ETHIOPIA: COUNTRY REPORT ON THE STATE OF PGRFA TO FAO

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CHAPTER 1

THE STATE OF DIVERSITY

The flora of Ethiopia is estimated to be between 6,500 and 7,000 species, of which 12% is considered to be endemic. Endemism is reportedly high on the plateaus, mountains, in the Ogaden region and in the western and south western woodlands. The centre of endemism on the highlands of Ethiopia can be identified as follows:

- the south-western centre, which is characterised by endemism of montane rainforest and evergreen bushland;
- the central plateau centre, which contains endemic deciduous woodland and montane grassland;
- the eastern escarpment and southeast slop centre, which has species such as *Spiniluma oxycantha* in dry evergreen forests and bushlands;
- the high montane centre, which contains endemic ericaceous bushland and Afroalpine grasslands such as *Jasmimium staus* and Rosularia semiensis.

About 23 vegetation types are recognized in Ethiopia, which could be grouped into the following eight major categories:

- Desert and semi-desert scrubland
- Acacia - *Commiphora* woodland
- Wet evergreen forest
- Lowland (Semi-) evergreen forest
- Broad-leaved deciduous woodland
- Dry evergreen montane forest and montane grassland
- Afro-alpine and sub-Afro-alpine
- Riparian and swamp vegetation

1.1 DIVERSITY IN MAJOR CROPS

Ethiopia is one of the richest genetic resource centres in the world in terms of crop diversity. This is principally attributed to the diverse farming systems, socio-economics, cultures and agro-ecologies. Crop plants such as coffee (*Coffea arabica)*, safflower (Carthamus tinctures), tef (Eragrostis tef), noug (*Guizotia abyssinica)*, anchote (*Coccinia abyssinica), enset (Ensete ventricosum),* etc. are known to have originated in Ethiopia. The country has a very high genetic diversity in four of the world's widely grown food crops (wheat, barley, sorghum and peas); in three of the world's most important industrial crops (linseed, castor and cotton); in the world's most important cash crop (coffee); in a number of food crops of regional and local importance (tef, noug, Ethiopian mustard, enset, finger millet, cow pea, lentil, etc.) and in a number of forage species of world importance (clovers, lucerne, oats etc.).

The major crops of Ethiopia include the following:

1.1.1 Cereals

Tef is grown under a range of altitudes, rainfall and soil types. It has an immense phenotypic diversity in plant height, size and compactness of panicle, and seed colour.

Ethiopia has a diverse wealth of sorghum germplasm adapted to a range of altitudes and rainfall conditions. It is one of the major food crops and ranks forth in total production and third (following maize and the major Ethiopian staple, tef) in cultivated area. Of the five morphological races of sorghum (bicolor, guinea, caudatum, durra, and kafir) all except kafir are grown in Ethiopia. Important traits reported from Ethiopian sorghum include cold tolerance, drought resistance, resistance to sorghum shoot fly, disease and pest resistance, grain quality and resistance to grain mould, high sugar content in the stalks, and high lysine and protein content.

Barley has no wild relative in Ethiopia. Nevertheless, the crop has an extremely high morphological diversity - regular; irregular and deficiens barley types. Many authors have identified Ethiopia as a centre of diversity for barley. In addition to phenotypic diversity, the Ethiopian barley is important source of genes for barley yellow dwarf virus resistance, high lysine, drought resistance, resistance to diseases such as powdery mildew, leaf rust, spot blotch, septoria, loose smut and barley stripe mosaic virus.

According to Vavilov, the diversity in Ethiopian wheats comprises six wheat species: *Triticum durum* subsp. Abyssinicum; *T. turgidum* subsp. abyssinicum; *T. dicoccum*; *T. aestivum*; *T. polonicum* and *T. compactum*. Currently, the five Vavilov's tetraploid species listed above are classified under *Triticum turgidum*. All these species of wheat observed by Vavilov in the mid-1920s are still grown by farmers as landraces. Although Vavilov regarded the Ethiopian region as a centre of origin and diversity for tetraploid wheats, the absence of wild relatives and lack of archaeological evidences suggest that Ethiopia could be a secondary centre of origin. The diploid einkorn and the hexaploid wheat do not seem to be native to the Ethiopian gene centre.

Maize plays a significant role in the national food security though it has limited genetic variability in the country.

1.1.2 Pulses

Ethiopia is probably one of the primary centres of diversity for faba bean. Although the small-seeded type of the Ethiopian faba bean is not well studied, there are some reports of tremendous diversity in protein content, chocolate spot and leaf rust resistance.

Field pea, one of the oldest crops in the country, has a unique subspecies developed in Ethiopia - *Pisum sativum* subsp. abyssinicum. The existing field pea germplasm in the country has a phenotypic diversity and tolerance/resistance to disease.

Chickpea is one of the ancient crops in Ethiopia. Archaeological evidence from Lalibela caves indicted seed samples with over 2500 years of age were discovered. Ethiopia is also considered by some authors as a centre of origin and diversity for chickpea. The phenotypic diversity observed in farmers' fields is considerable particularly in flower colour, seed colour, anthocyanin in the leaves, disease and

drought resistance. Related wild species of chickpea (*C. cuneatum*) has been found in northern Ethiopia.

There are conflicting reports as to the origin of lentil. Some authors regard Ethiopia as a centre of origin/diversity whereas some have reported lentil to be an early introduction to Ethiopia. The Ethiopian germplasm at present is diverse in earliness, seed yield, harvest index, number of seeds per pod and cold tolerance. The wild species *Linus ervoides* grows in montane grassland in the north and central regions of the country.

1.1.3 Oil crops

Gomenzer (Ethiopian mustard) grown extensively in the highlands has a considerable diversity for several vegetative traits. Since no wild relative of gomenzer is known, the hypothesis is that gomenzer is a tetraploid hybrid between *Brassica nigra* and *Brassica oleracea*. There are weedy forms of brassica growing throughout the highlands of Ethiopia which used as leafy vegetables.

Noug is an important oilseed crop in Ethiopia. There is little research on this indigenous oil crop with a very high edible oil quality. The phenotypic diversity in noug is more obvious for characters related to flowering, maturity and head size and other morphological characters.

Ethiopia is considered as a centre of diversity for linseed. Linseed, grown for oil production, has relatively high variability in flower colour, plant height, flowering and maturity duration, and capsule size and wilt resistance.

Sesame, the third most important oil crop in the country, occurs both as cultivated and in the wild. It shows a high phenotypic diversity for number of days to maturity, plant height, pod shape and size, and for seed size and colour.

1.1.4 Root and Tuber Crops

There are several indigenous cultivated or semi-cultivated root and tuber crops in Ethiopia. These crops have important place in the diet of the population.

Enset is endemic to Ethiopia and occurs throughout the country both as cultivated and wild species. It is an important staple to a large number of people in the south and southwest of the country. Although the plant is propagated vegetatively, there are tremendous variation in several characters including colour of pseudostem and leaf midribs, earliness, disease resistance and product quality.

Potato plays a significant role for food security, though it has very limited genetic variability in the country. Similarly, sweet potato is one of the major root crops in the country with a limited variability.

1.1.5 Stimulant Plants

Coffee is widely grown in the humid and sub-humid agro-ecologies of southern Ethiopia. The phenotypic diversity of arabica coffee is broad for both qualitative and

quantitative characters. There is an extremely high variability in disease and pest resistance, liquoring quality and other traits. It grows as wild, as moist montane forest shrub, as cultivated crop and as garden plant together with fruit trees and herbs in the backyards.

There is no systematic study on the diversity of chat (*Catha edulis*). However, striking diversity in leaf colour can be observed in south-eastern Ethiopia.

1.1.6 Industrial Crops

There are indigenous diploid cultivated and wild species of cotton in Ethiopia. It is believed that *Gossypium herbacium* var. acerifolium might have been domesticated in Ethiopia. The indigenous cultivated species include *G. arboreum* and *G. herbaceum*. The distribution of the wild species of the B genome (*G. anomalum* as subsp. se-marense) and those of the E. genome (*G. somalense, G. bricchettii* and *G. benadirense*) are recorded.

1.2 DIVERSITY IN MINOR CROPS Y

1.2.1 Cereals

Finger millet is very likely of Ethiopian origin. At present, it is mainly grown in the north-western parts of the country and shows less diversity compared to other indigenous cereals. The wild species, *E. africana*, the possible progenitor of the cultivated species, occurs as a weed in finger millet fields. Pearl millet (*Pennisetum glaucum*), though less important in production, is believed to have been originated in Ethiopia. Emmer wheat is also grown to a limited extent, though its diversity is believed to be narrow.

1.2.2 Pulses

Cowpea is mainly cultivated in Konso and Gambella in the west and south-western parts of the country. The two cultivated subspecies - *V. unguiculata* and *V. cylindrica* are found as landraces in the eastern part of the country. The two wild subspecies *V. aconitifolia* and *V. vekillata* are found in the northern, south-western and southern part of the country. Although there is no sufficient information on the magnitude of the diversity in this crop, it is believed that the African species might have been domesticated in Ethiopia. The species is divided into three cultivated and two wild sub-species.

Fenugreek is locally used as a pulse, spice and medicinal plant, and has a long history in Ethiopia. Even though the hectarage is limited, the species has a considerable genetic diversity in seed colour, maturity and other morpho-agronomic characters.

Diversity information on grass pea is limited. The crop is commonly grown in the highlands and has an important trait of drought resistance. The wild species *Lathyrus pratensis* and *L. sphaericus* are found in upland grassland.

Hyacinth bean (*Lablab purpureus*) is grown in Konso. Though this is under dispute, some authors have regarded Ethiopia to be the centre of origin/diversity for this species.

There is no common agreement on the centre of origin of pigeon pea. Nevertheless, Vavilov and other authors have indicated Ethiopia as a probable centre of origin.

1.2.3 Oil Crops

Some authors consider Ethiopia to be the probable centre of domestication of safflower. At present the crop is grown in small scale. No sufficient information is available on its diversity.

Both cultivated fields and wild population of crambe (*Crambe abyssinica*) are observed in the highlands of Ethiopia. However, the distribution now is shrinking and crambe fields are rare at present, indicating that there are conditions that threaten the existing diversity.

1.2.4 Root and Tuber Crops

Oromo dinich (*Coleus edulis*) occurs both as wild and cultivated species. The genus Coleus has about 30 wild species in Ethiopia. The cultivated species is grown in the wetter south and south western regions of Ethiopia whereas the wild species are found throughout the country.

Anchote (*Coccinia abyssinica*) is an endemic species found both as cultivated and in the wild in Ethiopia. Although the genus in Ethiopia is not well studied, there are more than eight taxa recorded, distributed throughout the country.

Yam might have its origin in Ethiopia. Even though yam is not a staple crop in Ethiopia, there are ten species recorded, distributed throughout the country. Some of the species have both cultivated and wild forms. It is reported that aerial tubers are common than root tubers in western Ethiopia. Some of the species are highly drought resistant.

1.2.5 Vegetables

Ethiopian mustard (kale), pumpkin, and chilli are important vegetable crops having narrow range of diversity.

Cabbage tree (*Moringa stenopetala*) is an important vegetable tree in the konso area of south-western Ethiopia. Five species of this genus are recorded in Ethiopia. One of this five species is horse-radish tree (*Moringa oleifera*) which is used as a source of oil and for the purpose of purifying water.

Several authors have indicated that okra might have been domesticated in Ethiopia. It has high diversity in Ethiopia and it is an important vegetable in some parts of the country particularly in the south-western low lands (550 to 650 masl) region. In addition to the cultivated species, the distribution of two other species *A. manihot* and *A. moschatus* are reported recently.

1.2.6 Stimulant crops

Gesho (*Rhamnus prinoides*) is an important garden plant used extensively in local brewery. It is a crop grown in a wide range of ecology across the country.

1.2.7 Industrial crops

Both cultivated and weedy/wild types of castor bean are widely distributed under a range of ecological conditions in Ethiopia. Because of the immense diversity in plant, fruit and seed characters, some authors consider Ethiopia as the origin of cultivated castor bean.

