Diversity and conservation of enset (*Ensete ventricosum* Welw. Cheesman) and its relation to household food and livelihood security in South-western Ethiopia

Almaz Negash

STELLINGEN

belonging to the thesis

Diversity and Conservation of Enset (Ensete ventricosum Welw. Cheesman) and its Relation to Household Food and Livelihood Security in South-western Ethiopia

Almaz Negash, 26 September 2001

1. The conservation of crop genetic diversity entails the actual genetic diversity together with the existing traditional knowledge, which nurtured the crop (this thesis).

2. The issues constituting and surrounding the problems of food security may appear complex and intractable, but they are manageable, and soluble. We need only the will at the level of policy, a more assertive and a more committed role at the level of the professional and a more free and a more decisive participation at the level of the peasantry (Mesfin Wolde-Mariam, 1999).

3. Increased production and consumption of indigenous crops such as enset will increase food supplies and may also broaden the food base at both household and national level (this thesis).

4. Conservation becomes more sensible and effective when it is linked to the food security and livelihood systems of the local communities (this thesis).

5. The Ethiopian proverb "A home without a woman is like a barn without cattle" indicates an awareness about the important role of women both in the house and on the farm.

6. Hardly anywhere are target groups taken as equal partners on the basis of respect for their knowledge, technology, world views and capability (Atte, 1992).

7. The diversity contained in indigenous agriculture at crop, field and regional level offers greater yield stability than does the less diverse industrial agriculture (Cleveland, 1993).

8. The fate of all forms of life depends on the continuity of variation. At the entrance of the CERES, the Controlled Environment Research Laboratory in Canberra (Australia), there is the following inscription: "Cherish the earth, for man will live by it for ever". We might have said with equal justification: "Cherish variation, for without it life will perish" (Sir Otto Frankel, 1973).

9. "The son of the Nile thirsts for water", as the Ethiopian saying goes, means that although rich in biodiversity, the country still cannot adequately feed its own people.

10. The Ethiopian saying "Dine with a stranger, but save your love for your family" points to the importance of family as a social asset.

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Chapter 1 gives a review of issues of agricultural biodiversity and food security. The importance of agricultural biodiversity as a major natural resource to communities and farming systems are discussed. Major causes for the loss of crop genetic diversity and impact of seed supply systems on small-holder farmers are addressed. As conservation is the basis for utilization of genetic resources, both global and national approaches to conservation, and the major conservation strategies employed are also discussed.

Ethiopia is considered to be a country rich in biodiversity. However, agricultural productivity has not grown in pace with the population and the country is among the most food insecure in the world. In this chapter, issues of food security both at macro and micro level are reviewed and, more in particular, food security in relation to enset genetic diversity at the household level is given major consideration. Explanations of why the present study was initiated and the relevance it has both for research and policy are discussed. In addition, the general approach to the research problem and the objectives of the study are presented.

1.1 Significance of (agro) biodiversity

Agricultural biodiversity is an important part of overall biodiversity. It refers to the variety and variability of animals, plants, and microorganisms on earth that are important to food and agriculture. It is a result of the interactions between the environment and genetic resources as effected by human management systems and practices. In other words, agricultural biodiversity is a creation of humankind whose food and livelihood security depend on the sustained management of those diverse biological resources that are important for food and agriculture (FAO, 1999b).

The diversity in agricultural crops, animals, farming systems and cultural practices is also of fundamental importance to social and economic development. It contributes to the sustainable production of agro-ecological systems. Agriculture has been and still continues to be the most important sector of the economy in tropical Africa. Economic development, growth of GDP, the assurance of food security and the welfare of the majority of the African people are heavily dependent on agriculture. However, the increase in population, the lagging food production in many low-income countries of Africa, the consequent need for food imports, and the increases in international grain prices has resulted in food insecurity in most of the continent's sub-regions.

