling to towns.

Table 9. Sweet potato varieties, their percentages, land area and production

Local variety name	%	Area (Ha)	Production (Tones/season)
Mushemeza/Musanyusa	69.2	0.86	9.58
Mukono	56.0	1.43	14.06
Kigabari	53.1	0.54	5.34
Nyinakamanzi	51.5	0.38	3.52
Kyebandira	45.5	0.35	3.33
Kwezikumwe	44.9	0.34	3.62
Kiribwakimwe	35.6	0.35	2.86
Mugorora	31.0	0.25	2.16
Ntegakatebe	18.1	0.13	1.51
Mukazi	17.4	0.11	1.04
Glori	8.9	0.07	0.79
Mulera	6.7	0.03	0.32
Sengamugabo	5.3	0.01	0.25
Kanyansi	5.6	0.03	0.22
Rwampala	4.8	0.01	0.31
Norah	3.0	0.02	0.25
Magumba	3.5	0.01	0.11

Nyinakamanzi was the oldest variety among the sweet potato varieties, grown on small plots or sometimes mixed with other varieties. It was mainly used for home consumption or sometimes sold when there is shortage of supply for other varieties. This variety was high yielding (8-15 tones/Ha) but had a low market potential because it has a rough skin (wrinkled), making it hard to peel.

The least grown potato variety was Magumba, with percentage (3.5%), land area (0.01Ha) and production (0.11 Tones/season). This variety is very sweet when raw and it is liked by wild rats. Other potato varieties facing genetic erosion were Kanyansi, Mulera, Sengamugabo, Rwampala and Norah.

3.3 Minor crops grown

3.3.1 Cereals

Maize (*Zea mays*. L), finger millet (*Eleusine corocana.* L) and wheat (*Triticum aestivum*). These are grown by few farmers and in small quantities. Most of the farmers stopped growing finger millet and wheat mainly due to much labor requirements of these species, shortage of land and lack of market.

3.3.2 Fruits

Passion fruits (*Passiflora spp*), Paw paw (*Asimina triloba*), Avocado (*Persea americana*), Oranges (*Citrus spp*), Mangoes (*Mangifera indica L*.), pineaples (*Ananus comosus*), tree tomato (*Cyphomandra betacea*), Guava (*Psidium guajava*). Exotic fruits like apples apples (*Malus domestica*), have been introduced by ICRAF and are being tried by few farmers.

3.3.3 Vegetables

Tomatoes (*Lycopersicon esculentum*), cabbage (*Brassica oleracea*), carrots (*Daucus carota*), onions (*Allium cepa*), Nakati (*Solanum aethiopicum*), Bbuga (*Amaranthus lividus*), Doodo (*Amaranthus dubious*), egg plants (*solanum spp*), pumpkins (*Cucurbita spp*), pepper (*Capsicum spp*). These are normally sold on road sides or sometimes taken to Kabale town.

3.3.4 Other crops

Yams (*Dioscorea spp*), tobacco (*Nicotiana tabacum*), groundnuts (*Arachis hypogea*), coffee (*Coffea spp*), cassava (*Manihot esculenta*) and sugar cane (*Saccharum officinarum* L.). Many farmers abandoned coffee mainly due to reductions in prices and shortage of land. However, introductions of Arabic coffee were in progress.

3.4 Genetic erosion and farmers' perceptions on its causes

3.4.1 Genetic erosion in major crops

3.4.1.1 Genetic erosion in Bananas and Plantains (*Musa spp*)

There were no banana and plantain cultivars reported completely lost over the years. However, some cultivars were abandoned by some farmers but were still grown by others. These include Gonja, Bogoya, Mabeere/Kitika, entundu, and engoote. They were still grown by 7.7%, 20.4%, 33.3%, 19.5% and 29.9% and were abandoned by 46.4%, 31.7%, 24.3%, 19.6% and 17.4% of the farmers, respectively. These cultivars were replaced with the cooking types. Low genetic erosion in bananas and plantains was a result of few new cultivars introduced in the area.

3.4.1.2 Genetic erosion in Sorghum *(Sorghum bicolor.* L*)*

There was no sorghum variety reported lost completely. However, some varieties are being threatened as many farmers abandoned them but were still grown by few. These varieties are Mabeere and Magune. They are still grown by 8.7% and 3.4% and were dropped by 43.8% and 72.5%, respectively. Less genetic erosion was also mainly attributed to few new varieties of sorghum released introduced in the area.

3.4.1.3 Genetic erosion in Peas *(Pisum sativum.* L*)*

Five pea varieties have been abandoned (Table 10). However, two of these (Misere and Amaharare) are still grown by few farmers (7.0 and 2.4%, respectively) but were at the verge of extinction. These varieties were dropped by 21.0% and 34.7% of the farmers, respectively. Varieties Kyambia, Rwantooro, and Nyakasaza were lost completely and could not be traced from other farmers. Less genetic erosion was also a result of few new varieties of sorghum released in the area.

Table 10. Pea varieties dropped

Local variety name	%
Kyambia	61.4
Rwantooro	57.9
Amaharare	34.7
Nyakasaza	32.1
Misere	21.0

3.4.1.4 Genetic erosion in Beans *(Phaseolus vulgaris.* L*)*

Fourteen bean varieties were reported abandoned (Table 11). However, some were still grown by few farmers and were facing extinction. Those dropped but were still grown by few farmers include Ruhendamagari (13.0%), Mwonyogwembeba (8.5%), Kijunde (5.6%), Rusavinyanza (4.1%) and kikoti (9.9%). These varieties were dropped by 21.2%, 21.6%, 41.5%, 14.9% and 13.7% of the farmers respectively. Varieties Ntemeroruhanga, Kanyamunyu, Makara, Mugyerahansi, Kesharingwa, Kyinganente, Mirankwongyere, Murundi and Kiribyonyami were lost completely and could not be traced. Much genetic erosion was mainly attributed to frequent introductions of new varieties in the area.