Kenaf is reported by many authors of being an Ethiopia origin. *Hibiscus cannabinus* occurs wild in a range of habitats. The cultivated species is *Hibiscus sabdariffa*. In addition to these, six wild *Hibiscus* spp. have been observed in Ethiopia.

Thirty different species of *Vernonia galamensis* have been identified in Ethiopia. It is a semi-arid plant. The oil characteristics make it suitable for industrial use in plastic formation and coating industry.

1.2.8 Spices

There are several important spices which are of Ethiopia origin. The most important species include *Aframomum corarima, Trachysperumum ammi, Coriandrum sativum, Nigella sativa, Capsicum spp., Cuminum cyminum, Diplolophium abyssinicum, Anethum graveolens, Ocimum basilicum, Allium cepa, Foeniclum vulgare, Ruta chalapensis* and *Piper longum*.

1.2.9 Forage species

The Ethiopian agriculture is heavily dependant on animals where forage and browse for all the animals comes from natural vegetation and crop residues. The Ethiopian flora is rich in grass and legume forage species. Although the magnitude of the diversity in the indigenous forage crops is not well studied, recent observations indicate that Ethiopia is a centre of diversity for *Trifolium,* and of its twenty six indigenous species, ten are found to be endemic. The list of the major forage species includes: *Stylosanthes* spp., *Neonotonia wightii, Alysicarpus* spp., *Indigofera* spp., *Tephrosia* spp., *Acacia* spp., *Erythrina* spp., *Pennisetum* spp., *Rhynchosis* spp. *Trifolium* spp., *Brachiaria* spp., *Cortalaria* spp.

1.2.10 Aromatic and medicinal plants

There are a number of indigenous and introduced aromatic and medicinal plants in Ethiopia. Some of these are *Commiphora* spp., *Boswellia* spp., *Cinnamomum cassia, Juniperus procera, Echinops* spp., *Olea europaea* subsp. africana, *Otostegia* spp., *Ocimum* spp., *Artemisia* spp., *Cymbopogon citratus, Cyperus bulbosus, Myrtus communis*.

1.3 WILD SPECIES AND WILD RELATIVES OF CROP PLANTS

The domestication of plants takes place through a series of stages of intensified usage of plants while in the wild. There are many wild plants which are used for food, especially during period of food shortages. The majority of such plants are those used as leafy vegetables, edible fruits, tubers and roots. *Corchorus* for example has nine species found in Ethiopia that are collected at a young stage and eaten as cooked vegetable, although, none of them are cultivated. There are also grass forms such as *Snowdenia polystachya*, seeds of which are used for similar purposes as tef in some parts of the country. Example of semi-domesticated plant species is *Avena abyssinica*.

Some of the domesticated plants still occur with their wild relatives in some parts of the country. Examples are *Thymus* spp. in the Afro-alpine regions of the country; *Enset ventricosum* which occurs both in wild and cultivated state in the medium to higher altitudes; *Gossypium* spp. in the lowlands, as wild and cultivated; and *Sesamum* spp. which is found both cultivated and wild at an elevation below 1,800 masl. There are other wild plants currently attracting attention as potential crops, primarily for their use value. *Vernonia* spp. with thirty species identified in Ethiopia is a potential source of industrial oil; *Cordeauxia edulis* which is used in the arid areas as both feed and food source; *Amaranthus* spp. found as common weed in some parts of the country of which young plants are cooked as vegetable and seeds used for porridge and local beer, are among few of them.

There is a considerable wealth of plants of various importance used by Ethiopians, though it is not fully possible to tell their current status of use. Those plants that are used in the traditional medicine are species of important social and economic value. Although it is estimated that the traditional medicinal plants cater for the health care needs of over 80 percent of the population, the major medicinal plants of Ethiopia are not cultivated except few herbs that are grown in the backyards. Among the major known Ethiopian plants of medicinal value are *Hagenia abyssinica, Glinus lotoides, Rumex* spp which are used as a source of taeniacide; and *Taverniera abyssinica* for treating stomachache, headache and fever. *Senecio* spp., *Adhatoda schimperiana*, *Chenopodium* spp., *Dioscorea* spp., *Solanum* spp., *Datura stramonium, Aloe* spp., *Ricinus communis*, *Plantago lanceolata* and many other wild species are used as a source of traditional medicine.

The Ethiopian region is also rich in resins and gums which mainly come from the three genera - *Acacia*, *Boswellia* and *Commiphora*. *Acacia senegal* is a source for the true gum arabica, and is widely distributed in the lowlands of Ethiopia. Fifty two species of *Commiphora* were recorded in Ethiopia, and thirty five of these are found in south and south-eastern Ethiopia.

1.4 CROP VARIETIES

Variety development for major crops began in 1966 with establishment of Institute of Agricultural Research (IAR) now EIAR, a semi-autonomous public organization. It is a principal plant breeding institution, undertaking responsibilities for cereals, legumes, oil seeds, fibres, horticultural and forage crops. Apart from EIAR, the regional research institutes and the universities are also involved in agricultural

research and variety development. The Ethiopian Pioneer Hi-bred International (EPHI) introduces and tests maize hybrids from parent company for adaptation and release in Ethiopia. The variety development, evaluation, release and registration procedures pass through several stages: observation nursery, preliminary yield trial, pre-national yield trial, national yield trial. Promising lines are evaluated on farmers' fields where new varieties are intended for release. The variety release and registration system has evolved over a number of years. Since 1984 variety release and registration has become the responsibility of the National Variety Release Committee (NVRC). Many varieties of cereals, legumes, oilseeds, fibre crops and vegetable crops have been developed and were recommended or released for use by farmers in Ethiopia. The major requirements for release of varieties are distinctness, uniformity and stability as well as quality parameters.

In Ethiopia, public and private companies are involved in the production and supply of seed. Farmers are also encouraged to participate in local level seed production and marketing within their communities. Formal seed production is dominated by the public sector. Ethiopian Seed Enterprise (ESE) is an autonomous parastatal organization governed by a Board of Directors and is responsible for production, processing, marketing and quality control of seed. The government, however, encourages the participation of the private sector both in variety development, seed production and supply. The government provides both technical advisory services and training supports for private seed enterprises. Since 1991, the EPHI and some private investors are involved largely in hybrid maize seed production and supply. The seed production follows a generation system: breeder, pre-basic, basic and certified seed.

The maintenance of released varieties and the production of breeder and pre-basic seed continue to be the duty and responsibility of the agricultural research institutions and universities that have developed the varieties. Modern varieties in production might loose their genetic purity through time. It is thus important to conserve seed samples of new cultivars in seedbank. With respect to this, the IBC has started a programme to conserve old and new varieties developed by the national agricultural research system over the years.

The major constraints as regards to the seed system in the country include limited capacity of NARES to supply adequate quantity of breeder and pre-basic seed, the weak formal seed sector, the fact that the farming community is resource poor and unable to purchase seed, inadequate credit facility, inadequate capacity to forecast demand/supply requirements, inadequate distribution and marketing system mainly due to poor infrastructure. Because of the above described limitations, the improved varieties of major crops account only for 15% of the cultivated land in the country. Nevertheless, some of the crops are enjoying an increasingly expanding market acceptance. For instance, coffee, haricot bean and sesame are widely grown for export. Where as, tef, wheat, malt barley, lentil, chick pea, pepper, tomato and onion are more important in local market. Similarly, there is a fast growing floriculture industry. Furthermore, there is tremendous market potential for spices, fruits and industrial crops even though it is not yet fully exploited. Agricultural research and development institutions are collaborating on scaling up and scaling out activities to help the country better exploit opened up export market opportunities.

1.5 FACTORS AFFECTING THE STATE OF DIVERSITY

Until the 1970's, the diversity in the landraces was unaffected significantly. However, due to repeated drought in some areas of high crop diversification in the country, and diffusion of exotic seed varieties that has been displacing the landraces, the pace of genetic erosion was tremendously increased after 1970's. Displacement of indigenous landraces by genetically uniform varieties, changes in crop pattern and land use have largely affected the magnitude of the genetic diversity in the indigenous crops. For instance, the highlands of Arsi and Bale are seriously affected areas with modern agricultural exercises for over the last three decades. In these and other regions, the native barley is suffering serious genetic erosion due to gradual displacement of the crop by other crops, especially by introduced varieties to the region. Durum wheat is giving way to tef and new bread wheat varieties, particularly in areas where extensive wheat breeding activities have occurred since the sixties. Recent study conducted in north-eastern Ethiopia revealed that drought and replacement of landraces with improved varieties were among the major factors contributing to genetic erosion particularly to sorghum. Because of commercialization and planting of uniform varieties over large expanses of land previously un-known diseases and pest problems are gaining importance leading to genetic vulnerability. In the central highlands including northern Shewa and Gojam region, introduced varieties of oats have replaced a wide range of crops grown in these areas.

Although much of the diversity is still in the hands of farmers, a lot of it has already been lost and the impact of the threat has also been extended to the traditional management systems of varieties of crops developed and used by the local people through generations. The situation therefore, has created awareness that long-term food security depends on the ability to systematically maintain and use the existing genetic diversity of the indigenous crops. As one of the strategies to meet the challenge, the Institute of Biodiversity Conservation (IBC) has developed in situ landrace conservation and enhancement programmes that involve breeders, farmers and others, in several stages of maintenance, restoration and improvement processes of traditional crop varieties. Based on a number of previous empirical data and survey conducted under a project entitled: A Dynamic Farmers'-Based Approach to the Conservation of Ethiopia's Plant Genetic Resources, which run from 1997 - 2002 funded by Global Environmental Facility (GEF), IBC identified twelve major areas of crop genetic diversity which have been used as Community Gene Banks (CGB). The CGBs have involved 22 crop species consisting of 400 farmer varieties in six agro-ecological zones of the country. A similar initiative has been proposed by IBC for conservation of crop wild relatives and wild plants relevant to food production.

The establishment of the CGBs on crops has served a useful purpose in terms of conserving crop diversity. More over, the conservation of wild plant species could play an additional role for food security. However, lack of adequate financial support and enough number of skilled human resources have constrained the efforts being made to expand conservation programmes aimed at ensuring food security.

Collection, conservation and utilization of plant genetic resources is a continuing process. The IBC currently holds, over 60000 accessions constituting more than 200 plant species. The vast majority of these materials are landraces. To further strengthen and enhance not only the collection but also the conservation and sustainable

utilization of this vast resource for food security short, medium and long term strategies are in place. For instance, at regional level, through the East Africa Plant Genetic Resources Network, efforts are under way to build the necessary capacity (laboratory equipments, training) and support the gene banks to under take further collections, multiplication and rejuvenation of plant genetic resources for sustainable use.

CHAPTER 2

THE STATE OF *IN-SITU* MANAGEMENT

In broad sense, *in situ* conservation is defined, according to the Convention on Biological Diversity (CBD), as the conservation of the ecosystems and the natural habitats and the maintenance of recovery of viable populations of the species in their natural surroundings and, in the case of the cultivated species, in the surroundings where they have developed their distinctive properties. The *in situ* conservation can take place on farmers' fields, on the pasture lands and in national parks or other types of natural reserves. For the cultivated species, the *in situ* conservation concerns the maintenance of the diversity available intra and inter local populations in the ecological and geographical sites. The concerned populations are those cultivated by the farmers and that they reproduce from generation to generation. This approach of conservation concerns whole agro-ecosystems and implies the communities of the farmers as direct actors of management of the diversity through their production strategies.

The primary objective of *in situ* conservation is to conserve the biodiversity of traditional crop varieties on the area where it adapted/evolved. No-farm in-situ conservation is one of the most important in-situ conservation methods where farmers' knowledge and traditional practices are exercised. On-farm conservation of agro-biodiversity is conservation in a dynamic agro-ecosystem, ideally one which is self-supporting and favouring evolutionary processes. Thus, it allows ongoing host-parasite co-evolution, which is likely to provide material resistant to diseases and pests. This contrasts with the efforts to conserve crop diversity in static off-farm gene banks. However, *in situ* maintained diversity is more difficult to access for breeders who like to use specific materials for their breeding programmes.