Many farmers in developing countries cannot afford expensive external inputs such as fertilizers, pesticides or commercial seeds adapted and improved for particular more favorable ecological and economic conditions. In many cases, improved seeds are not fit to the more diverse agro-ecosystems in tropical countries, in particular in more marginal environments. Therefore, existing adapted plant genetic diversity, both at intra- and inter specific levels, is of crucial importance to most farming systems. Varieties that farmers developed are usually adapted to poor conditions and with the use of these, farm households are able to secure sustainable yields. In highly variable environments, higher total household production may be obtained from employing a range of crop varieties, each of which is specifically adapted to the microenvironment in which it grows. Farmers often use intercropping employing a mixture of species with complimentary effects. Such diversity-based farming systems provide a range of products with various uses such as food, medicine and fuel.

Diversification of crops is also important from a nutritional perspective in order to balance people's daily diet. Root and tuber crops as well as enset for its pseudostem and corm, grown together with vegetables, provide carbohydrates, valuable minerals, vitamins and amino acids, making a substantial contribution to household food quality and security. Women farmers are particularly aware of the usefulness of plant genetic diversity, as they are the ones who bear the primary responsibility for the production of subsistence crops that are essential to household food security. They hold the knowledge of traditional varieties, their cultivation and maintenance as well as their utilization in the household.

In traditional farming systems, in Africa as well as other continents maintaining genetic variability within and between agricultural crops in local cropping systems is critically essential because:

1. It helps to provide stability to farming systems at the local, national and regional levels by leveling yield variability, through the cultivation of a wide range of crops and intra-crop diversity;
2. It compensates yield failure of a particular crop or variety by maintained yield of other crops or varieties;
3. It provides a general insurance against unpredictable changes in environmental conditions. As needs are constantly changing, today's genetic resources may later prove to provide yet unexploited useful characteristics such as resistance to new disease, or adaptability to changing climatic conditions;
4. It represents a "treasure chest" of potential resources for food security of which the future value is not yet known.

In Ethiopia, agriculture amounts to approximately one half of the gross domestic product (GDP), 90% of the foreign exchange earnings and 85% of the total employment (Ezra, 1997). The country's potential for agricultural growth is believed to be quite substantial and it is estimated that 70% of the total land area can be cultivated (Alemayehu, 1986). Among the three agricultural sectors existed in Ethiopia (individual small-holder producers, the state farms, and the settlement farms), the individual small-holder sector is predominant in terms of cultivated area and crop output. It accounts for about 94% of the cultivated area and to the majority of the crops grown in the country (Alemayehu, 1986).

Agriculture plays a major role in the Ethiopian economy and this is expected to remain so for some years to come. This situation makes over 80 percent of the population of the country dependent on agriculture for food and as a source of income. The agricultural sector is the basis for the entire socio-economic structure of the country and has a major influence on all other economic sectors and development processes. Therefore, the diversity contained in farmers' varieties and in wild crop relatives is a basis for agricultural and economic development of the population of Ethiopia. Native crops are highly adapted to the ecological heterogeneity that characterizes the agricultural landscape of the country. They offer risk-averting advantages to resource-poor farmers confined to marginal lands, and are adapted to low input conditions.

Vavilov (1951) indicated that some thirty-eight crop species (e.g. barley, wheat, sorghum, teff, noog, sesame, faba bean, grass pea, chick pea, Ethiopian mustard, coffee, enset, chat, oromo potato, etc.) are connected with Ethiopia as a primary or secondary gene center. The wide range of agro-ecological systems of the country together with the unchanged traditional farming system has contributed to the high concentration and conservation of diverse genetic resources.

1.2 Loss of crop genetic diversity

Extra fertilizers, improved machinery and better farming practices [...] accomplish nothing without genetically adapted varieties of crops to take advantage of them (Witt, 1985).

The broad range of genetic diversity existing in different parts of the world, mainly of landraces and wild genepools is presently subject to serious genetic erosion. This loss involves the interaction of several factors, and is now progressing at an alarming rate. The most crucial factors are discussed below.

