Forest Genetic Resources Working Papers

State of Forest Genetic Resources in Kenya

Prepared for

The sub- regional workshop FAO/IPGRI/ICRAF on the conservation, management, sustainable utilization and enhancement of forest genetic resources in Sahelian and North-Sudanian Africa (Ouagadougou, Burkina Faso, 22-24 September 1998)

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A co-publication of FAO, IPGRI/SAFORGEN, DFSC and ICRAF

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Forest Resources Division
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1. SOCIO-ECONOMIC AND ECOLOGICAL CHARACTERISTICS

1.1. Geographic position of the country

Kenya lies approximately between latitude 4° 40'N, and 4° 30'S and between longitudes 34°E and 41°E. The total area is 582,600 km^2. Kenya is boarded by Sudan, Ethiopia and Somali to the northwest, north and east respectively. To the west is Uganda, south Tanzania and southeast is the Indian Ocean. Lake Victoria is shared by Kenya, Tanzania and Uganda.

Kenya has a population of about 29.6 million people (2000). About 68% of Kenya's population live in the rural areas. The capital of Kenya is Nairobi and has a population of about 3 million people.

1.2. Socio-economic information

Kenya's population density is about 52 persons/km². The rate of population increase has been 2.0% (1995-2000). Agriculture is the main occupation of the Kenya population. Coffee and tea are the main cash and export crops. Sugar, fruits, horticultural crops and floriculture have become important export crops. Livestock farming for export of meat and daily products has recently decreased but production is enough for national consumption. Fish production from mainly Lake Victoria and less from Indian Ocean is exported to the EU countries and Japan. Tourism is an important and well-developed industry in Kenya

The GNP per capita for Kenya is US$330 and the annual growth rate of GDP is 2.1% (1999).

1.3. Ecological information

Figure 1 shows the agro-climatic zone map of Kenya. The described zones are a reflection of the rainfall distribution pattern in the country. Approximately 80% of Kenya falls within semi-arid eco-zones and only about 20% is considered to be in the potential agricultural land area.

In Kenya's dry zone, the climate is generally hot and dry. The sky is clear and daytime temperatures may rise to 38ºC. The soils are generally poor and are characterised by high sand content, low water content and low natural fertility. In the dry areas the air is dry, humidity low and the vegetation has less cover on the ground. Table 1 shows the most important climatic eco-zones and corresponding vegetation.

Table 1 Classification of dryland ecological zones

Classification	Mean annual Temperature Range (ºC)	Mean annual rainfall (mm)	Annual potential evapotranspiration (mm)	Typical vegetation	Potential for plant growth
Semi-humid to semi-arid	16-18	600-1000	1550-2200	Dry woodland and bushland	Medium
Semi-arid	18-20	450-900	1650-2300	Bushland	Medium to low
Arid	20-22	300-500	1900-2400	Bushland and scrubland	Low
Very arid	22-25	150-350	2100-2500	Desert scrub	Very low

The arid and semi-arid lands (ASALs) account for about 80 percent of Kenya's land surface. Much of the land falls under the lowlands, which are mostly interspaced by hills and small mountains.

Figure 2 shows distribution of soils in Kenya. The map shows a wide distribution range of soil types which is mainly a reflection of the physical landscapes rising from the coral reefs at the Indian Ocean to the snow capped Mount Kenya. Soils include the very fertile volcanic soils to poorly eroded soils arising from soil erosion that causes loss of nutrients, siltation of lakes and hydroelectric dams and pollution of marine ecosystems. The soils in the dry areas are sandy, dry and are therefore prone to soil erosion by wind and especially also by sporadic torrential rains (figure 3).

2. STATE OF FOREST GENETIC RESOURCES

2.1. Phytogeography of the country

Kenya is rich in biological diversity. The country harbours over 6000 species of higher plants (including 2000 trees and shrubs). Recorded species of butterflies are 875, of birds, 1079 and 379 species of mammals (KIFCON, 1994). Most of these species of fauna are associated with forest and woody vegetation. Further more the forest contains 50% of the nation's tree species, 40% of the larger mammals and 30% of the birds (KIFCON, 1994).

Kenya's forest estate totals 2.4 million ha or just under 3% of the country (KIFCON, 1994). As observed in table 1 above, four ecological zones (Fig.1) are defined in the country with different vegetation cover type and floristic composition. In addition woodlands, bushlands and wooded grasslands cover about 38.5 million ha. Farmlands and settlements take up some 10.02 million ha while forest plantations area occupies about 136,000 ha.

Acacia and *Commiphora spp* dominates the desert thorn-scrub lands. Grazing is nomadic and is the main occupation of the local people. The low montane forests in the ASALs are dominated by tree species and in some cases such trees form closed forest vegetations. The main tree species include: *Juniperus procera* (cedar)*, Podocarpus gracilior, Olea africana, Olea hochstetteri, Lawsonia inermis, Combretum molle, Casipourea malosana, Diospyros abyssinica* and *Teclea simplicifolia*.

The deciduous woodland occurs throughout the ASALs and is dominated by *Acacia tortilis.* Other more notable species include: *Hyphaene ventricosa, Salvadora persica, Acacia nubica* on the Northwest and northern Kenya and *Commiphora* and *Acacias* in the southern parts.

Deciduous and evergreen thorn bush constitute another extensive vegetation cover type. The main species in the north include: *Acacia reficiens*, *Acacia. senegal, Euphorbia sp., Pappea capensis* and *Combretum molle.*

The dominant species of the shrubland vegetation are *Acacia mellifera, Acacia senegal, Acacia reficiens* and *Acacia tortilis* in the more northerly parts. In the south, *Acacia reficiens* and *Commiphora sp.* are the dominant species.

2.2. Utilization patterns of forest species

Table 2 gives a list of tree species and their different purposes.