Table 11. Bean varieties abandoned

Local variety name	%
Ntemeroruhanga (B)	64.5
Kanyamunyu (B)	58.3
Makara (B)	58.5
Mugyerahansi (B)	47.9
Kesharingwa (B)	45.8
Kyinganente (B)	41.7
Kijunde (B)	41.5
Mirankwongyere (B)	39.4
Murundi (B)	26.6
Mwonyogwembeba (B)	21.6
Ruhendamagari (B)	21.1
Kiribyonyami (B)	14.6
Rusavinyanza (C)	14.9
Kikoti (B)	13.7

B = Bush type, C = Climbing type

3.4.1.5 Genetic erosion in Potatoes *(Solanum tuberosum.* L*)*

Twelve potato varieties were reported abandoned (Table 12), but among these, some were still grown by few farmers and were facing extinction. Those still grown include Malierahinda (5.8%), Katikamwe (10.6%), Kisoro (8.4%), Cruza (44.4%) and Kabeera (4.5%). They were dropped by 47.3%, 33.4%, 21.4%, 7.9%, and 14.1% of the farmers respectively. Potato varieties Kashari, Magojo, Joseline, Ruranda, Kakwirwa, Rushwiga and Kaposho were lost completely and could not be traced. Much genetic erosion was also mainly attributed to many new potato varieties being frequently released in the area.

Table 12. Potato varieties abandoned

Local variety name	%
Kashari	61.4
Magojo	54.9
Joseline	54.5
Ruranda	51.8
Kakwirwa	51.2
Rushwiga	49.7
Malierahinda	47.3
Kaposho	41.6
Kataikome	33.4
Kisoro	21.4

Kabeera	14.1
Cruza	7.9

3.4.1.6 Genetic erosion in Sweet potatoes *(Ipomea batatas.* L*)*

A lot of genetic erosion had occurred to sweet potatoes though there is still high diversity. Twenty six varieties were reported abandoned (Table 13) and some were still grown but on the verge of extinction. Those still grown include Kanyansi (5.6%), Mulera (6.7%), Sengamugabo (5.3%), Rwampala (4.8%), Ntegakatebe (18.1%), Norah (3.0%), Kyebandira (45.5%), and Magumba (3.5%). These varieties were dropped by 49.5%, 44.8%, 31.4%, 35.1%, 14.7%, 38.8%, 9.3% and 26.9% of the farmers respectively. Varieties Nyirasasi, Kakoba, Kikoyo, Magabari, Katere, Nshenhsera, Kashusha, Kahungyenzi, Kyitekamaju, Nkyiriza, Mukobwa, Nkijamundegye, Kyitambira, Kifefe, Nyinabusegyenyi, Kataikome, Nderera and Ruranda were lost completely and could not be traced from other farmers. Much genetic erosion was also mainly attributed to many new sweet potato varieties being frequently released in the area.

Table 13. Sweet potato varieties abandoned

Local variety name	**%**
Nyirasasi	87.9
Kakoba	72.5
Kikoyo	72.6
Magabari	69.3
Katere	66.1
Nshenhsera	61.8
Kashusha	61.5
Kahungyenzi	61.9
Kyitekamaju	57.7
Nkyiriza	56.7
Mukobwa	55.5
Nkijamundegye	55.3
Kyitambira	53.3
Kanyansi	49.5
Kifefe	49.7
Nyinabusegyenyi	47.9
Kataikome	46.5

Mulera	44.8
Norah	38.8
Rwampala	35.1
Nderera	35.6
Sengamugabo	31.4
Magumba	26.9
Ruranda	23.4
Ntegakatebe	14.7
Kyebandira	9.3

3.4.2 Genetic erosion in other crops

Other most threatened crop species include finger millet, wheat, tobacco, and pumpkins as they are still grown by very few farmers and were dropped by many. Many farmers also dropped Arabic coffee but introductions were in progress. Pyrethrum (*Chrysanthemum cinerariaefolium*) used to be grown in the area but it was dropped completely.

3.4.2 Farmers' perceptions on causes of genetic erosion

The most important cause of genetic erosion as mentioned by many farmers (93.7%) was the introduction of new/modern varieties (Table 14). This has also been reported by Frankel and Bennett, (1970); Frankel and Hawkes, (1975); Harlan, (1975a); Barlett, (1980); Zimmerer, (1992), Charles and Weiss, (1999); Kiambi, (1998) and FAO, (1999). Due to high influx of many new varieties of beans, potatoes and sweet potatoes, much genetic erosion had occurred to these crops. Due to superior qualities of modern varieties (high yields and high prices), farmers increasingly replace traditional varieties with modern varieties in many fields. This results in reduced diversity of the traditional varieties.

Another major suggested cause of genetic erosion was lack of market (68.8%). This is because most of the farmers rely solely on agriculture for all their family needs and so they

give high priority to varieties that are in high demand and neglect or sometimes drop those with low demand. Those dropped are in most cases traditional varieties.

Diseases (45.6%) and pests (33.4%) were other factors contributing to genetic erosion. The crop varieties that used to be resistant to most of the diseases and pests lost the resistance resulting in decline in yield. Arunachalam, (1999) also reported that natural disasters such as floods, droughts, diseases and pests can also bring about genetic erosion.