Displacement of indigenous landraces by new, genetically uniform cultivars

Replacement of local varieties by improved, often foreign varieties is one among the major causes of loss of genetic variability in local landraces. The genetic base of the total of improved varieties is usually reduced or modified to meet specific production conditions. In a way, these varieties are modified forms of farmer's varieties or landraces. Genetic erosion takes place since the genes found in the diverse farmer's varieties/landraces are not contained wholly in the modified varieties. The overall effect is that the sheer number of varieties occurring in the field is often reduced when commercial varieties are introduced into the traditional farming systems. Several examples exist. Under the Green Revolution, the introduced high yielding varieties of wheat and rice have led to serious genetic erosion in India, Afghanistan, Turkey, Iraq and Pakistan (Frankel, 1973). It was reported that in Indonesia alone about 1500 local rice varieties disappeared in a period of 15 years and nearly three fourth of the rice planted were descending from a single genetically homogenous line. Likewise, in Korea, a survey of farm households has shown that of their 14 crops cultivated in home gardens, an average of only 26 percent of the landraces cultivated in 1985 were found to be present in 1993 (PGRFA, 1998).

In Ethiopia, farmer's varieties of barley and durum wheat have been suffering serious genetic erosion because of displacement by introduced varieties of bread wheat and others. In addition, local crops such as teff have gradually replaced these crops due to market demand. Mooney (1985), recorded that 13 percent of the total area sown to 13 major crops of local varieties was being planted to new crop varieties in the country. According to Feyissa (1999), displacement of farmer's varieties of durum wheat in Eastern Shoa in Ethiopia even reached about 90 percent. This area originally exhibited a high diversification of durum wheat until intensive and indiscriminate diffusion of improved varieties occurred about three decades ago. Similarly other areas, where green revolution crops and varieties were introduced in the eighties, lost a large portion of their diversity within a very short period of time. Eventually, most of the introduced varieties of those days after some time proved to be susceptible to diseases, leaving farmers without viable options for planting materials (Feyissa, 1999).

Effect of drought

Drought has been continually responsible for adverse growing conditions, often resulting in accelerated and selective elimination of genotypes among populations or even in total crop failures, which repeatedly resulted in the complete wipeout of genetic materials. The drought that prevailed in Ethiopia in the last decade has caused considerable genetic erosion, and some times resulted in massive destruction of both animals and plants. The persistent famine that occurred in some parts of the country has forced farmers to eat or sell their reserve seeds in order to survive. This subsequently resulted in massive displacement of native seeds by exotic seeds provided by relief agencies as food grain.

During the last famines years occurring in the country, the cultivators of the native crop enset, located at higher altitudes of the Southern and Southwestern regions, did not face the crises and these regions of Ethiopia were not declared famine areas.

Impact of breeding approaches and genetic vulnerability

In many developing countries, breeders usually promote uniform high yielding varieties, which are either introduced as such or used in yield improvement of local varieties. Although landraces are a source of resistance against pests and diseases, and better adapted to adverse conditions, they are relatively low yielders and require genetic improvement to enhance yield. However, the predominant use of exotic seed stocks as breeding materials in order to increase production eventually results in a significant replacement of the native germplasm and in loss of genetic diversity.

In several cases, yield losses caused by genetic vulnerability occurred when widely planted uniform crops became susceptible to pests, pathogens or environmental changes that negatively affected the field performance of the crop. A famous and well-documented example of the fragility of crop production due to genetic uniformity is formed by the potato famine of 1845 to 1848. In Ireland an epidemic of late blight of potato (*Phytophthera infestans*) wiped out the potato crop in that country but also elsewhere in Europe and North America. This led to the death of 1.5 million people in Ireland alone, a country fully dependent on potatoes as its staple diet (PGRFA, 1998). The potatoes grown in Europe at that time were genetically highly uniform, as they descended from only two to four maternal varieties introduced from South America. Since the 1980's further outbreaks of the disease, which were caused by other races of the late blight fungus, have hit Europe, Asia and Latin America. It was after these incidences that resistant traits to the disease were sought and found among the many varieties and wild relatives of the Andes and Mexico, which are the main centers of diversity of the crop as well as the pathogen (Fowler and Mooney, 1990).

Banana forms another example of crop diversity, which has been affected by the spread of genetically uniform varieties. For instance, the major five varieties of banana used for commercial production are derived from one original banana variety named Cavendish. All these varieties are susceptible to a fungal disease known as black Sigatoka, which currently can only be controlled by regular chemical applications. There is a high cost incurred in controlling the disease and small-holder farmers cannot afford access to equipment and the finances required for fungicide applications. Due to these developments, yield losses, as high as 47 percent, have been reported in countries such as Honduras and other Central American countries (PGRFA, 1998).