The Conservation on Biological Diversity recognizes *in-situ* conservation as a primary approach to biodiversity conservation. In Ethiopia this conservation method is considered important and implemented primarily by IBC. Other institutions involved in *in-situ* conservation of biodiversity include the NARES, the Federal Ministry of Agriculture and Rural Development and the Regional Bureaus of Agriculture and Rural Development.

2.1 PLANT GENETIC RESOURCE INVENTORIES AND SURVEYS

Plant genetic inventories and surveys have been conducted by the IBC in collaboration with partner organizations such as the MOARD in order to gather and document information on the types and distribution of the farmers' landraces, forest and aquatic resources, medicinal plants etc. Following extensive survey undertakings, about twenty areas of rich biological diversity, distributed across six regional states, have been identified for conservation purposes. Subsequently, a number of habitat rehabilitation initiatives have been launched, contributing to food security and range land recovery.

Implementation of surveying and inventorying PGRFA has been constrained mainly because of lack of finance, skilled manpower and poor institutional capacity. There is

also lack of skilled manpower mainly in using modern technologies in the survey and inventory activities. This is mainly because of lack of appropriate use of the technologies such as Geographic Information Systems (GIS). The information and documentation systems being used for registering the PGRFA of the country are poorly organized and they are not amenable for upgrading and networking, requiring substantial improvement work for the future.

2.2 CONSERVATION OF WILD PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE IN PROTECTED AREAS

The conservation of crop genetic resources which include, the plants that feed us and their wild relatives, is one of the most challenging tasks for human kind today. Many of the species from which the crop plants were selected continue to survive in the wild, even to the present day. This 'pool' of wild species comprises the 'wild relatives' of crops. Many wild relatives have evolved to survive drought and floods, extreme heat and cold, and they have become adapted to cope with many natural hazards. They have often developed resistance to the pests and diseases that caused so much damage to the related crops. This is why they are still so valuable to agriculture today. By virtue of the fact that Ethiopia is the centre of diversity for many crops and wild plant species, there are multitudes of wild grass, legume and oil seeds, fruits, vegetables, root and tubers, medicinal plants, spices etc. that are extensively used for food, feed, medicine and other traditional uses.

To date, a wide range of wild plants that can be used as gene source for future improvement work on some of the economically important crops vis. coffee, sorghum, tef, have been identified. Many wild plants are known and widely used by the rural community as alternative food source especially during dry years, for curing illnesses and making household items. Although it is still at limited scale, the IBC is making an effort to conserve this valuable resource in its natural habitat (In-situ). In this regard the institute is also collaborating with concerned partners to protect and conserve the genetic pool in its natural environment.

2.3 ECOSYSTEM MANAGEMENT FOR CONSERVATION OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

Ethiopia's boundaries encompass the major part of eastern African highland massif. On the northern and western boundaries lie the foothills of the main massif. The Great Rift Valley cuts diagonally across the country from Red Sea to Kenya, creating a vast depression. The dry areas have isolated the highlands. Thus, there is great variation of altitude from 116 m.a.s.l to 4620 m.a.s.l. Rainfall also varies widely in amount and distribution. These factors strongly influence Ethiopia's extraordinary range of terrestrial and aquatic ecosystems and contribute to the high rate of endemism and biological diversity.

The existence of diverse ecosystems endowed Ethiopia with a diverse biological wealth of plants, animals, and microbial species. Over the years, this wealth has been exposed to various biotic and abiotic factors that diminished its diversity and attention given to its conservation and sustainable use has been inadequate. Some of the major contributory factors to accelerated decline of our biological heritages are; the size and

pattern of the distribution of human and animal population, the level of resource consumption, market factors and policies, which were unable to monitor the depletion of biological resources. Under-valuation of environmental resources due to low-level of awareness about the role of ecosystems and the rate at which it is being deteriorated or lost, and poor regard to the conservation problems have also contributed to under-investment in biological resources management.

Records on ecosystem conservation efforts in Ethiopia dated back to the days of Emperor Zera-Yakob (1434-1468 E.C.). The Emperor brought juniper seedlings from Wof Washa of North Shewa and planted in Managesha - Suba area, located in the south-western fringes of Addis. Modern conservation began by Emperor Menilik in 1908 E.C. This conservation initiative eventually evolved to the formulation of protected areas in 1960s and led to the establishment of Ethiopian Wildlife Conservation Organization, although they are still oriented to conserve game animals.

Although there are some conservation efforts in the country, the attention given to ecosystem conservation and management has been very low. There was also very low level of awareness about the role of ecosystem conservation in securing biological diversity. In recognition of the existing gaps and with present worldwide need of ecosystem approach of biodiversity conservation, IBC is under taking some activities regarding this approach. Albeit Although much has not been achieved in totally protecting the natural vegetation areas from maximum human interference, conservation of natural forests is developing through the establishment of protected areas and national parks. About 57 National Forest priority areas are identified, and attempts to study the general floristic composition of the natural forest and other protected areas are under way.

There are 10 national parks, 13 wild life resources and bird sanctuaries, and 14 controlled hunting areas. There are also protected forest areas and proposed ones. The Menagesha - Suba natural forest, which has been heavily exploited for many decades, has now been declared a protected forest area. The Megada natural forest in the southern part of the country is a protected forest where no forest exploitation is allowed, mainly, owing to failure in natural regeneration and poor under-growth establishment. The Wof Washa natural forest, because of ruggedness of the terrain and poor regeneration, is also considered a protected forest where no exploitation is allowed.

2.4 ON-FARM MANAGEMENT AND IMPROVEMENT OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

A practical measure has been taken with regard to on-farm *in situ* conservation programme of landraces that was initiated in 1989. The major objective of this Ethiopian *in situ* on-farm conservation for landraces is to support the farming communities in their efforts of maintaining crop/plant diversity, and producing food for their family and for the country as a whole. The *in situ* on-farm maintained landraces serve as a source of materials of wide range of adaptation, famine mitigating traditional varieties, and at the same time used as a basic material from which farmers select special lines to meet their changing needs.

The nature of the Ethiopian crop *in situ* on-farm conservation is such that diversity in crop species, multi-crop association, and cultural practices and factors contributing to the disruption of the traditional way of maintaining diversity are strongly considered. Traditional crop variety improvement components are integrated into the conservation and multiplication activities, to fill the existing production gaps in the utilization processes of landrace population. Under this system, joint formal and in-formal efforts in crop selection, in which pre-breeding work to enhance landraces is intended to be incorporated serve as a compromise between the need to utilize high-input varieties on the one hand, and sustainable production through the use of better adapted materials on the other.

Integration of the formal and informal crop improvement programmes, and promotion of community based seed networking is another component used to fill the gaps. Through community seed system, farmers are supported to control the choice of crop types and cultivars they want to grow, having at the same time, reliable access to planting materials adapted to their local crop growing conditions. The community seed system has also seed production/multiplication, marketing and distribution and community seed banks as components. The community seed banks serve as important mechanism to in-crease the number of options for using diverse crop types, and to decrease vulnerability to seed shortage and genetic erosion.

Ethiopian ***in situ*** for cultivated crops is decentralized and broader participation of farmers and other groups is its unique character. It is also complemented by ex situ conservation system for crops, which at the same serves as a source of genetic diversity for restoration and introduction of suitable landraces. Farmers participating in the programme perceive benefit to be involved in the in situ conservation and enhancement activities not through direct payment, but with long-term benefit including incentives of various nature, based on the interest of the community within a given locality. The principle of the incentives is that farmers themselves must perceive an advantage in continuing to grow traditional crops, and their participation in conservation of their folk varieties must be self sustaining. This condition however, requires at certain stage, a minimum of centralised support or subsidy to certain farmers or farm communities that have been detached of their landraces because of its displacement through modern agricultural practices or genetic erosion.

The IBC has developed in situ landrace conservation and enhancement programmes that involve breeders, farmers and others, in several stages of maintenance, restoration and improvement processes of traditional crop varieties. A project entitled A Dynamic Farmer Based Approach to the Conservation of Ethiopia’s Plant Genetic Resources funded by the Global Environment Facility (GEF) was initiated in 1994 addressing a neglected aspect of plant diversity that of indigenous crop varieties maintained by farmers in dynamic agro-ecosystems. This community-based in situ conservation project is designated to link farming communities and their varieties with the existing formal genetic resources conservation efforts of the Institute of Biodiversity Conservation by means of establishing Community Gene Banks (CGB). Conservation at the farm level allows for continuing farmer selection, interaction with the environment and gene exchange with the wild species so that evolution of landraces may continue.

The CGBs have involved 22 crop species consisting of 400 farmer varieties in six agro-ecological zones of the country. Farmer conservation associations have been formed for each in situ conservation site. Agro-morphological, nutritional, biochemical and ethno-botanical studies were conducted on some of the crop species under in situ conservation. Crop germplasm samples originally collected from the in situ sites and maintained at the gene bank were also restored at their respective sites. Indigenous knowledge of the farmers on their crop cultivars such as methods of selection, cultivation and use of different crops and cultivars, women's knowledge and role, seed exchange and movement were surveyed and documented.

In situ conservation areas for coffee have been identified in six administrative regions. The implementation of this approach can be of a great help not only for the conservation of the wild coffee alone, but also for the forest and other plant species. Medicinal plants on which 80 percent of the Ethiopian population depend is mainly derived from forest plant species, and thus, in situ conservation schemes would help safeguard the nation's pharmacopoeia from being lost.

Ethiopia's indigenous and diverse PGRFA needs to be enhanced on-farm through research, conservation and sustainable utilization activities. Abiding to the regional and international commitment, Ethiopia needs to collaborate and cooperate especially to raise available funds and promote PGRFA for the well-being of the world community. Inputs from the regional and international community are essential for the promotion of on-farm management of PGRFA. Besides, there is a need for awareness creation among the policy makers, stakeholders and the public on on-farm management of PGRFA. Recognition of farmers' contribution to on-farm management of PGRFA and provision of market and production incentives could enhance the sustainable use and management of PGRFA in the country.

2.5 ASSESSEMENT OF MAJOR NEEDS FOR *IN SITU* MANAGEMENT OF PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

The country has experienced disasters at different times where flood, drought and other natural calamities have led to rapid loss of valuable plant species which are the source of livelihood for rural communities. So far, there was very little effort to systematically assess the magnitude of such disasters and reintroduce locally adapted germplasm. Based on the information gained from a number of previous empirical data and surveys, Institute of Biodiversity Conservation made an effort to restore local varieties of field crops in 12 districts at different agro-ecological zones of the country under a GEF funded project. There were also efforts by FAO on seed fair and supply for sorghum in eastern Ethiopia. However, the support from international community to restore locally adapted varieties that are lost during those situations were minimal.

The expansion of modern farming which relay on improved, uniform crop cultivars is a threat for plant genetic resources. Furthermore, the resettlement programme currently launched in different regions of the country has forced farmers to leave their valuable plant genetic resources behind. There is a need for the country to establish a national programme for restoration of locally adapted germplasm and for the international community to support the scheme. Reintroduction of locally adapted

germplasm is a necessary action to be taken. For that technical and financial assistance from regional and international organizations is needed.

Thus, there is an urgent need to assess the strengths and weaknesses of the existing on farm in situ conservation schemes and to develop appropriate strategies for improving the effectiveness of the conservation programme, expand its coverage and scope. The existing CGBs are positively impacting on the conservation and sustainable utilization of farmer varieties at their adaptation area. For the reliable benefit support should be ensured both in terms of finance and technique. Furthermore, similar CGBs should be established in the remaining representative agro-ecological zones of the country based on the assessments to be made on the existing CGBs. The assessment should include gap analysis to identify gaps in the coverage of Ethiopia's ecosystems. For the future there is need to be proactive and rally concerned stakeholders behind for an extensive environmental impact assessment of current practices and launch a concerted effort to put in place an organized nation wide on farm in situ management programme.