Shortage of land (41.9%) and labor (23.5%) were other factors mentioned by farmers. Due to high population pressure in the district, there is shortage of land and farmers have to utilize their meagre acreages for more productive and high priced crop varieties. In due course, the lower yielding varieties, which in most cases are traditional, are dropped. There is also high rate of urban immigration especially with the young generation, which is still energetic. This reduces the labor force and results in abandonment of crop varieties requiring high amounts of labor. This trend has also been reported by Charles and Weiss (1999) and Zimmerer (1992).

Table 14. Underlying causes of genetic erosion

Cause	%
Introduction of new varieties	93.7
Lack of market	68.8
Diseases	45.6
Shortage of land	41.9
Pests	33.4
Shortage of labor	23.5
Change in weather	19.6
Loss of soil fertility	15.8
Others	10.6

Other factors for genetic erosion were change in weather (23.5%) and loss of soil fertility (15.8%). Some crop varieties were adapted to the weather conditions and were high yielding. However, due to change in weather, varieties could no longer yield highly and farmers shifted to other new varieties. Climatic changes also resulted in diseases and pests that were non-existent in the area. Due to frequent cultivation of the land without furrowing, there was decline in soil fertility and some varieties were dropped because their yields were low.

Other causes of genetic erosion (10.6%) were taste, color, size, and plant height. Farmers dropped some varieties due to bad taste, seed color (especially beans which were blue or black), seed size (small ones mostly dropped) and height (tall plants mostly dropped due to lodging).

3.5 Farmers' seed sources and seed exchange systems and its impact on crop genetic diversity

3.5.1 Farmers' seed source

There were two main sources of farmers' seeds; informal and formal. These are the two most important sources of farmers' seeds as mentioned by Pray and Ramasawmi, (1991); Cromwell *et al*., (1992); Friis-Hansen, (1992); Delouche, (1982); Osborn and Faye, (1991); Jaffe and Srivastava, (1992); Bal and Douglas, (1992); Linnemann and de Bruijn, (1987); Worede, (1992); Sperling, Loevinsohn and Ntabomvura, (1993) and Cromwell *et al*., (1993). The informal seed source was mainly for traditional varieties while the formal was for modern varieties as shown in Table 15. The informal seed supply is practiced by farmers themselves in conservation and exchange of their landraces while the formal is used by NGO's and research organizations to supply the modern varieties (Pray and

Ramasawmi, 1991; Cromwell *et al*., 1992; Pray and Ramasawmi, 1991; Cromwell *et al*., 1992 and Worede, 1992).

As shown in Table 15, the main source of farmers' seed for traditional varieties was from own stock (81.5%), which is an informal seed source. These varieties are mainly used for home consumption since they don't have market. The farmers consume but keep some seeds for the next season. For modern varieties, the main source was cash purchase from market (50.8%).

Table 15. Farmers' seed source

Seed source	Traditional varieties %	Modern varieties %
Own stock	81.5	31.3
Cash purchase from market	11.1	50.8
Cash purchase from shops	7.6	32.8
Cash purchase from other farmers	7.4	29.5
Exchange for other seeds	10.3	23.6
Free from other farmers	5.6	40.9
NGOs/CBOs/National/International programs	2.1	36.4

As well, NGOs play a big role in distribution of these varieties as 36.4% of the farmers depended on them. The NGOs/CBOs which were playing a crucial part include: AFRICARE, CIAT, ICRAF and KADFA. Therefore, the main sources of farmers' seeds for modern varieties were by formal means. Though some farmers get free seeds of modern varieties from other farmers (40.9%), these seeds were not enough and were supplemented by buying from markets, other farmers or from shops. However, buying from markets and other farmers was common because of proximity. But farmers who were engaged in selling new varieties could not produce enough seeds to supply all the farmers. The reason for farmers not depending on their own source for new varieties was

because of high demand for these varieties. Most farmers could not afford to keep some seeds when the demand is so high and they end up selling everything.

3.5.2 Seed exchange systems

Table 16 shows that a big number of farmers (41.7%) did not give out their traditional varieties to other farmers, while 17.2%, 23.1%, 6.3%, 7.5%and 4.2% did give out their traditional seeds to 1,2,3,4 and >4 other farmers respectively. Further more, a big percentage of the farmers (46.1%) did not receive traditional varieties from other farmers, while 21.1%, 15.4%, 8.3%, 6.3% and 2.6% did received traditional seeds from 1, 2, 3, 4 and >4 other farmers respectively. This means that few farmers gave out their traditional seeds to other farmers and also a few farmers received traditional seeds from other farmers. The above phenomenon shows that there was little seed exchange of the traditional varieties among the farmers. Therefore, traditional seeds can easily be lost due to little exchange.

To the contrary, many farmers (36.2%) gave out their seeds of modern varieties to four other farmers while 25.4%, 20.7%, 9.2%, 5.4% and 3.1% gave out their seeds of modern varieties to >4, 3, 2, 1 and 0 other farmers respectively. Many farmers (39.5%) did receive seeds of modern varieties from three other farmers while 22.2%, 14.6%, 8.1%, 10.1% and 5.3% also did receive seeds of modern varieties from >4, 4, 2, 1 and 0 other farmers respectively.