Crop insurance schemes and other forms of livelihood maintenance systems in some cases serve as a means to overcome the problems of crop failure and genetic vulnerability. Such schemes are a well-established means of protection against crop losses in many developed countries and, increasingly, in many developing countries (PGRFA, 1998). However, for many resource-poor farmers in developing countries who cannot afford to pay insurance premiums the only option to minimize risk is through the use of inter and intra-specific crop diversity.

Habitat destruction

The destruction of forests and bush lands is the most frequently cited cause of genetic erosion in Africa in general as reported by over 74 percent of the countries (PGRFA, 1998). It includes land clearance for agricultural crops, the collection of fuel wood and the burning of forests and bush to provide pastureland.

In Ethiopia forests, which are found at low, intermediate as well as high altitudes, contain the major diversity of the flora of the country. In particular, about 25 percent of the plant families, which form close relatives of cultivated crops, are distributed in the forest areas. This resource is sharply declining because of over-exploitation of the natural forests, woodlands and bush lands, at a rate higher than the natural regeneration (FAO, 1996).

The forest cover of Ethiopia, which once was 40 percent, has now declined to only 3 percent or less. Advances in agriculture and changes in land use have led to the loss of natural habitats as more and more land is devoted to cultivation at the expense of loss of the natural vegetation. Forest clearance and change in land use in the southwestern part of the country for example have resulted in the gradual loss of the wild gene pool of *Coffea arabica*. Such wild gene pools serve in maintaining close relatives of cultivated crops and in providing diverse traits that are highly valuable in modern breeding and crop improvement programs.

1.3 Seed supply systems and policies: impact on small-holder farmers

Seeds and planting materials are the most important input for crop-based agriculture. However, only a few developing countries have succeeded in the establishment of efficient seed production and distribution systems while in many, the public seed corporations which are mandated to multiply and distribute seeds of selected crops have failed to meet the diverse crop requirements of small-holder farmers (Jaffee and Srivastava, 1994).

In many African countries, the formal seed systems supply only a small amount of the seeds required by small-holder farmers and cover only a limited range of crops. For the majority of other crops, small-holder farmers use seeds, which are maintained by themselves on farm. However, little or no attention has been given to these informal seed systems. The drawbacks of the formal-sector seeds consist of the high purchasing costs for seeds and related other inputs, the unreliability of returns through higher yields and institutional inadequacies which limit production and supply of these formal sector seeds (Muliokella, 1999). The lack of consistent seed policies in many African countries has resulted in seed insecurity and widespread food self-insufficiency in general. Lack of attention in policymaking in regards to minor but potentially useful crops, which are essential for household food security, needs to be resolved through the involvement of both formal and informal seed producers and users.

The Ethiopian government introduced a national seed industry policy and strategy in 1993 to promote the development of the country's seed industry. The policy is aimed at improving the agricultural production base and supporting research, extension, infrastructure, irrigation schemes and the private sector (Dabi and Shaka, 1998). However, the efforts so far have not been able to meet the needs of the small-holder farmers for the following reasons:

- The approach is not sustainable under different agro-ecological or socio-economic conditions;
- Suitable and locally adapted varieties are not selected based on farmers needs and priorities;
- The use of a limited number of crop varieties reduces utility options and will eventually result in loss of traditionally managed land races;

- Fixed seed prices by the government, are much higher than the farm-gate price at which farmers sell their produce as local seeds;
- In most cases, the price of the formal seed is set far beyond the seed purchasing capacity of poor farmers; this is one of the reasons for low demand for seeds coming from the formal system;
- In cases where farmers are able to purchase formal seeds, either the supply is low or it is not timely supplied to farmers mainly due to poor transportation;
- There are no private seed firms, cooperatives or farmer's groups that are involved in and can play a complimentary role in the seed supply system.

It is essential that the government of Ethiopia reassess and broaden its seed supply strategy and encourages the different stakeholders to get involved in the seed supply system. New, efficient and cost effective strategies need to be designed and implemented in order to clearly identify and prioritize needs of small-holder farmers. Such an approach will definitely help to establish the link between crop genetic resources conservation and production and thereby enable people to tackle food security problems at the local community level.