Table 2: Different uses of forest species

Category of use	List of mains species used
Medicinal plant species	*Schlebera alata, Myrsine africana, Acacia nilotica, Juniperus procera, Warbugia ugandensis, Balanites aegyptiaca, Erythrina abyssinaca, Combretum molle, Carissa edulis, Acacia nubica, Ziziphus mucronata, Senna didymobotrya, Salvadora persica*.
Food tree species	*Balanites aegyptiaca, Cordia sinensis, Grewia spp., Ziziphus mucronata, Vangueria infausta, Carissa edulis, Ximenia Americana, Lannea schweinfurthii, Lannea alata, Balanites glabra, Ziziphus mauritiana, Tamarindus indica, Berchemia discolar, Adansonia digitata, Sclerocarrya birrea, Dobera glabra*
Fodder tree species	*Acacia gerrardii, Acacia tortilis, Acacia mellifera, Strychnos henningsii, A. senegal, Maytenus heterophylla, Achyranthes aspera, Olea europaea, Acacia brerispica, Acacia etbaica, Grewia tembensis, G. similis, Rhus natalensis*.
Timber species	*Melia volkensii, Combretum schumanii,Combretum zeyheri, Terminalia pruniodes, Terminalia kilimandscharica, Terminalia brownii, Azadrachta indica* (neem),*Newtonia hilderbrantii, Pinus caribaea*
Fuel wood species	*Acacia elatior, A. mellifera, Newtonia hilderbrandtii, Parkinsonia aculeate, Eucalyptus camaldulensis, E. tereticornis, Combretum molle, Prosopis spp*

2.3. Threats to Forest Genetic Resources and Impact

External intervention of natural forest and woodlands do impact on the state of the forest genetic resources in a positive or negative manner. Usually interventions induce certain kinds of changes to genetic processes that in turn affect the evolution and sustainability of forest ecosystems. Changes in genetic variation are attributable, in short term, to changes in the basic evolutionary processes, which are characterised by:

- Random genetic drift – the non-directed changes in genotypic frequencies among generations due to random change in small populations
- Selection – relative differences among genotypes in viability or reproductive success
- Migration – the exchange of genes between populations that differ in genotypic frequencies
- Mating – the process mediating the recombination and assortment of genes between generations.

The above evolutionary processes affect the level and distribution of genetic variation and the present state of the genetic resources is a result of their joint efforts. Human activities have influences on the above processes that affect genetic variations of the forest resources under management and use.

The major threats thus on forest and woodlands resources in Kenya include:

- Excisions – which have decreased the size of forest and woodlands ecosystems and populations therein and therefore loss of biodiversity.
- Changing land-use patterns – mostly from natural vegetation to farming, settlement, grazing etc.

- Changing lifestyles – which has tended to rely less on traditional methods of sustainable means of using natural vegetation. Some of these changes threaten indigenous knowledge of germplasm conservation and sustainable utilization.
- Lack of firm national strategies – for conservation of forest germplasm, training programmes to support the initiatives and appropriate and articulate supportive policy and legislative tools.
- Restricted use of trees to only a few species – which has tended to put pressure on such trees and shrub species. This trend has put a number of species in the rare and endangered categories.
- Low capacity to appreciate the importance of forest genetic resource – in future development initiatives. The public is yet to be fully sensitised on the value of forest genetic resource in forestry, agriculture, and medical, among others.
- Inadequate institutional frameworks – responsible and sensitive to the national needs for conservation and promotion of sustainable utilization of forest genetic resources.

The following human activities are more specifically elaborated to show the impact caused on forest genetic resources.

Kenya forests have numerous endemics as well as threatened species. Some 150 internationally threatened wood plants in the country have been identified (Beentje, 1988). In addition, 60 inland forests and 65 coastal forests are known to harbour threatened plant species (KIFCON, 1994).

Demography impact on forestlands

As population increases forestland has been cleared to settle people near major towns. Forests near towns are more threatened since the population increase and density are higher than in the rural areas therefore requiring more land for expansion. While the rural population has a growth rate of 2.1%, that of the cities and major towns is above 4%. New settlements in dry areas are followed by immediate clearing of the indigenous vegetation before residents start growing trees in their now smaller compounds. This scenario cause heavy losses of populations of tree species through clearing. Currently, some 465,000 ha of land is taken up by settlements as towns and expansion of this type of land use is increasing fast.

Impact of agriculture on forest lands

Agriculture is the main stay of the national economy. It contributes about 30% of the GDP, produces most of the national food requirements, generate 60% of the foreign exchange earnings and provide about 70% of Kenya's agro-based industrial raw materials and almost all employment opportunities in the rural areas.

Changes of land use from natural vegetation to farming as a result of increasing human population and the need for more food have greatly reduced the dry forest areas. Pressure on woodlands for cultivation, intensive grazing and settlement has continued to increase at an alarming rate.

Excisions of forestland to create land for farming have become a common practice and alarmingly notable. Over the last decade or two, the rates of loss of closed forestland stood at 5.000 ha/annum and 19,000 ha per year when other types of dry woody vegetation types are included. Loss of closed forestland has increased with a proposed excision of over 80,000 ha in 2001 alone. This will mean serious impact on forest genetic resources. FAO estimates that between 1990-2000, Kenya lost 931,000 ha (93,000 ha/annum) of its forest cover (FAO, 2001).

Such excisions are scattered, some large, others small, while others are done in small and isolated forest stands. This is likely to affect the genetic structure of the forest populations and thus leading to reduction of population sizes, few individuals to seed and produce pollen needs. The source of migration of genes may be cut off causing random losses of variation by drift. Random drift of alleles will severely reduce genetic variation that may be significant for future adaptability for several generations. It is feared that the later case could be enhanced for those small populations in isolated forest stands being cleared without any considerations of the danger of erosion of forest gene pools.

The situation in woody vegetation in dry areas is even worse since larger areas are being cleared to enable sustaining higher production of crops under the poor conditions for efficient agricultural practice. Furthermore even where land is left as fallow, recovery rate is very slow and the fallow period has become less and less as more population continue to migrate into the drier areas of the country.

Presently some 10.02 million hectares is estimated to fall under farmland form of land use, both in mainly medium and high potential land areas. The rate of expansion of agricultural land during the last decade has been about 100,000 ha/annum. This land has come from forest land but more so from the woodland vegetation types indicating that threats on wild tree genetic resource are real now and in the future.