Table 16. Farmers' seed exchange systems

Seeds given out to	Traditional varieties %	Modern varieties %
None	41.7	3.1
One farmer	17.2	5.4
Two farmers	23.1	9.2
Three farmers	6.3	20.7
Four farmers	7.5	36.2
>Four farmers	4.2	25.4
Seeds received from		
None	46.1	5.3
One farmer	21.1	10.1
Two farmers	15.4	8.1
Three farmers	8.3	39.5
Four farmers	6.3	14.6
>Four farmers	2.6	22.4

This means that many farmers received seeds of modern varieties from other farmers and also many farmers gave their seeds of modern varieties to other farmers. This shows that there was a lot of seed exchange of seeds of modern varieties among the farmers. There was a lot of giving and receiving of modern varieties than with traditional ones. This has resulted in wide and fast spread of the modern varieties, which has put traditional ones at risk of extinction. A lot of seed exchange of modern varieties among farmers has also been reported by Mugisa-Mutetikka (1997) on dissemination of new bean varieties in Kabale, and David and Sperling (1997) on new bean seed technology transfer in eastern and central Africa. Most of the seed exchange in Kabale was with potatoes, sweet potatoes and beans. These are the crops in which a lot of modern varieties have been released and are threatening traditional varieties through genetic erosion.

3.6 Conservation practices

On-farm conservation was the main practice used for vegetatively propagated crop species like bananas, sweet potatoes, pineapples, sugarcane and fruit trees. For crop species propagated by seeds with exception of potatoes, the main conservation practice was by drying the seeds and storing in either farmers' houses in gunny bags or by use of

traditional seed storage methods. The traditional seed storage methods were still used by few farmers (0.1%) especially the old ones (>60 years) and include:

- Use of grass thatched small houses locally called ‘’ebihumi’’ made of light sticks and hanging on strong poles with rat guards. These were mainly used for sorghum.

- Hanging unthreshed crops outside on verandah mainly used for sorghum and maize.

However, many farmers abandoned these traditional seed storage methods mainly because of thieves.

When seeds are to be stored for long periods, they are treated with dust formulations to control weevils. The commonly used dust formulation was Marathion. Some farmers were using wood ash but it was less effective.

For potato, seeds are displayed either on dry ground or raised level in darkness and stored for a period of 2-6 months depending on the variety.

3.7 Germplasm collected

Sixty seed specimens representing four crop species were collected from the three counties (Tables 17-22). The crop species include: beans *Phaseolus vulgaris.* L), sorghum (*Sorghum bicolor.* L), peas (*Pisum sativum.* L) and maize (*Zea mays*. L). For all the crops except sorghum, there are two growing seasons. The first season starts in March and ends in July while the second season starts in September and ends in February. For sorghum, the only growing season starts from December and ends in July-August. All the crop species were used as food except sorghum, which is also used as a beverage. In Rubanda, the soils were more of clay loam while in Rukiga and Ndorwa, soils were more of loam.

Table 17. Germplasm collected from Butare Parish, Rubanda County

Geographical position	Crop species	Local variety name	Seed color
Alt: 7402ft S01o11.480' E029o48.267'	Beans (*Phaseolus vulgaris* L.)	Kachwekano (K20) (B)	Red and white mottled
		Rusavinyanza (C)	Brownish black
		Nyinacanada (C)	Yellow
		Rusavinyanza (B)	Brownish black
		Kikoti (B)	Brownish black and light green
Alt: 7445ft S01o12.640' E029'46.461'	Sorghum (*Sorghum bicolor.* L)	Kyatanombe	Reddish black
		Buhuri	Red
Alt: 7977ft S01o12.788' E029o47.627'	Peas *(Pisum sativum.* L*)*	Meisho	White with black eyes
		Misere	Brownish green
		Rwemereza	White
		Amaharare	Brownish green with black eye
Alt: 7082ft S01o12.259' E029o48.183'	Maize (*Zea mays*. L)	Butiha	White, yellow, blue and red
		Binzari	Yellow and white

Table 18. Germplasm collected from Ikamiro Parish, Rubanda County

Geographical position	Crop species	Local variety name	Seed color
Alt: 6448ft S01o14.126' E029o49.908'	Beans (*Phaseolus vulgaris* L.)	Kachwekano (K20) (B)	Red and white mottled
		Bwanalesi (B)	Yellowish brown
		Rusavinyanza (B)	Brownish black
		Rushare (B)	Red
		Ngwinurare (C)	Pink with red and black mottles
Alt: 6497ft S01o13.507' E029o49.442'	Sorghum (*Sorghum bicolor.* L)	Kyatanombe	Reddish black
		Buhuri	Red
		Rwemereza	Red
		Magune	White
Alt: 6746ft S01o14.854' E029o50.094'	Peas *(Pisum sativum.* L*)*	Meisho	White with black eyes
		Rwemereza	White
Alt: 6511ft S01o13.803' E029o49.526'	Maize (*Zea mays*. L)	Butiha	White, yellow, blue and red
		Mahinda	White, yellow, blue and red
		Muriza	Red

Table 19. Germplasm collected from Rwene Parish, Ndorwa County

Geographical position	Crop species	Local variety name	Seed color
Alt: 6058ft S01o24.016' E030o01.667'	Beans (*Phaseolus vulgaris* L.)	Bikanja (B)	Brown
		Kabenga (B)	Blackish purple
		Matafu (B)	Yellow
Alt: 6216ft S01o23.471' E030o01.794'	Sorghum (*Sorghum bicolor.* L)	Kyatanombe	Reddish black
		Kabusiba	Reddish white
Alt: 6171ft S01o22.964' E030o01.768'	Peas *(Pisum sativum.* L*)*	Meisho	White with black eyes
		Misere	Brownish green
Alt: 6079ft S01o23.971' E030o01.871'	Maize (*Zea mays*. L)	Muriza	Red