This strategy should be applied to all farming systems in Ethiopia where similar approaches can be followed for conserving, enhancing, multiplying and distributing vegetatevely-propagating crops. Such an approach, which was initiated in Malawi for multiplication and distribution of sweat potato and cassava planting stocks took place through the involvement of farmers, government agencies, NGO's and donor agencies, was reported to be successful in improving food security and income for farming communities (Minde *et al.*, 1997).

Establishing formal and strengthening informal seed systems and supporting farmer-based seed multiplication and distribution through, for example, community based seed networking is regarded to be critically vital to ensure food security at the community level (Feyissa, 1999). Furthermore, it is essential to develop linkages between the seed systems, on-farm research and crop improvement as well as genetic resource conservation activities.

1.4 Approaches to the conservation of plant genetic resources: A global perspective

Understanding a conservation system means understanding not only the nature of what is being conserved, but also the view point of the conserver (Johannes, 1978).

Over the past years, erosion of crop genetic resources especially in developing countries has been a crucial problem that has attracted the attention of many nations. Recognition of the importance of genetic diversity, particularly of crops, has been the ground for more emphasis on *ex situ* approach in the 1970's followed by the recognition of the *in situ* approach in the early 1990's (FAO, 1999). Over the years, efforts were being made towards the development of preservation techniques for the maintenance of crop genetic resources in view of their essential role for food and agriculture and considering threats posed on them due to various factors.

Although conservation was not the major goal, in the early times, many national and international genebanks were established in Europe, North America and in Asia. The main purpose of establishing those genebanks was to maintain and make genetically wide-based materials available for breeding (Pistorius, 1997). After Vavilov's expeditions and collections of many plant species from the major world crop centers of origin and diversity in the 1920's, many crop collections were kept at Vavilov's institute in Russia. In the 1950's and 1960's the European Society for Research and Plant Breeding (EUCARPIA) and the United States Rockefeller Foundation also organized and set up a targeted collection network for some crop species (Pistorius, 1997).

Later in the 1960's, conservation rather than utilization of genetic resources became the key issue and the Food and Agricultural Organization (FAO) became the central player upon the initiative of several nations. Since then, the number and activities of International Agricultural Research Centers (IARCs) such as the International Rice Research Institute (IRRI, 1960), the Centro Internacional de Maiz y Trigo (CIMMYT, 1966), the Centro Internacional de Agricultura Tropical (CIAT, 1967) and the International Institute of Tropical Agriculture (IITA, 1967) have expanded. The IARC's were later incorporated in the Consultative Group for International Agricultural Research (CGIAR) network in 1971. In the early 1970's, the FAO panel of experts formulated guidelines for a global network for the establishment of an international system for the conservation of plant genetic resources (Pistorius, 1997). Establishment of the International Board for Plant Genetic Resources (IBPGR), with in the CGIAR in 1974 with a mandate to advance the conservation and utilization of plant genetic resources was a major development in the conservation and development of agricultural crops.

Additional national and regional genebanks have been established since then, particularly in the centers of origin and diversification of crops. The establishment of the Ethiopian Gene bank is one among others. Recently, development concern over the value of and the potential threat to crop genetic diversity among other issues of biological diversity, has been strongly emphasized in the Convention on Biological Diversity (CBD) (Razdan and Cocking, 1997).

Currently there are two major conservation strategies implemented for the conservation of crop genetic resources, i.e. *ex situ* and *in situ* strategies. *Ex situ* refers to the preservation of genetic resources outside the eco-system in which they naturally occur. Facilities used for this purpose include cool chambers for the conventional genebanks, field genebanks and community seed banks. *Ex situ* strategies aim to conserve as much of the existing diversity as possible ensuring its availability for immediate use for crop improvement programs and for future generations. The second strategy, *in situ* conservation, involves leaving species in their natural habitat, so as to allow adaptation and continued evolution. Diversity and evolutionary processes are maintained with minimum or no interference of human activities. On-farm conservation of agricultural crops, which is part of the maintenance of agro-ecosystems, focuses on *in situ* conservation of cultivated crops and their wild relatives.