Impact of livestock (grazing) on forest tree species and populations

Livestock in the arid and semi-arid areas (ASALs) includes the donkeys, camels, cattle, sheep and goats. The dry zone support 50% of the cattle, 55% of the goats, 75% of the sheep and nearly all the camels in Kenya. In numbers, Kenya has 12 million cattle, 19 million sheep and goats, 875,000 camels, 18 million poultry and 114,000 pigs.

The people living in the ASALs are mainly pastoralists, and derive their livelihood from keeping livestock. Crop farming is rare except along the permanent course of the river Tana. Apart from providing a livelihood, livestock is also a symbol of social status. With the increasing population, there has been a trend towards sedentarisation of communities. This has greatly interfered with the traditional grazing patterns. Migration of people from high potential areas into drier lands in search of space for cultivation is not only causing degradation of vegetation and causing erosion but is also changing socio-economics and general environmental situations.

It is observed that grazing in forest and woodlands by livestock mostly affect regenerating species especially of those more palatable. This results in a thinning effect thus changing the population densities of the palatable species. Grazing on such species could affect genetic drift. Grazing especially along riverine systems has been found to cause physical impact on the grazed sites by altering stand structure and environmental conditions. This is a common feature along rivers in the dry areas of northern Kenya and especially along the River Tana where there is a great concentration of pastoral communities. Such changes could affect populations of potential regeneration of plants and forest-dwelling herbivores and therefore, have a negative impact on richness in biodiversity.

Water in the dry lands is generally scarce, only a few rivers are perennial streams, the lakes are generally saline due to high evaporation and the major sources of reliable water are wells and bore holes established at strategic watering points. Unfortunately watering points have turned out

to centres of vegetation and environmental degradation due to concentration of high population pressure and grazing.

Forest exploitation (timber and non timber products)

Use of trees is restricted to a few species in different forest/woodland types for various requirements and according to traditional uses and this has tended to place unsustainable utilization on such tree and shrub species. Such utilization concentrating on a few species (eg. *Dalbergia melanoxylon, Melia volkensii, Acacia mellifera, Branchylaena huillensis, Acacia senegal, Hyphaenie copressa, Tamarindus indica, Carissa edulis*, among others), has put a number of species in the endangered category. This is a serious problem especially where no measures are being put in place to revert such trend.

Exploitation in forest has been through selective cutting and there are a lot of isolated poaching activities. This leads to depletion of quality timber species especially where cutting is not controlled. Operations at forest level that changes the environmental conditions of the forest or woodland will affect relative genotype viability and can also affect pollinator behaviour and other inter-species interaction.

Under the restricted cutting or logging will directly impact on genetic resources of the target commercial species by changing their population age and population density. Selection favours certain genotypes over others and some genes would be lost at higher rates than would be expected by drift alone. Very strong selection of a tree species, e.g. the case of *Prunus africana, Dalbergia melanoxylon* or *Milicia excelsa* could reduce population sizes below recuperation levels. The impact will be more on reduced production and survival of these species. This observation is presently apparent and common.

It is also apparent that uncontrolled cutting of a certain species or high selective cutting will also affect other non-commercial species and thus decrease biodiversity of the forest dependent plants and animal species. In isolated populations of forest stands the effect as stated earlier will be even worse.

Natural forests and woodlands are important sources of non-timber forest products. More important are collection of bamboo poles, fruits, fodder, honey production, herbal medicine, bush meat, etc. In dry areas fodder collection during dry and drought periods become destructive where trees and shrubs are cut down to access canopy foliage for animals. Collection of parts of trees (bark, roots, leaves, and branches) can be destructive as is common with several species (e.g. *Fagara macrophylla, Prunus africana* etc) where whole tree deaths are common when large portions of stem barks are removed for herbal medicine.

Collection of non-timber forest products will have varying effects on genetic evolution processes depending on the part of the plant harvested or collected for use. Harvesting of reproductive parts of a plant, tree or shrub, such as fruit or seed, reduces the effective size of pool of reproductive parents. Intensive harvesting of fruits and seeds cause severe genetic impact. Direct selection of e.g. a certain variety of a species will affect reproductive traits but the strongest genetic impact is on mating system and gene migration depending on the harvested parts.

Harvesting non-productive parts such as leaves or bark for medicine, as is the case with *fagara spp* and *Prunus africana*, will have indirect selection effects on viability and

reproductivity of affected individuals. Harvesting of whole tree/shrub for products other than timber, as is the case of shrubs cut by pastoralists to provide fodder, implies that the population size is remarkably reduced. This will have a serious genetic impact. In particular genetic drift will be affected thus causing random losses of variation. Reproduction capacity of the affected population is affected and this may impact on the genetic viability by reducing it and therefore affecting future adaptability of future generations.

Other types of threats

Droughts in the dry areas are common but rarely do they result in massive deaths of tree species since most of the species are adapted to such conditions. Natural disasters are not common in Kenya. The most other important threats to forests and woodland species in Kenya is forest and bush fires. The incidences of forest fires are very high especially during the drought periods. About 10,700 ha of plantations and natural forests are lost annually as a result of fire. In the process the Forest Department has been losing annually close to US$505,000 through loss of forest produce and suppression costs. This cost does not include bush fires in dry areas where timber production is not a management priority and therefore not put into cost in the computation of losses. The incidences of fire are more prevalent in dry woodland ecosystems and fire management is an important issue in Kenya but is less given the attention it deserves.

Fire may cause variable effects depending on the intensity and extent in space of the fire. Severe fire may have the same effect as clearing a forest especially where large patchy openings are created as a result of fire. The patterns and sizes of such openings versus the forest cover influences genetic diversity. The major impacts are heavy mortality on the burnt species thus reduced population sizes and this would increase genetic drift. For isolated populations this means the migration rates of seed and pollen exchange are affected. Sources of migration could even be cut off, thus reducing the effectiveness of pollinators.