More importantly, farmer-based research in addressing challenges, gaps and opportunities to make on-farm management sustainable is required. Genetic diversity in cultivated species and their wild relatives enables the research community to develop improved varieties of plants for human needs. Diversity in the wild plant species is mainly important as insurance for further food security. It is also important to have direct economic value today and may turn out to be economically valuable in the future. There are diverse wild edible plant species that could be domesticated to alleviate the food insecurity situation in the country. There is a plan already in place to conserve crop wild relatives and wild food plants in-situ. Ethiopia needs to prioritize crop wild relatives and wild edible plants to be conserved in-situ for the purpose of enhancing crop genetic diversity as well as number of food plant species. This could be achieved through mitigation of habitat destruction, adopting a good land use policy and promoting on-farm conservation activities of farmers' varieties as well as raising awareness among the public. Regional and international community could help in information exchange, training, collaborative research and financial support. Non-governmental organizations could also play a significant role in the area.

Chapter 3

The state of *ex-situ* management

The Convention on Biological Diversity specifically recommends that *ex-situ* measures be adopted as necessary in situations where *in-situ* conservation programmes do not prove to be adequate. These measures have most extensively been applied to conserve cultivated and domesticated agro-biodiversity, employing techniques such as seed banks, field gene banks, in vitro storage, and adaptive breeding measures. *Ex-situ* conservation is complementary to the rehabilitation and restoration of degraded ecosystems, and the recovery of threatened species. In Ethiopia, IBC which was established by decree in 1976 to lead *ex-situ* conservation in the country has basic facility necessary for collection, conservation, distribution and documentation of plant genetic resources. Other institutions involved in *ex-situ* conservation of biodiversity are very limited and include EIAR and ILRI.

Since the establishment of the IBC systematic crop germplasm exploration and collection operations have been undertaken in the different administrative regions of the country, covering a wide range of agro-ecological conditions by setting priorities based on the economic importance, degree of genetic erosion and diversity, researchers' need, the rate of diffusion of improved varieties, clearing of natural vegetation, market and agricultural policy, natural disaster and resettlement programmes etc. In most of the cases, the collecting strategy is based on broad or non-crop specific rather than pointed collecting.

3.1 THE STATE OF COLLECTIONS

The collections of the Ethiopian germplasm are composed of indigenous landraces including unique breeders' collections and lines. There are also some accessions repatriated from countries that hold a large number of Ethiopia's genetic material, some of which are not seen in the fields of Ethiopian farmers at present. Over the years, large number of regular as well as rescue germplasm collection missions have been organized emphasising on economically important crops with rich genetic diversity such as barley, wheat, sorghum and tef. The rescue collection missions were conducted in Gojam, Gonder, Wello and north Shewa on a range of crops including wheat, barley, maize, tef, sorghum, noug, linseed, lupin, finger millet, haricot bean, field pea, lentil, horse bean which were threatened by severe drought. About 446 samples were collected during this mission. All in all the holdings of the Ethiopian Gene Bank at present reaches over 60,000 accessions of about 200 crop/plant species. About 90% of the total germplasm holdings in the Genebank consist of field crops. The collection is composed of cereals, pulses, oil crops, spices and seeds of species of medicinal and industrial value. Aside from the crop germplasm collections, the gene bank also holds 650 collections of micro-organisms. More over, over 9000 accessions of horticultural crops, medicinal plants and herbs are kept in field gene banks. The type and nature of collection missions conducted, and number and list of plant species

and landraces collected are found in a wide array of publications (manuals, reports etc.) in English and local languages. The IBC has also produced a publication on principles and methods of seed conservation and distribution for wider use by those involved in germplasm collection.

Regular monitoring activities are performed for seed viability (at 5 to 10 years interval depending on specific crop species) and stock inventories. The germ plasm collection endeavour is supported primarily by the Ethiopian Government and also to a limited extent by regional and global networks including the East African Plant Genetic Resource Network (EAPGREN).

3.2 SEED PURITY, DRYING, VIABILITY TEST AND STORAGE FACILITIES

Before storage, important activities are performed in the physical purity and quantity analysis laboratory, namely determination of purity percentage, determining the proportion of impure seeds as well as the 1000 seed weight of a given sample. The latter one is essential to decide whether the seed sample is sufficient for long term storage. Any fewer seed which will not fulfil the long term storage criteria in terms of quantity is refused or multiplication might be recommended for certain types of species. The laboratory has a capacity of processing more than 3000 accessions annually. Seeds which qualify for long term storage in terms of quantity and purity are dried at the temperature of 15 ^{0}C – 20 ^{0}C, with a relative humidity ranging from 15-18%. The required storage seed moisture content is 5-7% for cereals, 4-6% for oil cops and 6-8% for legumes. The minimum number of seeds required for long term storage of heterogeneous sample is 8,000 seeds for seeds with Thousand Seed Weight (TSW) less than 200 grams and 3,200 seeds for genetically homogeneous materials. For pragmatic and economic reasons, the sample size for species with TSW greater than 200 g is reduced to a reasonable level of maintaining the initial genetic integrity of a sample. Seed samples fulfilling the required physical purity and quantity for long term storage will then be dried. In the seed drying section of the IBC, two seed drier rooms with the capacity of more than 4500 accessions are currently available.

It is also essential that the curator is able to assess accurately the initial viability of accessions prior to storage and then to monitor the viability of the samples during storage. Initial viability (before storage) and monitoring viability of stored seeds is undertaken in the seed viability testing laboratory. If the initial germination percentage is less than 85%, immediate rejuvenation is recommended to keep the sample in the genebank further. The laboratory has a capacity of testing about 3600 seed samples of field crops annually. In the future seed samples from species requiring dormancy breaking and those samples taking long period of time for germination (e.g. forest seeds) are expected to rise. Thus the laboratory is working to build capacity both in terms of skilled personnel as well as laboratory facilities.

Four cold rooms running at -10ºC with capacity of nearly 350 m^3 and one other cold room kept at +4 ^{0}C with a capacity of 5 m^3 are currently used for long term and temporary storages, respectively, in the IBC. In the year 2007/2008, the Institute is planning to install new cold room with capacity of at least 100 m^3 which will noticeably boost the long term storage capacity of the Genebank. The storage temperature for long-term purpose is -10 ^{0}C and for the short-term, it is +4 ^{0}C with 35% relative humidity. Samples are kept in laminated aluminium foils for long-term,

and in paper bags for short-term storage. The storage system is computerised with an easy access for monitoring the decline in sample size. Monitoring of decline in viability is made every 5-7 years, during storage and necessary rejuvenation will be made if the standard germination result is less 85%.

Though the Genebank of the IBC has made a remarkable effort in conserving germplasm of major food crops, there are still a lot that need to be conserved in the *ex-situ* (Genebank). A number of species (suspected of having seeds exhibiting orthodox storage behaviour) are in the short term storage awaiting long term storage. A large majority of these seed species are from horticulture, forages, medicinal and trees species. Major constrains for not being able to build up the Genebank's long term holdings in terms of number of species are: lack of adequate information on germination related problems (e,g. dormancy breaking mechanisms, storage behaviour) and lack of alternative storage facilities for the existing conventional cold store (e.g. in-vitro and cryo-preservation methods).

For plant species with recalcitrant and intermediate storage behaviour seeds, there are ten large scale field gene banks under IBC control, and small sized fields in the various research stations of the Ethiopian Institute of Agricultural Research and universities. The plan of immediate future is to increase the number of field gene banks in the different agro-ecological sites in the country. Community gardens, back yards, and holy places are considered to be included in the future plan. Spices, root and tuber crops and medicinal plants require such management at large scale, and with full involvement of the local communities.

3.4. SECURITY OF STORED MATERIALS

For security reasons, the collected and stored germplasm need to be conserved in duplicate genebanks. However, except the limited samples of Ethiopian germplasm reserved by the CGIAR, USAID and NORDIC genebank the bulk of the collections are still kept in single copy at the national genebank. Therefore, greater effort needs to be made to make an arrangement for storing duplicate collections to guard against unforeseen hazards such as fire and flood in the future. Ethiopia, as signatory of the world wide bio-diversity conventions, is entitled to get support in terms of acquiring duplicate germ plasm collections in case of natural disasters.

Regeneration activities are regularly performed to effectively maintain quality of stored germplasm collections for sustainable use. Complimentary activities such as timely viability testing during storage, selection of suitable regeneration environment, use appropriate sampling strategies, use of adequate isolation distance, and proper handling of regenerated materials are followed according to internationally accepted standard procedures for each specific crop type. A reliable power supply is also critical. The Ethiopian genebank has an independent power supply lines (a stand by generator) in addition to the hydro electric power supply.

To date over 5000 accessions are regenerated out of the 15000 accessions that are in need of immediate regeneration due to limited capacity. However, a plan is now in place to step up the effort and complete the regeneration activity in ten years time.

The urgently required activities include: viability test, and collaborating with partners to secure enough land in representative agro-ecologies for multiplication and rejuvenation. The regional governments should provide germplasm regeneration sites in different agro ecological zones of the country. The research activities being carried out and new academic institutions being established could provide an opportunity to address the problem of threatened *ex-situ* accessions for their regeneration. There is an opportunity for regional collaboration and cooperation as well as support from the international community both technically and financially for regeneration and conservation of germplasm.

3.5 DOCUMENTATION AND CHARACTERIZATION

Characterization is conducted by IBC, research organizations, and graduate students to choose materials of interest for further breeding and other crop improvement programmes. The descriptors in use for characterization are those developed by research institutes and the Bio-versity International.

Characterization and preliminary evaluation on basic morpho-agronomic characteristics have been undertaken on about 70% of the crop germplasm accessions since the establishment of the IBC. Additional evaluation on characters such as tolerance to drought and soil salinity, reaction to certain important diseases, and nutritional value have been undertaken on some crop germplasm accessions. Cytogenetic studies have been undertaken on indigenous field crop species. Furthermore, characterization and diversity studies have also been conducted on various field crop species based on agro-morphological, bio-chemical and molecular techniques.

Compilation of pertinent information starts with passport data right from the collecting field. Gene bank management data such as purity percentage, seed moisture content after drying, initial germination percentage, storage and monitoring date are also documented. Furthermore, characterization and evaluation as well as distribution data are documented. In the farmers' field and during sampling from market, farmers are important source of information on the collected germplasm. The information collected at this level include, those on sowing season, length of maturity, gastronomic value, local names of the variety, resistance to diseases and pests and to stresses, information on storability, soil types and altitude. All collected information through the entire process is documented and computerised with an easy access to user upon formal requests. Information is released in any convenient form to the user through consultation, delivery of printout or by letter, except in cases where repatriated or donated materials are coming without or with poor information that does not match the standard of the gene bank.

The IBC now has a fairly well organized documentation system and is in preparation to upgrade the existing data base. In addition to the genebank, source of information will be in situ maintained sites including parks and protected areas. Data from *in-situ*

conservation for landraces include information on indigenous knowledge such as traditional agronomy, farming systems and ethno-botany. In this process is included recording of information on wild relatives and plant species of traditional medicine. The activity requires more expertise in the fields of taxonomy and ethno-botany. More financial and material resources and integrated efforts are also required.

3.6 GERMPLASM MOVEMENT

In Ethiopia, source of germplasm for national breeding programmes is mainly indigenous germplasm and one of the responsibilities of the gene bank is to make germplasm available for breeding purpose. About 78000 seed samples are so far distributed from the Genebank holdings. In recent years, on average, the gene bank dispatched about 4000 seed samples per year for local research activities, and about 80% of these samples are used in national crop improvement programmes.

International research centres such as ICARDA, ICRISAT, are among the potential users of Ethiopian crop germplasm. For national programmes of other countries, germplasm is distributed upon formal request and negotiation. Germplasm supplied by the institute helped the generation of improved crop cultivars constituting valuable traits conferring increased yield, resistance to biological and environmental stresses.

3.8 ROLES OF BOTANANICAL GARDENS

Botanical gardens contain collections of plants for education, scientific purposes, and display. They can be taxonomic collections of a particular family, genus or group of cultivars; native plants; plants which share a common geographical or ecological origin; wild relatives; species of useful medicinal, aromatic or textile attributes. The initiative at national level for the establishment of botanical gardens is still at its infancy. However, it is believed that a wide range of plant species are maintained in old church and monastery compounds.