So far, *ex situ* preservation of crop genetic resources has been the major strategy where over four million accessions of various crop species are reportedly maintained in this way in various parts of the world (Pistorius, 1997). One of the perceived advantages of such a strategy is that materials under *ex situ* are seen as available and easily accessible for use in various breeding programs.

The need for the *in situ* conservation approach for plants was formally affirmed rather late, i.e. in 1973, during the FAO Technical Conference on Genetic Resources in Rome. Despite the acceptance of *in situ* as a strategy, its implementation has been an issue of academic debates by the formal sector. Issues such as lack of set guidelines for maintaining landraces; lower possibilities in maintaining evolutionary changes; difficulties in determining the appropriate sample size, and free access to *in situ* maintained materials, were considered as disadvantages and were the core points of arguments (Pistorius, 1997).

Nevertheless, implementation of *in situ* and *ex situ* as complimentary conservation measures for landraces and wild species has been emphasized since 1992, and funds from various sources have been allotted for effecting it. The Global Environment Facility (GEF) funded programs for the dynamic farmer-based conservation and management of landraces in Ethiopia and for the management of wild relatives of wheat in Turkey are examples of the efforts made along this line. Since this is a new approach, the issue of sustainability and economic viability has to be affirmed as well and the approach further developed.

There is no doubt that on-farm conservation is a vital component to be supported along with the formal (*ex situ*) conservation efforts as it allows continued maintenance and evolution of landraces under the traditional agricultural practices. However, the challenge here will be how to make the *in situ* program sustainable given that projects such as the GEF have limited time in funding. Furthermore, in the case of Ethiopia, selected conservator farmers are paid incentives to conserve landraces which otherwise would have been abandoned and lost gradually. The compensation paid is for the yield difference that farmers would have obtained when growing the best performing elite materials. Without the current support, it is difficult to guarantee that the on-farm conservation of landraces will continue in the future.

It is important to better understand the farmer's role as informal experimenters and identify factors influencing landrace production. The aspects of incentives need to be tackled through increasing market options for farmers to ensure the conservation and utilization of landraces in a sustainable way for the future (Worede, 1990). Enhancement of landraces through maintaining an appreciable level of diversity and by adding value to promote market demands will make landraces competitive on the one hand and ensure that farmers grow them not only for subsistence but also for the market.

The initiative carried out by institutions such as the International Plant Genetic Resources Institute (IPGRI) is vital, particularly in rendering support to the strengthening of the scientific basis for *in situ* (on-farm) conservation (Jarvis and Ndungu-Skilton, 2000). The project on monitoring of farmers' on-farm management of sorghum landraces in North Shewa and South Wollo in Ethiopia is part of the IPGRI program.

Current arguments on the efficient use of genetic material strongly stress the exploitation of genetic stocks with less emphasis on the maintenance of the primary gene pool. However, the use of germplasm of immediate value is sustained only when the primary gene pool is maintained as a backup for continuos flow of germplasm resources. It is therefore important that both *in situ* and *ex situ* conservation measures are implemented as complimentary, in order to fulfil the ever increasing demand for the acquisition of plant genetic resources (PGRFA, 1998). *Ex situ* conservation cannot completely replace or cover the service that *in situ* provides in maintaining genetic diversity or vice versa. Loss of viability in storage, difficulties in regeneration of materials, freezing of the evolutionary processes, difficulties in maintaining crops with recalcitrant seeds are some of the drawbacks in the *ex situ* system (Pistorius, 1997). Considering the advantages and disadvantages of the two strategies however, aspects such as continued evolution, accessibility, cost effectiveness and safety could be achieved when the two conservation strategies are employed in combination (Engels and Visser, 2000).

Since genetic diversity remains to be vital for current and future needs of humankind, there should be a concerted effort towards the safeguarding of these resources together with the farming systems and agro-ecological processes that shape the diversity itself.