Adverse fire may directly affect biotic dispersal agents and this may decrease migration of genes between populations. Migration may increase if the migration vectors are abiotic. A more devastating fire may affect traits that could have a direct bearing effect on fire resistant species and such action would have direct selection that indiscriminately remove all such genotypes.

List of threatened species and populations

At the species level it has been estimated that 39 species are currently rare, 32 are vulnerable, 20 are endangered and 1 species is feared extinct. Using local herbarium and a recent field species collection it has been established that about one third of all rare species (39 species) occur in the coastal forests. Table 3 shows general distribution of rare, vulnerable and endemic species nation-wide. Table 4 shows the case for the coastal region alone. More recently, the National Museums of Kenya in collaboration with WWF has concentrated its field survey in the coast and hence more information on this area is available (Robertson and Luke, 1995). Table 5 lists species that are known to be threatened and require urgent attention.

Table 3: Nation-wide distribution of rare, endangered and endemic tree species in Kenya

Forest Reserve	Total Species	Vulnerable or Endangered	Strict Endemic

Coastal Forests	32	25	12
Taita Hills	10	6	7
Central Kenya (dry forests)	9	6	6
North East Kenya (dry bushland)	10	2	3
Central Kenya (moist forests)	3	2	3
Central Kenya (riverine forest)	5	4	3
North Kenya (Central Hills	7	-	-
Cost (outside forests)	10	1	-
Coast (littoral thickets)	2	2	-

Table 4*: Distribution of species threats in the Coastal region*

Forest Area	**Total rare species**	**Vulnerable or endangered**
Simba hills	12	16
Arabuko-sokoke	8	6
Pangani rocks	7	7
Witu Forest	7	3
Cha Shimba Rocks	6	6
Tana River	5	2
Mangea	3	2
Mrima	3	3

Table 5*:* List of species or population of species threatened

Ecological zones	**Threats at species levels**	**Threats at population level**	**Causes of threats**
Semi-humid to semi-arid	*Albizia gummifera, Diospyros abbysinica, Newtonia hilderbrandtii*	*Albizia gummifera, Trichilia metica, Brachylaena huillensis, Barassus aethiopum*	Over exploitation for firewood, charcoal burning, construction, canoe and beehive making, animal browsing, poor regeneration, fruit gathering
Semi – arid	*Dalbergia melanoxylon, Newtonia hilderbrandtii, Carissa edulis*	*Melia volkensii, Diospyros mespiliformis, Mimusops fruticosa, Cordia sinensis, Tamarindus indica*	Same as above
Arid	*Strychnos spinosa, Hyphaene compressa, Populus ilicifolia*	*Acacia sengal, Salvadora persica, Grewia tenax, Acacia rovumae*	Same as above
Very arid	*Hyphaene compressa*	*Lawsonia inermis, Acacia tortilis*	Same as above

3. MANAGEMENT OF FGR

3.1. *In situ* conservation activities

Protected areas

Gazetted forest area comprises 1.7 million ha of which 1.22 million ha are closed canopy forest. Included in the 1.22 million ha are 0.16 million ha of plantations consisting primarily of exotic

species, established mainly in the high potential areas of the country. Most of the gazetted and closed forests outside the gazetted area (0.18 million ha) also occur in the wet zones of Kenya. Figure 4 shows the distribution in Kenya of the main closed forests.

In contrast, the highest population, density and diversity of Kenya's wild fauna is found in the dry zones of the country and about 90 % of the over 50 gazetted national parks, sanctuaries and game reserves are located in the arid and semi-arid areas (ASALs) (Fig.5). To date, Kenya has 26 national parks and 30 national game reserves (including one game sanctuary); thus 8% of Kenya's land is under some form of protection (Fig 4, 5). In addition, there are several private game sanctuaries, primarily set aside for the protection of the endangered Black Rhinoceros *Diceros bicornis* among other animals.

Table 6 shows the major National Parks and game reserves.

Table 6: Protected national Parks and Reserves Containing Significant forest areas

National Park	**Area (ha)**	**Ecological Zone/District**
Mt. Kenya	59,000	Humid – Nyeri and Meru
Aberdares range	76,570	Humid to semi humid - Nyeri and Muranga
Al Ndonyo Sabuk	1,800	Semi-arid – Machakos
Mt. Elgon	16,900	Humid to semi-humid – Trans Nzoia
Chyulu	47,100	Semi-arid to arid – Makueni
Marsabit	36,000	Arid – Marsabit
Total	**237,370**	
National Game Reserves		
Marsabit	113,000	Arid – Marsabit
Shimba Hills	19,200	Humid to semi-humid – Kwale
Tana River Primate	16,900	Semi-arid - Tana River
Boni	133,900	Semi-arid – Garissa
Dodori	87,700	Semi-humid to semi-arid – Lamu
Kakamega	4,470	Humid – Kakamega
Total	**375,370**	

Of the 210 gazetted forest reserves (fig 4), 84 are gazetted under government land and covers some 1,346,074 ha and 126 under trust land covering some 350,427 ha. Within the gazetted natural forest reserves managed by Forest Department on behalf of the Government some Nature Reserves are located therein. Table 7 gives a list of Nature Reserves occurring in gazetted forests.

Table 7: Nature Reserves in Gazetted Forests

Nature Reserve	**Area (ha)**	**Ecological Zone/Location**
Kisere	484	Humid - North Kakamega
Yala	469	Humid - Central Kakamega
Kakamega Station	210	Humid - Kakamega Forest
S.W. Mau	43,032	Humid to semi-humid - S.W. Mau
Arabuko-Sokoke	4,332	Semi-humid - Arabuko-Sokoke Forest
Langata	96	Semi-humid - Nairobi West
North Nandi	3,434	Semi-humid - North Nandi Forest
Uaso Narok	1,575	Semi-arid – Nyahururu East

Total	**53,536**	

Sacred forests

The sacred forests are traditional forests and woodlands respected by local tribes. In Kenya the sacred forests are more common in the coast and are referred to as the "Kaya" forests. These forests are set aside by nine coastal tribes (miji kenda) for performing rituals according to their traditional and customary laws. In addition they are the source of traditional food plants and medicines. There are some 23 such kayas mainly in Kilifi and Kwale districts in the coast. The total area of major "kaya" sacred forests distributed along the coast is about 21,480 ha. Areas of some smaller kayas have not been established. The distribution of the major kayas is shown in figure 6.