3.9 AN ASSESSMENT OF MAJOR *EX SITU* NEEDS

In a country like Ethiopia where there is accelerated environment and biodiversity degradation, *ex-situ* conservation is crucial. Therefore, there is a need to expand *ex-situ* conservation both in the gene banks and botanical gardens. Setting priorities for PGRFA to be conserved *ex-situ* is essential. Priorities should consider threats to crop genetic resources, use value of the genetic diversity, crop endemism and identification of areas of high diversity. Cooperation and collaboration of regional states on exchange of genetic materials for research and conservation could help expand *ex-situ* conservation. The IBC and the concerned international institutes need to work together to strengthen collaborative research and build the necessary capacity for alternative *ex situ* conservation methods. International financial institutions could also play various roles in assisting *ex situ* conservation efforts and the establishment of duplicate gene banks in Ethiopia.

Having a well organized *ex-situ* conservation system is indispensable for countries like Ethiopia which are home to a wealth of rare plant genetic resources. In depth

characterization, evaluation and documentation as well as establishment of core collections for major crops is considered by Ethiopia as a prerequisite for setting up the improved *ex-situ* management system. Furthermore, evaluation of existing collections for biotic and abiotic stresses and quality should be intensified in collaboration with the national crop research programme. In order to ensure safety of the existing *ex-situ* collections, due attention should also be given to the establishment of duplicate genebank in a separate and safe location. In this regard, IBC is making an effort to secure budget for the construction of duplicate genebank. Collection gaps should also be assessed and potential sites identified using GIS and further collections made accordingly.

Conservation of germplasm is a very expensive task especially for developing countries like Ethiopia. Hence, the international community should come forward and share the costs and provide all possible assistance for the up keep of the *ex-situ* management system, which houses rare plant genetic resources that are not only the property of the country but also the global community at large. With this regard the effort of global thrust fund should be strengthened. For crops that are having recalcitrant or intermediate seed, establishment of botanical gardens and additional field genebanks should be considered as a matter of priority.

CHAPTER 4

The state of use

Plant Genetic Resources of immediate use in Ethiopia include diverse cultivated food and forge crops and their wild relatives, semi-wild and wild species, spices and medicinal plants are widely used plant genetic resources in the country. Genes from such sources have helped to adapt crops to the various Agro-ecology of the country. Moreover, plant genetic resources are sources of genes/genetic material for disease and insect pest and salinity tolerance etc.

4.1 UTILIZATION AND CONSTRAINTS FOR USE

Indigenous germplasm is the basic source of genetic materials for national crop improvement programmes. The national germplasm collections at IBC gene bank comprise of 60,000 accessions of over 200 plant species from which about 78000 seed sample are distributed to users. Some of the major crops intensively used by the national crop improvement programmes and other users are indicated in Table 1. The whole genetic resources used for national coffee improvement programme is from the national coffee germplasm collections. About 80 percent of the demand for medicine is covered by using traditionally developed medicinal plants. However, there is still a multitude of under utilized plant species within the Ethiopian plant genetic pool. There are encouraging developments in the country to promote wide scale use and commercialisation of some of these species.

Table 1 Gene bank's crop germplasm distribution for national research and crop improvement programme over the last three years

Crop type	Total Holding	Distributed Material
Barley	15000	17000
Wheat	13000	7500
Sorghum	9000	8000
Maize	1000	1000
Tef	5000	5000
Oil crops	7000	16000
Pulses	4000	16000
Others (medicinal, forestry and forage)	3000	7000
Total	**57000**	**77500**

Plant breeders and explorers from different countries of the world have long recognised the importance of Ethiopian crop diversity to world agriculture. Since the first exploration of H.V. Harlan, in 1923, dozens of international expeditions have

been made to Ethiopia to collect barley and many other crops. Vavilov's collections of Ethiopian Wheat in 1927 have been extensively used by breeders in many East and West European countries as well as in North America. A large number of samples of various species representing a wide range of diversity, have also been collected and extensively utilised by international programmes such as the International Centre for Agricultural Research in the Dry Areas (ICARDA), the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) and etc. Ethiopian germplasm has therefore, actively been utilised in breeding works of various nature world wide, at times a good deal more than Ethiopia is given credit.

Over 1,800 accessions of Ethiopian wheat were introduced to CIMMYT from gene banks in the USA, Germany and Italy. ICARDA holds over 2,500 systematically collected accessions of Ethiopian barley, mostly 6-rowed and deficient types, which have a high value in early heading and maturity as well as high protein content. It also holds, among others, over 900 accessions of Ethiopian chick pea and over 375 accessions of lentil used in its breeding programme. More than 300 accessions of minor millet and 4,500 sorghum accessions of Ethiopian material are held by ICRISAT, of which the sorghum line E 35-1 has been selected from a zera-zera landrace sorghum of Ethiopia which is introduced for direct cultivation and breeding programmes to various countries.

Through International Research Centres, that hold Ethiopia's germplasm material, many national programmes of the developing countries including various seed companies of these countries have secured full access to Ethiopia's germplasm materials. In this process of using and distributing Ethiopia's genetic material, though it is a donor of the germplasm, it is hardly that Ethiopia comes into the picture at all. In general, genes from varieties of Ethiopian farmers have widely been used in many countries to sustain crop production, while insignificant or not any of the benefit derived from the use of these germplasm materials is accrued to Ethiopia.

Characterization is very essential for effective utilization of conserved germplasm. In this regard, currently 34648 accessions of cereals, 8037 accessions of oil crops, 5355 accessions of pulses, 424 accessions of coffee and 360 accessions of fenugreek have been characterized for morpho-agronomic traits. Furthermore, large number of germplasm accessions have also been characterized using bio-chemical and molecular markers largely by graduate students. The so generated characterisation data is often handled by Microsoft excel, Microsoft access, NISM-GPA and IBCR Database Management System.

Characterization and evaluation of conserved germplasm as well as expanding number of core collection are important areas of work to facilitate the utilization of genetic materials in Ethiopia. The major obstacles to establish the core collections are limited capacity and shortage of characterization data at various levels, morpho-agronomic data, bio-chemical and molecular data. Therefore, more work has to be done on characterization and evaluation of germplasm conserved in the gene banks to

meet some of the challenges in areas of food production in the country. More specifically, well equipped molecular laboratories and skilled manpower for genomic analysis of ex-situ conserved germplasm is highly needed. Morphological and molecular data on the germplasm should support in-depth evaluation of the genetic materials for utilization.

The data have to be properly documented and made available for the research community. National and regional institutions should also collaborate in the characterization and evaluation of Ethiopia's germplasm mainly through information exchange, training, collaborative research and genetic material exchange. International financial institutions should greatly contribute in capacity building effort for this work to be effective in Ethiopia. Data on characterization and evaluation handled by different organizations as well as data on uses of germplasm should be shared among the stakeholders. With this respect, the initiative by the NISM-GPA of sharing information on PGRFA at global level should be strengthened.

Ethiopia has a fairly well organized agro-ecology based plant breeding programme addressing major cereals, pulses, oil seeds, horticultural crops, coffee and fibre crops, and fortunately the number of crop researchers including breeders is increasing. Genetic enhancement and pre-breeding works have been done on limited crop species such as tef for lodging resistance and wheat for rust resistance.

As a result of national plant breeding a large number of improved crop varieties have been released. However, their commercial scale production is constrained to a greater extent by the limited capacity of the national seed system. To overcome the long lived seed production and distribution problem, a National Seed Policy is formulated to strengthen the role of public seed enterprises and private seed growers including farmers. To solve the problems of shortages of seeds of different genetic level, mechanisms have been developed for the continuous multiplication of breeders and basic seeds, with a well maintained genetic purity, uniformity, and stability. Improvement and enhancement of elite landraces by farmers is also among the major areas with a strong national emphasis.

4.2 ASSESSEMENT OF NEEDS TO IMPROVE UTILIZATION

The ultimate goal of conservation is to make germplasm of plant genetic resources available for utilization so as to contribute to the livelihood of the Ethiopian People. With regard to the utilization of the conserved germplasm, Ethiopia has limited success. Rather, other countries have better benefited from various Ethiopian germplasm until today. In this regard, fair and equitable sharing of benefits arising from the use of Ethiopia's germplasm needs to be recognized among the international community as clearly stated in Article 15 and 19 of the Convention on Biological Diversity.

In order to achieve the objective of conservation, genetic enhancement and base broadening effort of economically important varieties of crops is useful. Identification and information sharing of those varieties has to be the first priority. Research on genetic diversity of crops and their evaluation should lead conservation effort to utilization. These activities are currently constrained due to: 1) lack of appropriate laboratories, 2) skilled personnel, 3) research sites (land) and 4) finance.

To facilitate the implementation of the aforementioned needs and activities there is a need for national and regional collaboration among institutions. With respect to this, the National Information Sharing Mechanism and future publicizing of the conserved germplasm is an opportunity to enhance the utilization of the country's plant genetic resources. International community should put this into its priority agenda in order to strengthen Ethiopia's capacity in conservation and sustainable utilization of plant genetic resources.

CHAPTER 5

THE STATE OF NATIONAL PROGRAMMES AND LEGISTLATION

5.1 NATIONAL PROGRAMMES

The IBC which was established by decree in 1976 is the national focal point for plant genetic resources conservation for food and agriculture. The overall objective of the Institute is to undertake conservation and promote the development and sustainable utilization of the country's biological resources. Ethiopia has set clear national policy directives on conservation of biological resources. In the past, conservation efforts focused on plant genetic resources and priority was given to field crops. Since 1998, the Institute was given a wider mandate of conservation and sustainable utilization of all forms of biological resources including plants, animals and microbial genetic resources. Ecosystem management is also recognized as one of the areas to be given top priority. As to the importance of biodiversity and our dependence on biological resources, biodiversity conservation efforts give emphasis to local and national needs and values. The Institute, thus, has power and duties related to the conservation and promoting the sustainable utilization of biodiversity. This includes maintaining and developing international relations with bilateral and multilateral bodies having the potential to providing technical assistance. The Institute, on the basis of national legislation, has the responsibility and duty to implement international conventions, agreements and obligations on biodiversity to which Ethiopia is a party.

To enhance the conservation and sustainable utilization of PGRFA, the institute launched a project entitled: a dynamic farmers' based approach to the conservation of Ethiopian plant genetic resources. This project was implemented from 1997 - 2002 in twelve districts representing six agro-ecological zones with full participation of the farming community.

The key to protecting the biological heritage of Ethiopia lies in the involvement of local people and in the support provided by competent institutions for the conservation and sustainable use of bio-diversity, the government of Ethiopia recognised the importance of these measures in the preparation of the Conservation Strategy of Ethiopia, and in becoming a signatory to in 1992, and ratifying the Convention on Biological Diversity (CBD) in 1994. Other treaties for which Ethiopia is a party include: Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture, International Treaty on Plant Genetic Resources for Food and Agriculture, National Information Sharing Mechanism on the Implementation of the Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture. The common feature of all the conventions and treaties is their emphasis to the need for

surveying, inventorying of PGRFA; supporting on-farm management of PGRFA; supporting planned and targeted collecting of PGRFA; expanding in situ and ex situ conservation activities; supporting seed production and distribution; building strong national programmes; promoting networks for PGRFA; constructing comprehensive information systems for PGRFA; expanding and improving education, and training and promoting public awareness of the value of PGRFA conservation and use.

As party to the East African Plant Genetic Resource Network, IBC is benefiting from enhanced networking and exchange of information among national programs in the region, capacity building including training of experts and provision of laboratory facilities and to some extent collections and conservation of under utilized plant species.

In addition to long term degree training opportunities, the following short term targeted training sessions have been organized with support of donors and regional networks. These trainings were: tailor-made training on informal seed multiplication scheme, genebank database management system, and the role of genebanks in combating desertification and promoting sustainable utilization of plant genetic resources. The trainings focused on supporting seed production and distribution, agro-ecological and eco-regional surveying, sustaining existing *ex-situ* collections, constructing comprehensive information systems for PGRFA, indigenous knowledge, supporting on-farm management and improvement of PGRFA, assisting farmers in disaster situations to restore agricultural systems, and promoting *in-situ* conservation of crop wild relatives and wild plants for food production.