Fowler and Mooney (1990:218) have listed five major points, which they considered 'laws' or 'ingredients of a successful strategy' as regards the current and future efforts in the conservation of genetic diversity.

a. *Agricultural diversity can only be safeguarded through the use of diverse strategies.*

The use of a single strategy will not be a feasible way to preserve and protect our natural resources as it has taken so much effort for its establishment. Conservation strategies should complement each other so that the shortcomings of one method will be compensated by the strength of the other.

b. *What agricultural diversity is saved depends on who is consulted. How much is saved depends on how many people are involved.*

The involvement of different sectors of the community is vital as they have different interests towards the conservation and use of agricultural diversity. Their participation ensures that the total needs of the community are met. More involvement of communities will encourage the efficient conservation of genetic diversity.

c. *Agricultural diversity will not be saved unless it is used.*

In order to value genetic diversity, society should be able to make use of it. People will strive to maintain genetic diversity if they are aware of the benefit of it.

d. *Agricultural diversity cannot be saved without saving the farm community. Conversely, the farm community cannot be saved without saving diversity.*

Diversity is part of the community that produced it. It co-exists with the community and the Predicament that gave rise to it. Saving the farm community implies saving genetic diversity and at the same time, communities should be able to save their agricultural diversity in order to maintain their own options for future development.

e. *The need for diversity is never ending. Therefore, our efforts to preserve this diversity can never cease.*

Because of the occurrence of genetic erosion, genetic resources continue to be lost and therefore, conservation should also continue everlastingly. We should bear the responsibility to preserve agricultural diversity for current and future generations by making use of the different conservation strategies. We should also be able to involve the community at different levels, and insure that diversity is actively used. Furthermore, the survival of the farm community should be given due consideration, as they are the basis for the existence of agricultural diversity.

1.5 The issue of food security: global approaches

Safeguarding the basic right of people to have access to the food they need is perhaps the greatest challenge facing the world community. The challenge is more critical in low-income, food-deficit countries. Achieving a sustainable increase in food production in developing nations requires strategies that address both sustainable agriculture and rural development.

The concept of food security was highlighted in the early 1970's i.e. during the world food conference in Rome (RAWOO, 1986). The issue was given due attention at the time because of the rising of international grain prices and the lagging food production in many low-income countries, which led to mass starvation. The conference focussed on increasing food security by either increasing food production in food-deficit countries or creating a system of international grain reserves. However, little attention was paid to the issues of demand such as ensuring the provision for an adequate diet for those groups that are nutritionally vulnerable. In many developing countries, the poor are malnourished not only because of the inadequacy of the supply of food, but also because they lack the resources to gain access to food, which might be available in the market.

World food production at present is adequate to meet the global food demand. However, regional disparities in production, distribution and economic power to secure access to food leaves nearly 800 million people undernourished and this number is not expected to change until 2020 (IFPRI, 1995). It is stated in Bindraban *et al.* (1999) that 20% of the population in developing countries do not consume enough food to lead an active and healthy life.

Hunger or total food insecurity occurs not because the poorer countries are incapable of providing for their subsistence needs. It occurs because of lack of resource ownership and use rights which are usually monopolized by those elite who enjoy the most power of all kinds to gain from the current world system (Smits, 1986).

Like in some other parts of the third world, a number of countries in Africa face a rueful agricultural development history where food production per capita has shown a continuous decline since 1960's (Grigg, 1993). The pace of promoting agricultural productivity, which does not match with the rate of population growth of the continent, is one among the causes that attributed to severe production problems and low level of access to food sources in Africa. Ethiopia for instance, is reported to be one of the top ten countries in the world projected to show the highest population increase. It is estimated that the size of the population that was 60.1 million in 1996 (CSA, 1998), will increase to 80 million between the years 1995-2025 (Bhattacharya *et al.*, 1999). For many years, crop failures resulting from changes in rain patterns, recurrent droughts and the outbreak of disease and civil unrest have become common events affecting the situation of food security in the country. In most countries of sub-Saharan Africa including Ethiopia, Somalia, Sudan, Mozambique and Angola, Liberia, Sierra Leone, agriculture has been disrupted by political strife and armed conflicts, whereby the continent has moved from near self-sufficiency to that of net importer of food in some cases (Jones, 1990:173).