The Coast sacred forests (kayas) are remains of the northern most elements of the Zanzibar-Inhambane phyto-geographical region, which stretches along the East African coast from northern Mozambique to southern Somalia. (White,1983). There is substantial body of botanical and zoological evidence to indicate that it was part of a more extensive coast forest system. The climate of this type of vegetation is semi-humid to semi arid.

The greatest role of the Kayas is the conservation of the most threatened species that includes: *Afzelia quanzensis, Brachystegia spiciformis, Brachylaena huillensis, Julberardia* and *Manilkara* species, all of which have been over-exploited. *Milicia excelsa and Sterculia appendiculata* have already been eliminated from the forest reserves around through commercial logging.

Traditional agro-forestry parklands systems

A number of indigenous tree species are left behind after clearing vegetation for purposes of cultivation. Such trees are left by farmers over a large area of the northern Kenya and are valued as component species in the dryland farming system. The main parkland systems are scattered over the 80% of the country's arid and semi-arid lands. The few main tree species left on farms are *Faidherbia albida, Erythrina abyssinica, Balanites aegyptiaca, Adansonia digitata, Acacia tortilis, Acacia nilotica, Terminalia brownii, Melia volkensii, Phoenix reclinata,* among others.

Farming systems along the tradational parklands in dry areas is by fallowing where land is left for a couple of years to rejuvenate its fertility levels for improved productivity of cultivated crops, mostly the cereals.

3.2. *Ex situ* conservation activities

Seed banks and gene banks

The Kenya Tree Seed Centre undertakes national tree seed collection, distribution and sale, both nationally and internationally (ICRAF, 1997). The Centre collects seed from identified sources, which covers both the dry and wet areas of the country. The centre also provides phytosanitary certificates for tree seed and is currently involved in the formulation of tree seed regulations and its incorporation into the predominantly agricultural Seed Act. National control of agricultural seed is done by the Kenya Plants Health Inspectorate Services (KEPHIS).

The Kenya Tree Seed Centre maintains a national system of seed orchards and seed stands. The main tree seed collected are those of plantation species (*Cupressus lusitanica, Pinus patula*, *Eucalyptus grandis, Eucalyptus saligna* and *Eucalyptus camaldulensis* among other minor species). Demand for seeds of agroforestry species has gone up. Such demand has been notable with species like: *Grevillea robusta, Calliandara spp, Sesbania spp. Markamia lutea, Moringa oleorifera*, among few others. The Kenya Tree Seed Centre stocks about 7000Kg of various tree seeds in its cold and warm storage facilities.

Forest plantation

Much of the forest plantations are established of exotic species. The main exotic species are *Pine* (31%), *Cypress* (45%) and *Eucalyptus* (10%) while 14% is taken by other species. Limited plantations have been raised from indigenous trees species. Table 8 shows the distribution of plantation crops according to ecological zones. More of the plantations are in the humid and semi-humid zones and very little plantation cover is found in the dry zones. There are well established seed stands and orchards but the situation is not the same for the more drier areas. Collection of seed for raising planting materials is usually in the open and in dry areas is more of indigenous trees.

Table 8: Forest plantations in the country

Ecological zones	Areas (ha)	Local and exotic Species planted	Seed sources	Current management situation
Semi-humid to semi-arid	40,000	*Pinus patula, Cupressus, lusitanica, Eucalyptus grandis E. saligna, E. camaldulensis, Cordia africana, Prunus Africana, Grevillea robusta*	Seed stands Seed orchards Open collections	According to management plans
Semi – arid	15,000	*Cupressus arizona,, Croton megalocarpus, Olea europaea, Markamia lutea, Branchylaena huillensis, Pinus caribaea*	Seed stands open collection	Management plants and small stands with no plans
Arid	370	*Melia volkensii, Dalbergia melanoxylon, Faidherbia albida, Eucalyptus* camaldulensis, *Phoenix spp.*	Open collection	No proper approved management plans
Very arid	*not significant*	*Schinus molle, Acacia tortilis*	Open collection	No approved management plans

Botanical and home gardens

There are several botanical gardens mostly situated in or near towns or within premises of forestry institutions and universities. Nairobi, Mombasa, Nakuru, Kisumu and other major towns have Arboretums of tree species. Most of the species planted in the Botanical gardens are those suitable for the local climatic conditions and are also common in the plantation stands and residential compounds. In four of the major arboretums at Muguga, Nairobi, Gede near Malindi and at Nyeri Forest department offices, among others, the planting is done according to plan and with the purpose of testing species performance. Assessments are done and data analysed to determine growth rates under the prevailing conditions.

The dominant arboretum species in the humid and semi-humid are: *Cupressus lusitanica, Acacia mearnsii, Grevillea robusta, Eucalyptus spp, Olea europaea, Croton megalocarpus, Teclea nobilis*. The dominant species in the coast are: *Afzelia quanzensis, Casuarina equisetifolia, Eucalyptus spp* etc. Garden and Arboretums situated in drier towns are popular with *Acacia* species, *Grevillea robusta, Casuarina* species, *Croton, megalocarpu*s, *Terminalia* spp and *Eucalyptus* species adapted to dry areas.

3.3. Selection and genetic improvement

Species and Provenance trials

It is not easy to list separately experiments meant for provenance testing and those whose objectives are for species selection trials. Objectives of testing are recorded as both for species selection, testing and provenance trials although there are a few cases of just species trial experiments.