5.2 NATIONAL LEGISTLATION

Ethiopia being the major centre of origin/diversity for many plant species has still a diverse wealth of plant genetic resources. This resource is vital to the economic, social and environmental development of the country. However, as is the case common to many parts of the world, the diversity in this resources is threatened because of mismanagement and environmental degradation that have caused selective and total loss of genetic diversity. The absence of clear policy guidelines on plant genetic resources for many years has contributed to the loss of valuable indigenous genetic resources, introduction of disease, pest, weeds and genetic material unfit to the local agro-ecological systems.

At present, it is recognised that conservation and development of genetic resources is unlikely to succeed without a national commitment through an appropriate government policy. To this effect, a National Policy for the Conservation and Development of Plant Genetic Resources is formulated based on the rational that the conservation of plant genetic resources is one of the bases for the overall socio-economic development and sound environmental management goals. The main objectives of the National Policy for Plant Genetic Resources Conservation and Development are to:

ensure that the Ethiopian plant genetic resources are conserved, developed, managed, and sustainably used; assert national sovereignty over genetic resources, and develop mechanisms that will ensure the effective control of movement and management of genetic resources; build scientific capacities in order to explore, collect, assess, study, systematize, introduce, improve, manage and sustainably use biological resources; develop capacities for the improvement, generation, development and sustainable use of biotechnology and its transfer; integrate programmes for PGR conservation and development into national and regional development strategies and plans; recognise, foster and augment the traditional methods and the knowledge of local communities relevant to the conservation, development and sustainable use of PGR; and encourage the participation and support of local communities in PGR conservation and development, and insure that farmers/communities share the benefits accrued as a result of using indigenous germplasm; create a functional and efficient organizational structure and inter-institutional linkage to facilitate cooperative action and coordination in PGR conservation and development; promote international and regional cooperation in PGR conservation and development.

National Environment Protection, Seed and Quarantine Lows are already in place. The policy and strategy for plant genetic resources conservation and use are there. Rules and regulations for the flow of genetic resources into and out of the country are developed pending ratification. Within its environmental law Ethiopia has legislations for biological resources conservation which deal with the definition of commitments of the Federal Government and Regional States, with the rights and obligation of communities and citizens, with ownership and use rights, and with monitoring, development and sustainable use of plant genetic resources.

In line with national seed legislation, the crop genetic resources legislation will define legal provisions for germplasm ownership and control, accessibility, exploration, collection, conservation, distribution, introduction, regeneration, testing, exchange, utilization, and rights of Ethiopia's farming communities and plant breeders. The existing legal instruments regarding plants of traditional medicine will be adjusted to sustain the conservation, development and use of medicinal plants and to define obligation and intellectual property rights of local traditional medicine practitioners. The legislation on flora and vegetation will address ownership and control, accessibility, exploration, landscape and ecosystem conservation; and ecological restoration of degraded landscapes, ecosystems, biological communities and species. Legal environ-ment for the sustainable management of protected areas; participation, re-sponsibilities,

rights and obligations of the communities and individuals; ac-cessibility, introduction and exchange, monitoring, ownership and use rights of the communities and individuals will be defined. Legal instruments dealing with the conservation, importation, translocation, development and use of microbial genetic resources, and products of biotechnology and biosafety me-chanisms to minimize public and environmental risks will be set.

5.3 ASSESSMENT OF MAJOR NEEDS

Conservation of plant genetic resources for food and agriculture and its sustainable utilization is not an activity to be accomplished by a single institute or country. Rather, there is a need for collaboration and cooperation among institutions within and outside Ethiopia. Ethiopian institutional networks within the country and collaborative linkage with international institutions on conservation and sustainable utilization of PGRFA are weak. As a result, the country's enormous diversity of plant genetic resources has not been properly utilized to improve the livelihood of its people. To use these potentials, there should be a project designed to promote national and international network. Support from international institutions in the area of human resource development and training on information technology is very crucial to improve the country's capacity for efficient networking.

There is no comprehensive and standardized information system on Ethiopia's PGRFA. There is also lack of hardware and software resources and trained personnel. This has constrained the research activity for the efficient management of PGRFA in the country. For this to be solved there is a need to develop comprehensive and standardized database and information system that could be easily accessible to all users. Moreover, strong national information sharing mechanism supported by modern technology such as database driven websites, Geographic Information Systems and trained manpower in the area is highly needed. Technical and financial support from regional and international community is very important.

There is an urgent need for creating a critical mass of high caliber professionals in plant genetic resource conservation, management and utilization. Further more, short term consolidated training opportunities are needed in some of the priority areas including: surveying and inventorying plant genetic resources for food and agriculture, supporting on-farm management and improvement of plant genetic resources for food and agriculture, assisting farmers in disaster situation to restore agricultural system, targeted collection of plant genetic resources for food and agriculture, characterization and evaluation of plant genetic resources for food and agriculture, genetic enhancement and base broadening, molecular biology with special emphasis to alternative *ex-situ* conservation methods (In-vitro, DNA and Cryo-preservation), ICT, seed physiology and seed technology, and national and international policies, laws, regulations, and rights on biodiversity.

One of the major problems facing today's conservation effort is lack of awareness among the public. Although there is an experience for the conservation of PGRFA in Ethiopia, still there is no adequate awareness among policy makers, government officials, development workers and the public at large. A comprehensive curriculum should be developed and integrated into the formal education system of the country in order to train people at different levels on effective use and management of genetic resources. Finally, the government should give due consideration to further strengthen intuitions involved in conservation and promotion of PGRFA in terms of capacity building.

CHAPTER 6

STATE OF NATIONAL, REGIONAL AND INTERNATIONAL COLLABORATION

The Ethiopian plant genetic resources related activities have various global and regional links to different institutions. The federal and regional research institutes and the universities have various collaborative research activities in the areas of crop improvement. To develop a full-fledged national plant genetic resource conservation system and ensure improved access and sustainable use of the resource for the benefit of mankind, participation and contribution of global, regional and national organizations is of paramount importance. Here below an outline is given of the current status of collaboration in the conservation effort of PGRFA at national and international levels.

6.1 COLLABORATION AT NATIONAL LEVEL

There are many stakeholders that have interest on PGRFA of Ethiopia, and for conservation, management and utilization efforts of the resource to be successful effective collaboration of all sectors of the society is essential. The federal and regional governments are some of the most important stakeholders with overall responsibility for providing an adequate policy and legal framework, enforcing regulations, building capacity and providing incentives and funds for the conservation of plant genetic resources. The policies and programs of key federal ministries (Ministry of Agriculture and Rural development, Finance and Economic Development, the Ethiopian Science and Technology Agency) and regional bureaus are crucial to the conservation and sustainable use of PGRFA. IBC is the lead agency for the coordination and implementation of National Biodiversity Strategy and Action Plan (NBSAP) in collaboration with Environmental Protection Authority (EPA). Implementation of the NBSAP is carried out at both the federal and regional levels by establishing linkages with the planning process.

Research and higher learning institutions are responsible for documenting elements of PGRFA in Ethiopia and monitoring the health of ecosystems. Training institutions play an important role in building professional capacity in the fields of conservation and sustainable use. As direct users and potential managers of biological diversity, local communities have one of the most important stakeholders' role in the resource conservation and use. Non-governmental organizations (NGOs) can help bridge the existing gap between government and local communities to enhance conservation efforts. NGOs can be particularly valuable in providing technical tools and building capacity and awareness for the environment both locally and with government. An initiative is in place to strengthen the collaboration and coordination effort at national level, to bring together key actors and agree on a mechanism that would enable them to know their relative tasks and act synergistically to protect and enhance the plant genetic resources of the country.

6.2 COLLABORATION AT REGIONAL AND INTERNATIONAL LEVEL

Over the years, national institutions involved in the conservation, management and utilization of plant genetic resources in Ethiopia have been working in close collaboration with the CBD, FAO, GTZ, CGIAR, regional and global networks for the shared goal of protection and sustainable utilization of the PGRFA. ILRI, Bioversity, ICARDA, EAPGREN, CYMMIT and ICRISAT are among the collaborators in this noble mission. The IBC has a cooperative link with Bioversity, specially, in the development of conservation techniques, data management and training. Through this collaborative link Bioversity had financially supported long and short-term trainings. ICARDA and ICRISAT have also been supporting some short-term training programmes. There is also a strong collaboration with certain international and regional NGOs directly or indirectly involved in the plant genetic resources activities.

Most of the research programmes have germplasm collection as a major component and have been using Ethiopian germplasm materials, where in some cases duplicates of these materials have been deposited outside Ethiopia through various programmes and activities. Certain collaborative research programmes are some times not based on a long-term programme and rarely leave developed local capacity and facilities behind for the continuation of the initiated activities and programmes. The existing experience shows that national programmes hardly benefit from such collaborative research activities and this remains one of the gaps to be corrected in the implementation of joint research programmes.

Through regional intergovernmental initiatives such as African Ministerial Conference on Environment (AMCEN), Ethiopia plays an important role in the regional biodiversity activities and serves as coordinating unit of African Biodiversity Network and the Community Biodiversity Development and Conservation (CBDC) programme for Africa. CBDC is a global programme for Africa, Latin America and Asia where various government institutions and non-governmental organizations are working together at global, regional and national level.

Ethiopia is making efforts to fulfil its commitments of International agreements such as Agenda 21 and the Convention on Biological Diversity. At the moment, policies are formulated to meet the commitments and institutional structures are organised to effect policies and strategies. It is also a firm position of Ethiopia that all Nations prepare themselves to fulfil the International Agreements they are adhered to. Developed Nations and the International Communities are expected to support the developing Nations in materialising different Global commitments. However, support coming through international fund should be based on country driven programmes and priorities rather than being top-down, donor commanded programmes, as some of the past experiences teach us.

6.3 ASSESSMENT OF NEEDS TO IMPROVE NATIONAL AND INTERNATIONAL COLLABORATION

Ethiopia's interest in the creation of an efficient global mechanisms for properly addressing issues of genetic resources such as use, ownership rights, and fair and equitable sharing of benefits deriving from plant genetic resources. These issues are well addressed by the Convention on Biological Diversity, but it is important that concerned international agencies support the developing nations in the process of implementing the Convention. Concerned parties could start playing active role in the realization of matters of great concern for developing countries such as Farmers Rights and the ex- situ collections excluded from the Convention.

International agencies are expected to strongly support and facilitate the protection of the neglected interest of the farming and indigenous communities of the developing nations. Like all other developing nations that have signed the Convention on Biological Diversity, Ethiopia expects that international agencies develop strong mechanisms and take the responsibility of protecting the gene donors' rights. Obviously, it is the right of having access to their germplasm materials held under the CGIAR systems and by National Governments of others, including their right of sharing benefits of any form deriving from the use of these materials.

At national level, National Biodiversity Taskforce (NBT) could be established to coordinate and follow up the NBSAP implementation process in the country. This body should at least include IBC, EIAR, EPA, MOARD, Ethiopian Wildlife Development and Protection Department, Ministry of Water Resource, Ethiopian Science and Technology Agency, The National Herbarium and other relevant NGOs and higher learning institution's representatives. All other environmental units, which are established in the federal ministries, will have to work closely with the NBT. The NBT will have regular meetings and produce reports to be submitted to environmental protection council. The NBT will organise annual national meetings to discuss all the progress made and challenges faced by NBSAP implementation process.

At the regional level, similar body will have to be established to coordinate biodiversity conservation efforts in the different parts of the country. Its mandates and roles will be the reflection of the NBT at regional level. A system should be established to link up the regional and national bodies and harmonize their operations. Awareness creation and capacity building efforts must be strengthened in order to carry out the monitoring and evaluation (M & E) at all levels; especially local communities should get the necessary support in order to be involved in the whole process. Substantial budget is required to carry out the M & E process. Technical guidelines and monitoring methodologies must be formulated to assess the performance of NBSAP at national, regional and local levels.