Table 20. Germplasm collected from Bugarama Parish, Ndorwa County

Geographical position	Crop species	Local variety name	Seed color
Alt: 6771ft S01o19.138' E030o03.002'	Beans (*Phaseolus vulgaris* L.)	Kachwekano (K20)	Red and white mottled
		Bwanalesi	Yellowish brown
		Vuninkingi	Red
		Bwanalesi	Yellowish brown
Alt: 6831ft S01o18.852' E030.02.533'	Sorghum (*Sorghum bicolor.* L)	Kyatanombe	Reddish black
		Rwemereza	Red
		Kabusiba	Reddish white
		Munyarwanda	Red
Alt: 6811ft S01o19.068' E030o02.882'	Peas *(Pisum sativum.* L*)*	Rwemereza	White
Alt: 6698ft S01o19.071' E030o03.438'	Maize (*Zea mays*. L)	Binzari	Yellow and white

Table 21. Germplasm collected from Karorwa Parish, Rukiga County

Geographical position	Crop species	Local variety name	Seed color
Alt: 6086ft S01o12.557' E030o08.074'	Beans (*Phaseolus vulgaris* L.)	Rushare	Red
		Ruhendamagari	Brown and red mottled
		Mugyerahansi	Brownish yellow
Alt: 6244ft S01o13.166' E030O08.326'	Sorghum (*Sorghum bicolor.* L)	Kyatanombe	Reddish black
Alt: 6103ft S01o13.569' E030o06.171'	Peas *(Pisum sativum.* L*)*	Meisho	White with black eyes
		Rwemereza	White

Table 22. Germplasm collected from Nyakisiru Parish, Rukiga County

Geographical position	Crop species	Local variety name	Seed color
Alt: 6062ft S01o13.081' E030o09.337'	Beans (*Phaseolus vulgaris* L.)	Kachwekano (K20)	Red and white mottled
		Gisenyi	Brown and black mottled
		Ruhendamagari (B)	Brown and red mottled
		Kabanda	Brown and black mottled
		Kahura	Red and black mottled
Alt: 6143ft S01o12.543' E030o08.895'	Sorghum (*Sorghum bicolor.* L)	Kyatanombe	Reddish black
Alt: 6127ft S01o13.213' E030o09.448'	Peas *(Pisum sativum.* L*)*	Rwemereza	White
		Misere	Brownish green
Alt: 6052ft S01o12.066' E030o08.147	Maize (*Zea mays*. L)	Mahinda	White, yellow, blue and red

3.8 Conclusions and recommendations

Results of the study indicate that much as there is still much genetic diversity on farm, so many traditional varieties or landraces have been lost and replaced with modern varieties especially with regard to beans, potatoes and sweet potatoes. The most important cause of this erosion is the frequent introductions of modern varieties, which are now grown on a much big area compared to traditional ones. There is also a lot of seed exchange of modern varieties among the farmers and distribution by NGO's, thus putting the traditional ones at risk of extinction. The loss of these genetic resources is a threat to national food security. The loss of traditional varieties results in reduction of the genetic base of the remaining varieties that may have a consequence upon changing environmental and ecological conditions. Landraces or traditional varieties are varieties that have been bred and selected by farmers, and tend to contain high levels of genetic diversity and can adapt to changing environmental and ecological conditions. Modern varieties are the products of

formal, institutional and scientific plant breeding, typically having a high degree of genetic uniformity, and therefore cannot cope up with changing conditions. Therefore, the loss of landraces is a threat to global food security.

Whereas, modern varieties, which are high yielding, may answer current problems associated with increased demand for food, in the long run, without adequate reservoirs of diverse genetic resources, future genetic improvement programmes will be jeopardized. There is therefore, an urgent need to collect, document, conserve and utilize the traditional crops and formulate policies that will protect them from further genetic erosion. Much as some seed specimens of crop species were collected in this study, due limited resources and time, there is still an urgent need to collect, preserve and evaluate more germplasm from Kabale. More funds are needed to maintain the collected germplasm. Collection emphasis was mainly on seed specimens, as these can be easily handled in the gene bank. However, much genetic erosion has occurred to sweet potatoes and potatoes as well, which are not easy to handle, as they require *in situ* conservation. These crop species should also receive conservation attention. There is a need to sensitize farmers and policy makers about the value of maintaining crop genetic diversity.

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Appendix I. Questionnaire on on-farm diversity and genetic erosion of six major cultivated crop species in Kabale District, Uganda

1. Location

County…….Sub-county……Parish……..

Village……..

Altitude……..Longitude……Latitude……

Date of interview…… Language of interview…….

2. Identification of person interviewed

Name……

Sex
a) Male
b) Female

Family size
a) 1-5
b) 6-10
c) >10

Length of residence
a) 1-10
b) 11-20
c) 21-30
d)>30 years

Age level
a) 20-30
b) 31-40
c) 41-50
d) 51-60
e) >60 years

Marital status
a) Married
b) Single
c) Widowed
d) Separated

Education
a) None
b) Primary
c) Secondary
d) Tertiary

Ethnic group
a) Bakiga
b) Bafumbira

Land tenure
a) Customary
b) Mailo

c) Banyarwanda
d) Banyankole

c) Lease
d) Freehold

3. On-farm diversity

Which crops do you grow?