The following species are included in experimental testing of species and provenances. Majority of the tests and much of the area cover are on provenance testing. The largest cover and number of provenance trials are on *Calliandra calothyrsus, Eucalyptus grandis, Grevillea robusta, Eucalyptus camaldulensis, Eucalyptus tereticornis*, and *Acacia* spp the later three in the dry areas. Provenance trials of agroforestry species have increased recently while there has been a drop of new provenance trials of industrial plantation tree species.

Vegetative propagation experiments

There are vegetative propagation experiments on *Populus ilicifolia, Eucalyptus grandis, Eucalyptus grandis* × *Eucalyptus camaldulensis* hybrid, several bamboo species*, Melia volkensii, Grevillea robusta, Pinus patula* and *P. radiata*. The objectives of such experiments are mass propagation to increase production of a particular species in high demand, difficulties of obtaining enough seedlings through seed eg. *Melia volkensii* and tree improvement of selected species. Clonal experiments of *Pinus patula, P. radiata, Eucalyptus grandis, Grevillea robust* and *Eucalyptus grandis* × *Eucalyptus camaldulensis* have been in progress for several years now. Many indigenous fruit trees in the dry zones are raised through vegetative propagation methods.

The area of vegetative propagation experiments is specifically not easy to pin point since planting out has been mixed up with the species/provenance trial experiments. Actual area of vegetatively propagated experiments is however relatively negligible.

Table 9: Distribution of species and Provenance trials

Ecological Zone	Species under Species/Provenance trials	Total approximate area
Humid to semi-humid	*Cupressus lusitanica, Eucalyptus grandis, E. saligna, E. regnans, E. fastigata, Pinus patula, P. radiata, P. pseudostrobus, Casuarina funghuhniana, Acacia koa, P. taeda, P. maximinoi, Casuarina equisetufikuam, P. patula sub-species tecunumanii, C. macrocarpa, E. urophylla, Olea welwitschii,, A. mearnsii, A. melanoxylon, Eucalyptus spp., Agathis robusta, Prunus africana, Grevillea robusta, Sesbania sesban, Markamia*	121.5 ha

	lutea, Croton megalocarpus among few others.	
Semi-humid to semi-arid	*Pinus elliotti, P. oocarpa, P. caribaea, E. camaldulensis, E. urophylla, Casuarina equisetifolia, Grevillea robusta, Croton megalocarpus, E. tereticornis, Calliandra scabrela, Populus ilicifolia, Senna siamea, Dalbergia melanoxylon, Melia volkensii, Pinus kesiya, Azadirachta indica, Leucaena spp.*	60.6 ha
Semi-arid to arid	*Acacia nilotica, A. tortilis, A. eriobola, A. karoo, Faidherbia albida, Dalbergia melanocylon, Terminalia pruniodes, Albizia spp, Azadiracta indica, Eucalytus tereticornis, Schinus molle, Pinus bruita, E. alba, Parkinsonia aculata, Prosopis chilensis, Pinus caribaea.*	20.3 ha

Species improvement and characterization

The most notable tree improvement efforts have been directed to *Cupressus lusitanica, Pinus patula* and *Pinus radiata* which are the most widely planted industrial plantation species since some five decades ago. Starting in 1962, a national tree improvement was initiated in Kenya, which ended up in selecting plus trees nation-wide and establishing two live tree seed banks. A system of seed stands was identified for seed collection using well researched traits, useful in identifying good tree forms for timber production. Stem taper, stem form, wood grain angle, stem branches, susceptibility to key diseases, among others, were considered in the selection of trees for a national tree improvement programme.

There has been an extensive testing of the plus trees, exotic provenance trials and progeny testing on the three species. Eventually a network of seed orchards was established. *Pinus radiata* was however later dropped from the national tree planting programme due to serious attack of the tree by needle bright disease (*Dothistroma pinii*). On the average a net improvement of 30% increment in growth and volume has been achieved through the national tree improvement programme of the three species.

Recently efforts in tree improvement have been directed to the *Eucalyptus spp.* especially*, E. grandis, E. grandis* × *E. camaldulensis* and *E. urophyalla*. Improvement efforts have been started on *Grevillea robusta* and *Melia volkensii* growing in semi-humid and semi-arid to arid areas respectively.

3.4. National priority species

The criteria used for short-listing tree species for priority action are presented below. In several cases a combination of more than one criteria was considered in helping to identify a priority species for action.

- Social popularity of the species as elaborated by the contacted stakeholders,
- The distribution of the species in area; A more widely distributed species was favoured.
- Commercial contribution in terms of products trade, marketing and services
- Species easier to work with and likely to be improved through genetic manipulation was selected
- The degree of threat on the species influenced its selection especially as it relate to a need for conservation

- Introduced species in the initial species list are few, popular with local people and forest managers and except for the *Prosopis* species, were selected for possible development action.

Table 10 below provide priority tree species for the different ecological zones in Kenya.

Table 10: National priority species

Ecological zone	Priority species
Semi-humid to semi-arid	*Grevillea robusta, Eucalyptus camaldulensis, Branchylaena huillensis, Borassus aethlopum, Trichilia ametica, Newtonia hilderbradtily Diospyros abbystanica, Carissa edulis, Eucalyptus grandis x Eucalyptus camaldulensis* hybrid
Semi – arid	*Azadirachta indica, Balanites aegyptiaca, Faidherbia albida, Moringa oleifera, Sclerocarya birrea, Tamarindus indica, Terminalia brownii, Melia volkensii, Dalbergia melanoxylon*
Arid	*Hyphaene compressa, Acacia nilotica, Acacia tortilis, Acacia senegal, Acacia seyal, Moringa stenopetala, Ziziphus mauritiana, Populus ilicifolia, Eucalyptus tereticornis*
Very arid	*Hyphaena compressa, Lanssonia inermis, Acacia tortilis, Grewia* spp., *Acacia nilotica*

4. POLICY, PLANNING AND INSTITUTIONAL MECHANISM

4.1. National forest policy

To support an effective institutional framework for a national programme that ensure sustainable conservation and utilization of forest genetic resources in the dry zone, relevant policy intentions and legislative tools are a pre-requisite requirement. The currently revised forest policy statements, that are yet to be endorsed by parliament, support the need for conservation of forest biodiversity. The Forest Act, intended to support the forest policy intensions, is currently undergoing revision and it is hoped that this will be elaborate in areas of forest genetic conservation and development. More important in the elaboration would be to identify responsibilities and coordination of a grassroot supported national programme in the management, conservation and sustainable utilization of forest and tree genetic resources.