CHAPTER 7

THE STATE OF ACCESS TO PLANT GENETIC RESOURCES AND BENEFIT SHARING

Plant genetic resources of immediate use in Ethiopia include diverse cultivated crops, their wild relatives and wild and semi-wild species. Root crops, spices, forage crops are widely utilized part of the country's plant genetic resources. Furthermore, indigenous germplasm is the basic source of genetic materials for national and international crop improvement programmes. Some of the major crops intensively used in the crop improvement programmes include the following: wheat, barley, sorghum, millet, tef, faba bean, peas, chick pea, lentils, grass pea, noug, flax, sesame, rape seed and castor bean.

The Ethiopian plant genetic resources activities have various global and regional links to different institutions. Research institutions and the universities have various collaborative research activities in the areas of crop improvement. CGIAR Centres such as ICARDA, CYMMIT and ICRISAT are among the collaborators. To facilitate increased access and sustainable utilization of the Ethiopian plant genetic resources all parties work in collaboration according to set out national rules and regulations and global treaties and conventions.

7.1 STATE OF ACCESS AND BENEFIT SHARING OF PLANT GENETIC RESOURCES

In many cases, source of germplasm for breeding programmes is mainly indigenous germplasm and one of the responsibilities of gene banks is to make germplasm available and accessible for national breeding programs. To promote the broad utilization of plant genetic resources both within the country as well as at international levels, the national genebank of Ethiopia on average dispatches about 4000 seed samples of crops with relatively wider genetic diversity annually. International research centres such as ICARDA and ICRISAT and national programes from Africa and else where are among the potential users of Ethiopian crop germplasm. For international centres and national programmes of other countries, germplasm is distributed upon formal request and negotiation based on local regulations and international treaties. To get access to germplasm, requesting parties from within the country should submit formal letter of application as well as a short proposal on intended use according to the proclamation (no. 482/2006) which was ratified in 2006.

Proclamation no. 482/2006 which stipulates about access to genetic resources and community knowledge, and community rights constitutes seven parts. It is designed to regulate access to genetic resources and associated community knowledge, innovations, practices and technologies, and to protect the rights of local communities. In the second part of the proclamation, protection of community rights which includes rights of the community, rights to regulate access, use right and rights to share benefits are clearly stated. Subsequent parts of the proclamation state about: access to genetic resources in which requirement of permit, basic pre-condition to access and conditions for denial of access; special access permit which grants specific access permit to Ethiopian national public research and higher learning institutions; and required follow up and compliance mechanisms for execution of access agreements. Based on the provisions of the above proclamation, the IBC is expected to work closely with the communities at different levels to facilitate access to plant genetic resources and related indigenous knowledge, and workout the benefit sharing arrangements thereof.

The CBD is the first international convention, which acknowledges state's sovereign rights over the genetic resources within its jurisdiction and the resulting authority to regulate and control access to these resources (article 15). However, the degree and extent to which the state could exercise this right has to be determined by national law. Parties to the convention are also required to promote the fair and equitable sharing of benefits arising from the use of genetic resources (article 15 and 19).

Unlike other countries in the region, as a repository of a wealth of plant genetic resources, conservation activities are very extensive in Ethiopia. To effectively execute the broad conservation and management programes and facilitate improved access of the international community to the rich genetic resource in the country, availability of adequate financial resources is indispensable. According to Article 20 of the CBD each party is required to provide financial support, in accordance with its capabilities, for the national activities which are undertaken to implement the convention. Article 20 also commits the developed nations to provide financial resources to assist developing countries like Ethiopia with their biodiversity conservation and management programes. Ethiopia is beneficiary of such arrangements for financial support which are often channelled through the GEF. Further more, the successful implementation of Ethiopia's Biodiversity Strategy and Action Plan requires a significant financial investment, which is largely expected to be covered by the Ethiopian government. Upon the successful execution of the NBSAP, the conservation activities of the plant genetic resources is bound to strengthened creating an environment for increased collaboration and networking and access and exchange of germplasm within and outside the country.

7.2 IMPLEMENTATION OF FARMERS RIGTHS

Ethiopia has been supporting the role of international agencies' undertakings and has also been playing an important role in their activities. Ethiopia's interest is the creation of an efficient global mechanism for properly addressing issues of genetic resources such as use, ownership rights, and fair and equitable sharing of benefits deriving from plant genetic resources. These issues are also well addressed by the Convention on Biological Diversity, and the role of international agencies in supporting the developing nations in the process of implementing the Convention is significant. International agencies may start their active role in the realization of the Resolution 3 of the Nairobi Final Act, where among other things, Farmers Rights and the ex situ collections excluded from the Convention are matters of a great concern for the developing nations. It will also be appropriate for international agencies to strengthen their system and capacity to create functional complementarity, enforce the International Code of Conduct for Plant Germplasm collecting and transfer and the Convention on Biological Diversity. In this process, international agencies are expected to strongly support and facilitate the protection of the neglected interest of the farming and indigenous communities of the developing nations.

Like all other developing nations that have signed the Convention on Biological Diversity, Ethiopia expects that international agencies develop strong mechanisms and muster the courage of taking the responsibility of protecting the gene donors' rights. Obviously, it is the right of having access to their germplasm materials held under the CGIAR systems and by National Governments of others, including their right of sharing benefits of any form deriving from the use of these materials.

At national level, a proclamation has been ratified very recently concerning access, farmers' rights and benefit sharing. The proclamation (Proclamation no. 482/2006) is under consideration to draft detailed regulations for its implementation. One of the important components of the proclamation is farmer rights on benefits sharing arising from use of plant genetic resources.

7.3 NEEDS REGARDING ACCESS AND BENEFIT SHARING OF PLANT GENETIC REOURCES

Ethiopia is data deficient in many respects. Information about the biodiversity of Ethiopia is presently scattered among a wide range of institutions (national and global), and current capacity to collect, store, analyse, and disseminate information is limited. If Ethiopia is to fulfil its commitment under the international conventions a considerable assistance and collaboration is needed from both national and international communities.

Furthermore, mechanisms should be established and enforced to address the issues of rights and rewards for farming and other communities for their past, present and future contribution to the genetic resources conservation and development.

Serious follow up should be made jointly by all concerned to enforce the provisions of the proclamation (Proclamation no. 482/2006) on access to genetic resources, community knowledge, and community rights.

Agreement is in place for rapid acquisition of PGRFA from international, national and regional sources following disasters. Major benefits are also gained by countries through PGRFA networks through the Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture. How ever, there is much to be desired as regards to exchange of germplasm and information between national programs. Forums will have to be created to bring together concerned parties to workout a more efficient system that could facilitate enhanced collaboration and exchange of plant genetic resource.

Access to information on plant genetic resources are un-equally and poorly distributed around the globe. In particular, there is an information gap between developed and developing countries which must be bridged. A provision on exchanging of information in plant genetic resource conservation has now become a standard addition to international environmental and conservation agreements. Article 17 of CBD urges parties to take into account the special needs of developing countries and include repatriation of information, where feasible. Much original and unique information about species and ecosystems in developing countries is held by museum and other research institutions in developed countries, yet this information is often very difficult to access by the country where those plant specimens were collected. The current trend has to change, because the convention encourages the holders of such information, largely in the developed countries, to take measures to ensure that the information held is shared with the countries where it originated.

CHAPTER 8

THE CONTRIBUTION OF PGRFA MANAGEMENT TO FOOD SECURITY AND SUSTAINABLE DEVELOPEMENT

Ethiopia is a country of more than 1.1 million km^2, with an estimated population of 75 million. According to CSA (2005) and FAO (2006) data, close to 32 million ha of the area is agricultural land but an average of about 12 million ha of this potential agricultural area is cultivated annually. Agriculture is the most important enterprise, providing employment for more than 85% of the country's population and accounting for more than 40 percent of the total GDP and 90 percent of the export earnings. This country possesses wide ranges of agro-ecological diversity and is endowed with wealth of plat genetic resources.

As outlined by the FAO in the Global Plan of Action for the conservation and sustainable utilization of plant genetic resources, a more efficient use of plant genetic diversity is a prerequisite to meeting the challenge of development, food security and poverty alleviation. Poverty reduction is the focal point of economic and social development objectives of the country.

The genetic improvement of PGR, followed by successful cultivation and marketing or consumption of the improved materials, is probably one of the most sustainable ways to 'conserve' valuable resource for the future. The inclusion of accessions in plant breeding programmes and the subsequent development of released cultivars are the most generally recognized use of genetic resources. Over the years, conserved accessions of the major crop species have been widely utilized by plant breeders, farmers and other users. Many underutilized species were also used as unique source of genes for stress tolerance in crop improvement programe for marginal areas. In addition to the use of conserved accessions for crop improvement task, there has been an increasing interest in the direct use of crop genetic resources as part of the response that might be made to drought disasters and other events that result in severe loss of plant materials by communities or countries.

Information on the scale of use of conserved material for crop improvement and other uses are not readily available in Ethiopia, due to poor feedback system and linkages between research and development partners in the country. However, using exploratory surveys, the IBC has gathered some preliminary information on the extent of use of conserved germplasm for food security.

8.1 CONTRIBUTION AND IMPORTANCE OF PGR FOR FOOD SECURITY AND SUSTAINABLE DEVELOEMENT

Ensuring food security and economic development in agrarian countries like Ethiopia presupposes wide use of adapted, indigenous plant genetic resources. As repository of wide range of plant species of high economic significance, Ethiopia is better placed to make use of such resource to overcome the incessant food shortage problems, increase agricultural production and improve the overall household income of the farming community. As primary genetic pool center, there exists tremendous diversity in Ethiopia particularly on coffee, tef, durum wheat, sorghum, field pea, chickpea,

noug, enset etc. This resource has been put to use to benefit the farming communities within the country and beyond. The state of use of conserved germplasm of major indigenous crop species and their relative contribution to food security, agricultural sustainability and economic development in general is briefly described below.

8.1.1 Cereals

Cereal crops play a major role in Ethiopian agriculture. The recent data from CSA indicate from the total hectarage of 9.8 million, 7.6 million hectare is covered by cereals, accounting for 77% of the total cultivated area and 84% of total production. The major, indigenous cereal crops grown in Ethiopia are tef, durum wheat, barley and sorghum.

Tef is the most important staple food crop covering over two million ha and accounting for over 20% of the land allotted for cereal production in the country. The versatility of the crop, the relatively high market price for its grain and straw make tef one of the very few cereal crops which play very important role in the lively hood of Ethiopian farmers. Apart from its importance locally, official figures in 1997/98 and 1998/99 indicated that 9 million and 14.6 million birr, respectively, were obtained from the export of tef. The trend indicates that there is a good export market for this crop in the Middle East, North America and Europe, mainly for the immigrant Ethiopians. The IBC currently signed an agreement with a Netherlands food company interested in commercialization of tef products. As tef is an indigenous cereal to Ethiopia, most of the available genetic variation has been generated naturally and through crop improvement research, and exist in germplasm collections of new and old varieties, landraces, breeding lines and related wild species.

Durum wheat is a major industrial and food crop and it is grown on over 500000 ha of land. Until 2001, about .....improved varieties of durum wheat of Ethiopian origin have been developed and released. Farmers involved in the production of durum wheat varieties have managed to increase their income substantially in recent years. At present, the demand for durum wheat is showing a growing trend. The local pasta manufacturing industries which import thousands of tones of durum wheat from abroad, worth tens of millions of dollars in foreign exchange are also showing increased interest on locally available varieties. The ever increasing demand for durum wheat both in the global and domestic market, combined with availability of varieties developed from local germplasm meeting the required quality offer an excellent opportunity for commercialization of the crop, contributing to a large extent in reducing foreign currency expenditures required to import the material.