No	Vernacular name	New variety or landrace	Area cultivated (ha)	Price per kg	Total production this season /year(kg)	Principal characteristics		Is there a good market for this cultivar? If so, where	Trend in area cultivated (1)	
						Positive	Negative		By the farmer	In the area
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										

(1) D = decreasing, I = increasing, S = stable

3. continued

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4. In the last 10 - 20 years, the number of local varieties has:

In your farm	**In your village**
a)Increased	a) Increased
b) Decreased	b) Decreased
c) Stayed the same	c) Stayed the same

5. If the number has decreased, which local varieties/cultivars did you drop in the last few years?

Which?	When did it happen?	Why did it happen?

6. What do you think are the causes of genetic erosion?

a) Shortage of land b) Change in weather

c) Diseases d) Lack of market

e) Pests f) Introduction of new varieties

g) Loss of soil fertility h) Shortage of labor

i) Others (specify)

7. What are your sources for:

Traditional seeds?
a) Cash purchase from market
b) Cash purchase from shops
c) Cash purchase from other farmers
d) Own stock
e) Free from other farmers
f) Exchange for other seeds
g) NGOs/National/International programs

Modern seeds?
a) Cash purchase from market
b) Cash purchase from shops
c)Cash purchase from other farmers
d) Own stock
e) Free from other farmers
f) Exchange for other seeds
g)NGOs/National/International programs

8. How many farmers did you give seeds to during the past year?

Traditional seeds?
a) None
b) 1
c) 2
d) 3
e) 4
f) >4

Modern seeds?
a) None
b) 1
c) 2
d) 3
e) 4
f) >4

9. How many farmers did you receive seeds from during the past year?

Traditional seeds?
a) None
b) 1
c) 2
d) 3
e) 4
f) >4

Modern seeds?
a) None
b) 1
c) 2
d) 3
e) 4
f) >4

10. What is the impact of introduction of modern varieties on traditional ones?

11. Do you think it is possible to trace the lost varieties?

12. Does it matter to you that these varieties are lost?

13. How do you conserve your germplasm?

14. Are there traditional seed storage methods and are they still used to day? If not, why? If yes, for which varieties?

15. Do you have traditional seeds in storage now ? If yes, which ones?

16. What are the advantages and disadvantages of modern varieties?

17. What are the advantages and disadvantages of traditional varieties?

Thank you very much for you information and co-operation.

Appendix II. Germplasm collecting form

General for wild and cultivated species

CN NUMBER (assigned by IPGRI for internal use)					
EXPEDITION					
COUNTRY/AREA					
1. COLLECTOR NAME (S)					
2. COLLECTOR'S NUMBER		**3. SITE NUMBER**			
4. DATE (DD/MM/YYYY)					
5. GENIUS					
6. SPECIES					
7. SUBSPECIES/VARIETY					
8. LOCAL SPECIES NAME	**LANGUAGE**	**ETHNIC GROUP**			
9. CONFIRMATION required of local name/language/ethnic group			1. Yes	2. No.	
10. COUNTRY					
11. PROVINCE					
12. LOCATION	Km from	In a	Direction		
13. LAT (^{o}min)	N/S	**LONG (^{o}min)**	E/W	**ELEVATION**	m
14. MAP NAME AND REFERENCE					
15. STATUS OF SAMPLE					
1. Wild	2. Weedy	3. Primitive cultivator/landrace			
4. Breeders line	5. Advanced cultivar	6. Other (specify)			
16. COLLECTION SOURCE					
1. Wild habitat: forest/woodland	2. Farm: field	3. Market: town			
shrubland	orchard	village			
grasslands	garden	urban			
desert/tundra	fallow	Other exchange system			
	pasture				
	store				
4. Breeders line	5. Other (specify)				
17. PARTS OF PLANT USED					
1. Stalk/trunk	2. Branch/twig	3. Leaf	4. Bark		
5. Rhizome	6. Flower/inflorescence	7. Fruit	8. Seed		
9. Root	10. Tuber	11. Sap/resin			
18. PLANT USES					
1. Food	2. Medicine	3. Beverage	4. Fibre		
5. Timber	6. Craft	7. Fodder, forage	8. Building		
9. Omamental/cultural	10. Other (specify)				
19. TYPE OF SAMPLE	1. Seed	2. Vegetative (specify)			
	3. Other (specify)				
20. NUMBER OF PLANTS FOUND	Per site	Site size/area(m^2)			

21. NUMBER OF PLANTS SAMPLED				
22. HOW WERE THE PLANTS SAMPLED?				
23. OTHER SAMPLES FROM THE SAME SPECIES GROUP OF PLANTS			1.Yes	0. No
24. PHOTOGRAPH NUMBER	1. Yes	0. No	Number	
25. HERBARIUM SAMPLE	1. Yes	0. No	Number	

Cultivated Material

26. MICROENVIRONMENT			
1. Boundaries	2. Forest margins	3. Water courses	
4. Forest clearing	5. Houseyard	6. Wood lot	
7. Other (specify)			
27. CULTURAL METHODS			
a) TYPE			
1. Irrigated	2. Intercropped	3. Shifting cultivation	
4. Fertilizer (org.)	5. Fertilizer (inorg).	6. Use of animal traction	
7. Mechanized			
b) DIVISION OF LABOUR (gender)	Male	Female	
1. Field preparation			
2. Planting			
3. Weeding/fertilizer application			
4. Plant protection			
5. Harvest/seed handling			
c) LAND TENURE			
1. Public lands	2. Open communal lands	3. Freehold	4. Tenancy
5. Reserves/parks	6. Other (specify)		

DATE: SOWING	**TRANSPLANTING**	**HARVEST**	**(DD/MM/YYYY)**

28.			