Presently a debate is in place on modalities for access of germplasm and rights of utilization. Access and use will no doubt be influenced by external factors realising that potential for genetic utilization in various development avenues go beyond the national boundaries.

The present legislation is not supportive of elaborate training and capacity building in genetic conservation initiatives. There is still a serious lack of adequate awareness on the importance and role of genetic resources in development. More notable is lack of focal point in the coordination and awareness creation of the role of sustainable management and use of forest genetic resource, and more so in the dry areas where environmental conditions are more fragile.

4.2. Laws and others rules

The Government has put in place national laws and regulations to guide proper management and use of forest and trees resources. In doing so the Government has taken into consideration

the international interests as declared in the various conventions and agreements. The table below lists the government's expression of interest in the various areas of natural resource development and conservation.

Table 11: Laws and others rules on FGR management

Laws and others rules	Creation or ratification
Convention on biological diversity (CBD)	Ratified
Convention on CITES	Ratified
National forest policy	Revised 2001
National Forestry Law	Revised 2001
National Environment Law	New Act
RAMSAR Convention	Ratified
World heritage Convention	Ratified
FCCC	Ratified
Convention to Combat Desertification	Ratified

4.3. Institutions involved in forest genetic resources

A number of national institutions and NGOs exist that undertakes activities related to tree germplasm conservation, management and utilization especially as component of biodiversity initiatives. But on-going activities on genetic conservation are small, disjointed, uncoordinated and of no likely consequent impact on a national scale. In any case the approaches and methodologies used are narrow in their genetic conservation perspectives. Table 12 below shows the role of various organisations in forest genetic resources development.

5. TRAINING AND RESEARCH CAPACITY BUILDING AND REINFORCEMENT

As indicated in Table 12, a number of organisations are involved in research and training on forest genetic resources. Topics on forest genetic resources are taught both at the college and university depending on the levels of training.

Nairobi, Mombasa and Eldoret polytechnics train technicians at diploma and advanced diploma level. Londiani College teaches forestry to certificate and diploma level while polytechnics produce a small number of technicians with applied biology.

Moi University has a faculty of Forestry, wildlife and wood science. Nairobi, Egerton, Kenyatta, Maseno and Jomo Kenyatta Universities have departments of botany or natural sciences that offer training relevant to biological diversity and plant genetics. The capacities produced are different in the various universities and with the recent crash programme on parallel degrees by almost all the above national universities, the statistics on capacities produced has not been easy to record or confirm with certain. Kenya institutions of higher learning have, however, made great contribution to the human capacities in forestry and biological sciences in the eastern and southern Africa region, especially Lesotho, Swaziland, South Africa, Botswana and Namibia.

Table 12: Organisations involved in Development and issues of forest genetic resources

Organisation	Role in FGR Development
Forest Department (FD)	Manage indigenous, plantation forests, nature reserves and control their use

Kenya Wildlife Service (KWS)	Manage national parks, game reserves, sanctuaries and marine parks in the country
County Councils	Manages over 350,000 ha of mainly woodlands under the trust land
Kenya Forestry Research Institute (KEFRI)	Carry out research and advisory services in the areas of natural forests, forest plantations, farmlands and dry lands. Also disseminates information on tree and forestry development.
National Museums of Kenya (NMK)	Manages the network of national herbarium, collect plants materials and manage national monuments.
National environment Management Authority (NEMA)	Regulate environmental management law and ensure compliance according to regulations, rules and environment impact assessment for development initiatives.
Kenya Plant Health Inspectorate Services (KEPHIS)	Regulates import and export of plant products through ensuring health controls
African Centre for Technology Studies (ACTS)	Undertake studies on biodiversity policy, MTAs, and trade in biotechnology materials and related issues.
Local Universities	Research in natural resources and plant sciences. Training in plant biodiversity, genetics and plant breeding.
ICRAF, IPGRI, IRLI, etc	Research in Agroforestry and conservation of on-farm germplasm and fodder for agricultural and livestock development in collaboration with national institutions and NGOs.
NGOs and Community Based Organizations (CBOs)	Several involved in lobbying for conservation and sustainable management of forests. CBOs are involved in the implementation of mostly conservation projects in collaboration with local communities.

6. REGIONAL AND INTERNATIONAL COOPERATION

Kenya has joined hands with a number of countries and institutions in the development of forestry, environment, natural resources and agriculture, which are important sectors relevant to the conservation and management of forest genetic resources. Table 13 summarises the most important regional and international co-operation relevant to the pursuit of forest genetic resources and environmental development.

Table 13: Co-operation in FGR Related Development

Nature of the cooperation	**Partner Institution or country**	**Nature of Cooperation**
East Africa Community (EAC)	Kenya, Uganda, Tanzania. (Rwanda and Burundi proposed to be members when situations improve)	The regional cooperation, based in Arusha, Tanzania, has an agenda on forest sector and issues of biodiversity, management, trade, MTAs in forestry will be addressed.
Intergovernmental Authority on drought and Development (IGADD)	Kenya, Somalia, Djibouti, Ethiopia, Eritrea, Sudan and Uganda	Forest sector development is an important agenda within the "Development of environmental protection and agricultural research".
Association of Forestry Research of East Africa (AFREA)	Sudan, Eritrea, Ethiopia, Djibouti, Kenya, Uganda, Tanzania, Rwanda, Burundi	Co-operation in research in forestry focusing on priority areas and sharing of information for development in the region.