Sorghum is a traditional food crop widely grown in the country, in 13 of the 18 major agro-ecological zones, covering over 1.3 million hectares. The crop is mainly grown in the lowland arid and semiarid areas. It is predominantly used for food, 80% of it for injera (flat pancake like traditional bread) making. The crop is second only to tef for injera making. Sorghum is one of the traditional crops fairly well utilized by the crop improvement programmes in the country. Hence, over 10000 accessions have so far been evaluated for highland and intermediate elevation, where the indigenous landraces are widely cultivated. Developing varieties for lowland areas mainly depends on introduction and evaluation of materials from exotic sources due to low diversity associated with recurrent drought and stalk borer. However, for the

highlands where there is immense diversity, the emphasis has been on the evaluation of indigenous sources. So far, the national and regional research institutions in Ethiopia have released about 33 varieties for commercial production. Six of the nineteen varieties on the current recommendation list were developed from local sources.

Barley is one of the first domesticated cereals in Ethiopia. The cultivated area devoted to barley is over 1 million hectares. The country is endowed with diverse barley germplasm. The barley landraces existing in the country are of varied morphology (two and four rowed) and colour (black, white and pink). Barley research dates back to 1960s. Ethiopian barley landraces have been widely used as sources of resistance to BYDV, powdery mildew and other foliar diseases. Furthermore, landraces with high lysine content have been discovered and used in the development of varieties with improved protein content. In the early 1970s, when exotic cultivars appeared to show narrow adaptation and susceptibility to disease and pests, research was directed toward evaluation and selection of local landraces. In total over 8000 accessions were evaluated. Out of all accessions 547 were selected based on high tillering capacity, medium height, erect leaves, resistance to foliar diseases, good vegetative vigour and plump grains. These selections were intensively used by the national crop improvement programme and the international community to develop improved varieties. Currently there are about 50 released varieties sizable number of which are of local origin.

8.1.2 Pulses

Ethiopia is one of the major centres of diversity for several grain legume crops: field pea, grass pea and wild ancestors of cowpea. In Ethiopia, pulses are major crops next to cereals and are cheap source of proteins and play an increasingly important role in export market. The total allotted area for the production of pulses is nearly 1.4 million ha, accounting for 13% of the total cultivated area and 11% of the total grain production. The major, indigenous pulse crops grown in Ethiopia are field pea, chick pea, lentil and grass pea.

For the last few decades, the IBC has distributed a total of over 11000 locally collected accessions of grain legumes to research Institutions, Universities, and development organizations; constituting about 21 percent share of the total germplasm of field crops distributed. Although it is difficult to describe the current status because of the poor feedback system of the country, some information received does indicate that the supplied germplasm has been successfully utilized in the legume crop improvement endeavours.

Field pea is the second most important legume crop in Ethiopia after faba bean in terms of both area and total amount production. According to CSA, field pea covers over 254000 ha with a total production of 230000 tons which accounts for 17% of the total grain legume production. The origin of field pea is controversial however Ethiopia is undoubtedly the centre of diversity for this crop, and wild and primitive forms are known to exist in the high elevations of the country. Out of the hundreds of landrace accessions since improvement programme, a number of varieties have been selected and released for their superiority in grain yield and other agronomic traits.

The landrace accessions were reservoir of genetic variability and were sources of valuable genes especially for adaptation.
Ethiopia is considered as centre of diversity for chickpea. Chick pea covers over 160000 ha with a total production of 160000 tons which accounts for 12% of the total grain legume production. The crop is widely used in different forms. There are two types of chickpeas; dessi and kabuli. In Ethiopia, dessi type chickpea accounts for more than 90% and is grown across a wide range of ecologies. Improved varieties of chickpea, which were released for production were by enlarge selected from the Ethiopian chickpea collections.

Lentil is among the principal food legumes widely grown in diverse agro-ecological zones ranging from hot sub-moist low lands to cool humid mid highlands. Lentil covers over 76000 ha with a total production of over 54000 tons. The crop is cultivated mostly for domestic consumption. Several local accessions of lentils were identified as resistant to rust, tolerant to drought and early maturing; forming the bases for the development of a range of varieties currently under cultivation in the country.

Ethiopia is considered as one of the primary centres of diversity for grass pea. Grass pea covers over 110000 ha with a total production of over 125000 tons. The Ethiopian grass pea landraces have high level of the anti-nutritional factor called ODAP. Land race cultivars with high ODAP content are grown by the great majority of Ethiopian farmers. Studies on grass pea germplasm collected from Ethiopia exhibited great diversity for seed coat colour, primary branches/plant and ODAP content in the seed. Development of improved varieties in grass pea is very challenging because of the high ODAP content. Past breeding efforts resulted in the identification of promising varieties. However, the grass pea production in the small scale agriculture system of the country is still largely dominated by local landraces.

8.1.3 Oil crops

Ethiopia is one of the major centres of origin and diversity for several oil crops. Gomenzer (*Brassica carinata*), noug (*Guizotia abyssinica*), sesame (S*esamum indicum*) and linseed (*Lens culinaris*) are the major, indigenous oil crops having considerable diversity in the country. These crops are primarily used as sources of oil for local consumption and also contribute to the national economy through import substitution by helping save scarce foreign currency spent for importing cooking oil. The total allotted area for the production of oil seeds is nearly 0.8 million ha, accounting for about 8% of the total cultivated area.

Noug is one of the widely cultivated indegenous oil seed crops particularly in the highlands of Ethiopia. Legend has it that the crop originated as selection from its wild relative (*Guzotia scabra*) which is also considered native to Ethiopia. Noug stands first in both total area and production among the Ethiopian oil seeds. It covers 358828 ha with a total production of over 187000 tons. The phenotypic diversity in noug is more obvious for characters related to flowering, maturity, head size and other morphological characters. Noug is famous for its high quality oil although productivity per unit area is still very low. The national oil seed improvement program has released five varieties that are currently under production.

Linseed is one of the major oil seed crops of the highlands of Ethiopia next to noug. Ethiopia is considered as centre of diversity for linseed. It covers 250702 ha with a total production of over 150000 tons. Linseed is known for its high quality oil and its use as row material for agro-industries. Linseed is grown for oil production has relatively high variability in flower colour, plant height, duration of flowering and maturity and capsule size and wilt resistance. Six improved varieties of linseed have so far been developed and released through selection from local germplasm collections.

Sesame is the third most important oil seed crop in Ethiopia showing substantial genetic diversity. The crop is largely produced for export. Sesame is grown in 136220 ha with an annual production of over 115000 tons. The high quality oil makes Ethiopian sesame varieties popular and competitive in international markets. The intensive improvement research conducted on the crop so far resulted in the development of 10 improved varieties for commercial production.
Gomenzer (Ethiopian mustard), is grown extensively in the highlands, has a considerable diversity for several vegetative traits. Gomenzer covers over 40000 ha with a total production of over 35000 tons. There are weedy forms of brassica growing through out the high lands of Ethiopia that are gathered to be eaten as leafy vegetables. Studies conducted on Ethiopian mustard land races for oil content and productivity reveal that the indigenous crop is more productive, resistant to diseases and more drought tolerant compared to their exotic counterparts. The oil seed improvement program has so far released seven varieties from local selections which are extensively grown around the country.

8.1.4 Stimulant crops

There are several important stimulant crops of Ethiopian origin. Among the ones with high commercial value are coffee and chat (*Catha edulis*). These two stimulant crops are primarily produced for local consumption and export market. Although exact statistics is hard to come by, coffee and chat are extensively produced on vast expanse of land in many parts of the country.

Coffee (*Coffea arabica*) is one of the major stimulant, which is consumed through the globe. It grows in many parts of the country; however, the bulk of the produce comes from western and southern part of the country, and a limited area in the east. This is a genetic resource that Ethiopia has given to the world community. The phenotypic diversity of arabica coffee in Ethiopia is overwhelming in both quantitative and qualitative characters. There is an extremely high variability in disease and pest resistance, liquoring quality and other traits. Fairly adequate research attention has been given to this important crop which is the number one foreign currency earner for the country. Over the years, research has released 32 varieties among which 26 are under production

Chat is one of the early domesticates in Ethiopia. Though there is no much information on its diversity, a striking variation can be observed in morphology and leaf colour in the major growing areas. It is consumed in Ethiopia as stimulant plant. It is exported to neighbouring countries such as Yemen and Djibouti for foreign exchange earning. The national research system has not given due attention to the

improvement of this important commercial crop. However, there are certain widely recognized farmers' varieties which can fetch relatively higher market price.

8.1.5 Other crops

Ethiopia is either a primary or secondary centre of origin for such spices like korerima (*Aframomum korerima*), long pepper (*Peper longum*), black cumin (*Nigella sativa*), white cumin (*Carum copticom*), coriander (*Coriandrum sativum*), and fenugreek (*Trigonella foenum-graecum*); and root and tuber crops such as enset (*Ensete ventricosum*) and anchote (*Coccinia abyssinica*). These indicated crops are very important in local diets, local and export market. Among the listed crops, enset is far more extensively produced and consumed in various forms. It is particularly known for its value as insurance crop during dry seasons when other annual crops fail. It is estimated that about 15 - 20% of the Ethiopian population in south and south-western Ethiopia depend on this crop. There is tremendous untapped potential for Ethiopia to exploit the rich and diverse plant genetic resources on spices and root and tuber crops. However, in spite of their potential for food security and export, very little research has so far been done to improve the productivity of these important category of crops.

The country is known to be endowed with a wide range of other crop species that can potentially be used for industrial and medicinal purposes. A wide array of wild plant species have been used as source of medicine for centuries. About 80% of the rural people in Ethiopia depend on traditional medicine, and more than 95% of traditional medicines are of plant origin. Efforts are being made to promote wider use of indigenous medicinal plants in pharmaceutical industries. Among the crop species generating renewed interest is Vernonia (*Vernonia galamensis*). Its seed contains about 42% oil of which ca. ¾ is vernolic acid. The oil characteristics make it suitable for industrial use in plastic formation and coating. Due to this and various other reasons, increasing number of investors is showing interest to start commercial production. Thirty different species have currently been identified for the intended purpose.

8.2 NEED ASSESSEMENT ON FUTURE USE OF PGR FOR FOOD SECURITY AND SUSTAINABLE DEVELOPEMENT.

Ethiopia is recognized as one of the few remaining genetic pool centres and home of a wide diversity of crop and wild plant species of great economic significance. However, past efforts made to exploit this untapped resource in an organized manner and help the country lift itself out of poverty was not satisfactory. Greater strives need to be made in the future to carefully assess and catalogue the extent of existing diversity (the number of species conserved so far is considered very low in view of the immense genetic diversity of the country) and establish a mechanism that could bring together all concerned for more focused and organized efforts for sustainable utilization of this national treasure for economic gains. It can be safely argued that as regards to PGR conservation and utilization for food security and sustainable development, the country is not operating as a system as yet.

Lack of awareness of the general public is a major weakness that is hampering protection, enhancement and sustainable utilization of PGR in Ethiopia. Agricultural research and development agencies should take it upon themselves to raise awareness

of the public and help it organize itself to contribute its share to the nation wide efforts for sustainable utilization of PGR. The general public particularly the rural community should be helped to broaden its view on the diverse uses and benefits that can be accrued from PGR beyond the very limited uses such as medicinal uses that it is aware of. Community approach to the conservation and sustainable utilization of PGR is indispensable. The public, the rural community in particular must be made aware that it is in its best long term interest to work jointly with agricultural research and development partners to identify and categorize PGR according to its uses and potential value.

There was limited use of the already conserved PGR for food security and sustainable development in the country. The main reasons for this were;

- ☞ poor networking and collaboration between research and development institutions leading to lack of concerted effort and weak synergy and complementarity. This partly emanates from the wrong perception that conservation and utilization of PGR is the business of one institution.
- ☞ lack of awareness on the range of conserved germplasm leading to demand centring on only limited range of species in the genebank.

In addition to the use of conserved accessions for crop improvement task, there is an increasing interest in the direct use of crop genetic resources as part of a response to mitigate drought disasters and other events that result in severe loss of plant materials. In many cases, governmental and non-governmental agencies respond to such events by providing materials that are not suitable for the affected areas, rather than soliciting locally adapted materials from genebanks. In the future such trends have to be rectified to help farming communities facing disasters to get proper assistance.