29. DISTRIBUTION OF CROP SAMPLED IN FARMING CYCLE – TEMPORAL NICHE		
1. Main crop	2. Harvest prior to main crops	3. Harvest after main crops
4. Alongside main crops	5. Continuous harvest/gathering	

30. POST HARVEST HANDLING (gender division of labor)		
	Male	Female
1. Husking/milling		
2. Fermentation		
3. Drying		
4. Seed selection		

31. COMMERCIALIZATION	
1. Mostly consumed locally	2. Mostly for sale – local markets
3. Mostly sold to buyers outside community	4. Partly sold

32. SITE PHYSIOGRAPHY			
1. Plain	2. Basin	3. Valley	4. Plateau
5. Upland	6. Hill	7. Mountain	8. Other (specify)

33. SOIL DRAINAGE		
3. Poor	5. Moderate	7. Well-drained

34. SLOPE (^{o})
35. SLOPE ASPECT (direction N,S,E,W)
36. SOIL TEXTURE

1. Clay	2. Loam	3. Sandy loam
4. Fine sand	5. Coarse sand	6. Organic
7. Other (specify)		

37. STONINESS

0. None 3. Low 5. Medium 7. High

38. METHOD OF PROPAGATION

1. Seed 2. Vegetative 3. Both

39. RELATED WILD AND WEEDY FORMS GROWING NEARBY

40. DO YOU NOTE ANY RELEVANT SOCIOCULTURAL DIFFERENCES IN THE CULTIVATION AND USE OF THE CROP?

41. DESCRIBE CROP ROTATIONS IN COLLECTING SEASON: (and/or intercropping)

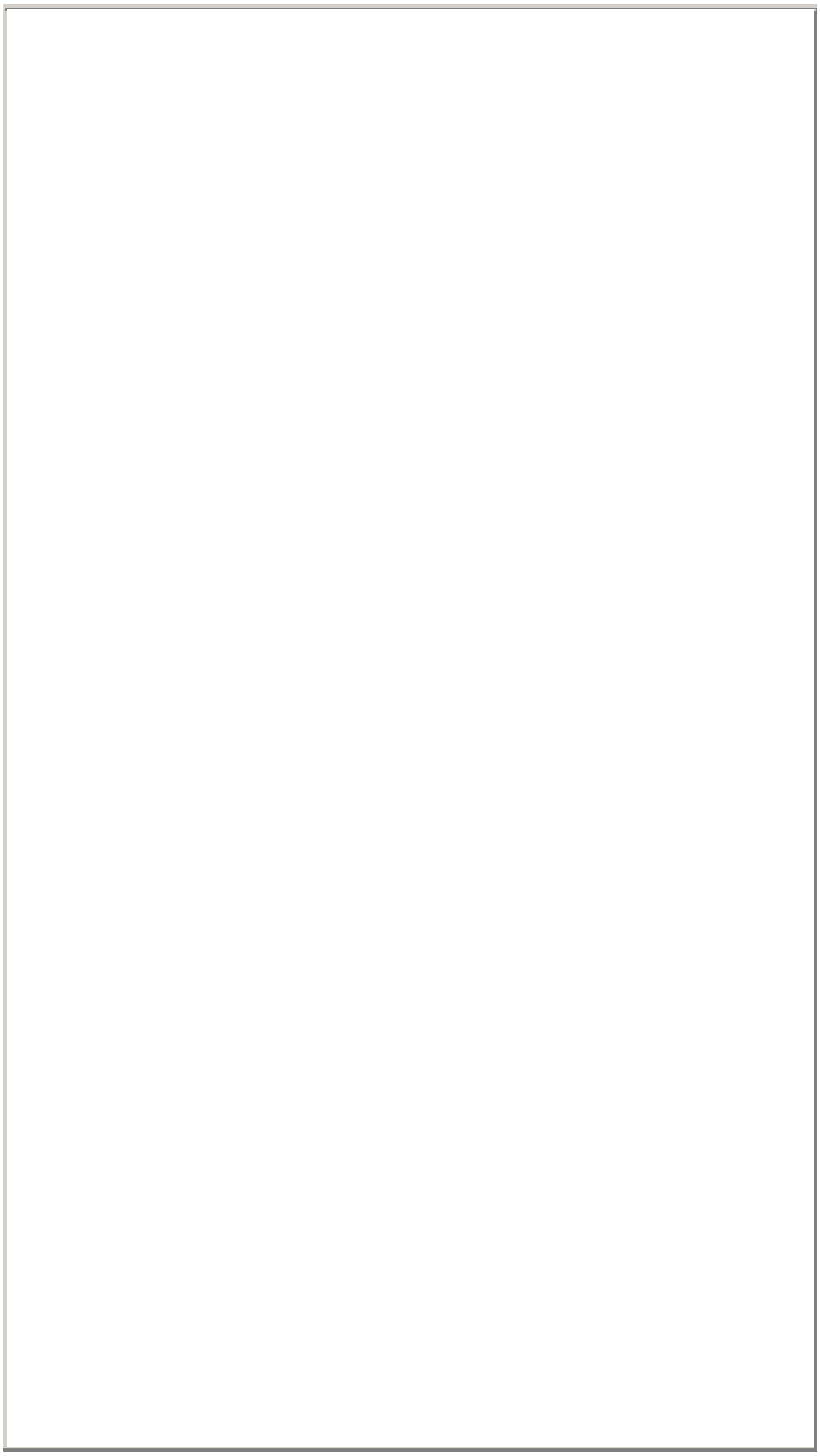
42. COMMENTS ON MORPHOLOGICAL VARIATION, DISEASES AND PESTS, GENETIC EROSION

Morphological variation

Diseases/pests

Genetic erosion (Major causes and extent at population and variety levels)