Global Forest Information System (GFIS)	Global. In Africa nodes at Kenya, Ghana, Zimbabwe, Senegal, Madagascar (Proposed)	Global sharing and exchange of information in forestry and institutional strengthening in formation technology for forestry development.
Sub-Saharan Programme on Forest Genetic Resources (SAFORGEN)	IPGRI, FAO, DANIDA, ICRAF, Regional member countries	Research and development in forest genetic resources. Capacity building in FGR

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ANNEXES

Annex 1: Values and use of target, priority species

Name of priority species	Value code	Present, future or potential use										
		ti	**po**	**Wo**	**Nw**	**Pu**	**Fo**	**fd**	**sh**	**ag**	**co**	**Am**	**xx**
Acacia nilotica	2	x	x	X	X					x	x		
Acacia tortilis	2		x	x				x		x			
Acacia senegal	1				X		X	x		x			
Acacia seyal	1				X								
Azadirachta indica	2	x			X							X	
Balanites aegyptiaca	1				X		X			x			
Eucalyptus camaldulensis	2		x	x									
Eucalyptus tereticornis	2		x	x									
Faidherbia albida	1		x					x		x			
Hyphaene compressa	1				X		X						
Melia volkensii	1	x	x		X					x			
Moringa oleifera	2				X		X						
Moringa stenopetala	1				X		X						
Sclerocarya birrea	1						X						
Tamarindus indica	1			x			X			x			
Terminalia brownii	2		x	x				x					
Ziziphus mauritiana	1			x			X						

Key

Value:
1. Species of current socio economic importance
2. Species with clear potential or future value
3. Species of unknown value given present knowledge and technology

Utilization:
ti timber production;
po posts, poles, round wood;
pu pulp and paper
wo fuelwood, charcoal;
nw non-wood products (gums, resins, oils, tannins, medicines, dyes...)
Fo food;
fd fodder;
sh shade, shelter;
ag agroforestry systems;
co soil and water conservation;
am amenity, aesthetic, ethical values;
xx other (specify).

Annex 2: Management and location of genetic resources by natural site and species

Species/ecological zones	Reserve, natural park	Protected natural stands	Protected planted stands	Villages fields, homesteads	Experimental trials
Acacia nilotica **(Zone 3,4,5)***	>1,000				
Acacia tortilis **(Zone 4,5)**	>10,000				
Acacia senegal **(Zone 4,5)**	>1,000				
Acacia seyal **(Zone 4,5)**	>1,000				
Azadirachta indica **(Zone 3, 4,5)**		>1,000	>1,000		>500
Balanites aegyptiaca **(Zone 3,4,5)**	>1,000				
Eucalyptus camaldulensis **(Zone 3,4)**			>10,000	>10,000	>1,000
Eucalyptus tereticornis **(Zone 3,4)**			>1,000	>1,000	>500
Faidherbia albida **(Zone 3,4,5)**	>5,000		>1,000		
Hyphaene compressa **(Zone 4,5)**	>5,000	>500			
Melia volkensii **(Zone 3,4)**	>1,000		>1,000	>500	>1,000
Moringa oleifera **(Zone 3,4)**			>100		
Moringa stenopetala **(Zone 3,4)**	>500	>500			
Sclerocarya birrea **(Zone 3,4)**	>1,000	>5,000			
Tamarindus indica **(Zone 3,4,5)**	>5,000	>1,000	>100	>100	
Terminalia brownii **(Zone 3,4)**	>10,000	>5,000	>100	>500	>100
Ziziphus mauritiana **(Zone 3,4,5)**	>1,000	>1,000	>100	>100	

***** *Estimated Tree density*

Ecological zones:

Zone 1 : Humid to semi-humid
Zone 2 : Semi-humid to semi arid
Zone 3 : Semi-arid
Zone 4 : Arid
Zone 5 : Very arid

Annex 3. Species and populations degree of management and security

Species /ecological zones	Protected in parks	Managed for			Unmanaged but		Threatened by (causes)			Degree of security
		Soil water protection	Wood, non wood production	Animal grazing	Used and harvested	Used and grazed	Environment	Clearing	Over grazing	
Acacia nilotica **(Zone 3,4,5)***	>1,000		>500		>500		20%	5%	20%	2
Acacia tortilis **(Zone 4,5)**	>10,000		>1,000	>500	>500	>500	40%	10%	40%	3
Acacia senegal **(Zone 4,5)**	>1,000		>100		>500	>500	20%	5%	20%	4
Acacia seyal **(Zone 4,5)**	>1,000		>100		>500	>500	20%	5%	20%	2
Azadirachta indica **(Zone 3, 4,5)**		>1,000	>100						10%	2
Balanites aegyptiaca **(Zone 3,4,5)**	>1,000		>500	>100	>100	>100	50%	15%	50%	3
Eucalyptus camaldulensis **(Zone 3,4)**			>10,000						20%	1
Eucalyptus tereticornis **(Zone 3,4)**			>1,000						20%	1
Faidherbia albida **(Zone 3,4,5)**	>5,000	>1,000	>500				30%	10%	40%	4
Hyphaene compressa **(Zone 4,5)**	>5,000				>5,000	>1,000	60%		5%	5
Melia volkensii **(Zone 3,4)**	>1,000	>500	>1,000	>100	>500	>100	30%	10%	40%	5
Moringa oleifera **(Zone 3,4)**			>100						2%	2
Moringa stenopetala **(Zone 3,4)**	>500	>100			>100		40%	5%	40%	3
Sclerocarya birrea **(Zone 3,4)**	>1,000	>100	>100		>100		20%	2%	20%	4
Tamarindus indica **(Zone 3,4,5)**	>5,000	>1,000	>100		>500		40%	10%	30%	4
Terminalia brownii **(Zone 3,4)**	>10,000	>5,000	>500		>1,000		40%	15%	50%	3
Ziziphus mauritiana **(Zone 3,4,5)**	>1,000	>500	>100		>500		20%	5%	30%	4

Degree of security
1: Low risk of genetic erosion
2, 3, 4: intermediate risk of genetic erosion
5: High risk of genetic erosion

Ecological zones :
Zone 1 : Humid to semi-humid
Zone 2 : Semi-humid to semi arid
Zone 3 : Semi-arid
Zone 4 : Arid
Zone 5 : Very arid