43. OTHER NOTES/COMMENTS



Wild and forage material

26. SITE PHYSIOGRAPHY

1. Plain	2. Basin	3. Valley	4. Plateau
5. Upland	6. Hill	7. Mountain	8. Other (specify)

27. HABITAT

1. Forest	2. Woodland	3. Bushland	4. Shrubland
5. Grassland	6. Wooden grassland	7. Desert	8. Alpine
9. Health	10. Arable	11. Wasteland	12. Swampland

13. Other (specify)

28. MICROENVIRONMENT

1. Mountain/hilltop	2. Rockface/cliff	3. Hillside
4. Valley Bottom	5. Plains/steppe	6. Forest margins
7. Burnt forest area	8. Burnt grassland	9. Sand bank
10. Shore (river/sea)	11 Tidal areas	12. Urban/peri-urban
13. Roadsides		

29. SOIL DRAINAGE

3. Poor	5. Moderate	7. Well-drained

30. SLOPE (^{O})

31. SLOPE ASPECT (direction N,S,E,W)

32. SOIL TEXTURE

1. Clay	2. Loam	3. Silt
4. Sandy loam	5. Fine sand	6. Coarse sand
7. Organic	8. Combinations e.g. Silty clay	9. Other (specify)

33. STONINESS

0. None	3. Low	5. Medium	7. High

34. SOIL CHEMICAL ROPERTIES	Estimate	Field Measurement	
a) pH 1. Very acidic	(pH 2-5)		
2. Acidic	(pH 5-6.5)		
3. Neutral	(pH 6.5-7)		
4. Alkaline	(pH≥7.5)		
b) Sanity	1. High	2. Medium	3. Low

35. SOIL SAMPLE

1. Yes	2. No

36. OTHER NOTES ON SOIL (e.g. Colour)

37. RHIZOBIUM SAMPLE

1. Yes	2. No

38. HUMAN MANAGEMENT OF HABITAT (land use)

1. Grazed areas | 2. Managed forest | 3. Fallows

4. Abandoned fields | 5. Regenerating forest | 6. No human management

7. Other (specify)

39. DISTURBANCE FACTORS

a) Describe if an area is regularly used or traversed by large mammals and humans

b) Key animal species using the habitat

c) Other factors, e.g. fire, flooding, mining, logging

40. MAJOR THREATS TO THE POPULATION – Genetic erosion

Overuse, habitat destruction e.g. desertification, soil erosion, deforestation, others (specify)

41. WHAT IS THE NATURAL MODE OF PROPAGATION?

a) 1. Seed | 2. Vegetative | 3. Seed and vegetative | 4. Apomicitic

Give relative importance of mode of propagation

b) - Seed 1. Predominantly selfing | 2. obligate outbreeding | 3. Facultative outbreeding | 4. Others (specify)

- Vegetative Rhizomes, stolons, tubers, etc

- Apomicitic

42. IS THE POPULATION WELL ISOLATED FROM OTHERS?

1. Yes | 2. No

43. WHAT ARE THE BARRIERS BETWEEN POPULATIONS IN THE AREA?

44. WHAT IS THE PLANT POPULATION DENSITY?

1. Few scattered individuals | 2. Very scarce (<1% ground cover)

3. Scarce (1-5% cover) | 4. Present (>5-25% cover)

5. High (>25%)

45. WHAT IS THE SPATIAL DISTRIBUTION OF INDIVIDUAL PLANTS IN THE POPULATION?

1. Patchy | 2. Uniform/mixed stand | 3. Pure stand

46. WHAT IS THE DOMINANT PLANT SPECIES?

47. WHAT ARE THE ASSOCIATES SPECIES?

48. CLOSEST METEROLOGICAL STATION

49. COMMENTS ON MORPHOLOGICAL VARIATION

50. COMMENTS ON DISEASES AND PESTS

51. ARE RELATED CULTIVATED FORMS GROWN NEARBY?

1. Yes 2. No

52. OTHER NOTES

ADDITIONAL INFORMATION FOR ECOGEOGRAPHICAL SURVEYS

Soil descriptors

SOIL TYPE (UNESCO/FAO)					
SOIL PARENTAL ROCK					
SOIL DEPTH Analysis of soil sample					
SOIL pH					
SOIL PHYSICAL ANALYSIS (Distribution of particle size, etc.)					
SOIL CHEMICAL ANALYSIS (P,K,Ca organic content, etc.)					
Climatic descriptors					
7. ANNUAL RAINFALL (mm)					
8. RAINFALL SEASONALITY					
JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC
9. MEAN ANNUAL TEMPERATURE					
10. TEMPERATURE SEASONALLY					
JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC
11. FROSTS (Occurrence and severity)					
Site descriptors					
12. SUCCESSIONAL STATUS OF VEGETATION					
1. Recently colonized	2. Pioneer	3. Intermediate			
4. Climax					
13. CURRENT PROTECTION OF SITE (Specify)					
14. IS THE PROTECTION EFFECTIVELY ENFORCED?					

1. Yes	2. No	3. Do not know
15. PROTECTED SITE (In conjunction with local community stewardship or use rights)		
16. SUGGESTIONS FOR FUTURE PROTECTION		