On the other hand, most Asian countries to some extent have shown a positive progress in increasing their food production faster than their population growth rate. This has been achieved through efforts made in land reform, by conducting effective agricultural development research, through the development of rural infrastructure by promoting mass education, and last, but not least, by the green revolution. But still the adopted technology in many cases favours the wealthier farmers who can afford the necessary packages, at the expense of decapitalizing small-holder farmers, which has led to landlessness of such farmers (Jones, 1990:171).

In many developing countries, the transformation of small-holder farms from subsistence agriculture to the cultivation of export crops and the imposed use of high input uniform varieties by small subsistence farmers have worsened the situation of food security. In marginal areas, high-input farming practices are impractical, as their environmental costs are unbearable to low income farmers who do not have the resources and expertise to adopt such practice. Farmers of this level need low-input crop varieties that can easily be adapted to the eco-system and be productive under marginal conditions. Biological methods of disease and pest control and management strategies of farming systems that blend traditional knowledge with research innovations would be very beneficial under such conditions. It is also important that small-scale farmers be given the opportunity to participate in the designing and implementation of research activities according to their objectives and needs. Participation of farmers in decision-making and extension programs can certainly improve the farmers' role in boosting production and can increase impact of programs aiming at social/economic change. A participatory approach, which involves farming communities in crop breeding and selection processes, is vital in overcoming the problem of the lack of well-performing planting materials under varying agro-ecological conditions.

Adoption of policies that ensure the attainment of sustainable food security at the household and national levels remains an issue of top priority in many developing countries. Elimination of development barriers such as unemployment and lack of access to proper means of production that adversely affect the attainment of food security is crucial (FAO, 1999). Achieving food security and food self-sufficiency, as complex as it is, requires policy commitments as well as approaches which are multi-disciplinary and participatory (Bindraban *et al.*, 1999). Improvement of food security may be possible if sufficient food is available, and if problems of access at household level can be resolved.

1.6 From macro to micro perspectives: correlated trends

The level of analysis of food security and entry points for resolving the problems related to it are becoming wider and wider in scope. There are two key issues or trends in this regard, the change in the level of aggregation from macro- to micro-level and from supply- oriented to access-oriented strategies.

In the early 1970's, most of the definitions of food security used to focus on the availability of aggregate food supplies at global, regional or national levels. The definitions in the 1980's focussed on a household and individual level of access and entitlement to food resources rather than availability of resources. In this regard the work of Sen (1981), brought a shift of perspective. It led to more attention for food security at the micro-level, emphasizing access and entitlements. Attention has since then been paid to household and individual levels of food security, due to the growing understanding that increasing food production, supply and sufficiency at global, regional or national level, does not necessarily ensure that all households and their members are food secure.

There is a necessity to look at food security at the household or individual level, as food supplies can be unequally distributed within or between countries and within and between households. Food insecurity can occur in situations where food is available but not accessible because people do not have access to or entitlement to food (Borton and Shoham, 1985). In cases where food is available, the needy people may not have enough purchasing power, or do not have the capacity to produce enough food for themselves. At times households are forced to buy food from the market soon after their first harvest, which may not even be sufficient for their needs. This indicates the low capacity of households to produce food on which they can live from one harvest to the other.

As indicated by Sen (1981), more attention should be given to access than availability of food sources in order to ensure food security. Sen's theory also stresses that access to food is related to food entitlements, which is the right to obtain enough of the available food. In his analysis of famine, he has used the concept of entitlement to prove that it is not the lack of food, which lets some households starve, but rather their lack of any right to share the food. This is related to lack of access to land, water, money, assets, etc., which directly affect the capacity to produce, buy or exchange food resources. Sen's approach argues that people go hungry as a result of loss of their possessions, and lack of entitlements because of the interruptions in the relations governing their access to food.

The search for food security is complex. At rural household level, gaining adequate food is a result of how the individuals or households concerned conceptualize and materialize their livelihoods (Omosa, 1998). At the local community level, households traditionally have various entitlements to resources and assets that enable them to secure food sources. These entitlements need to be protected in order to ensure household food security, thereby improving the quality of food consumption through subsistence farming, buying, borrowing or bartering.

Subsistence farmers have preserved and used in a sustainable manner many indigenous crop varieties and landraces *in situ* (on farm) for many centuries. *In situ* conservation is a dynamic process in which genetic resources are considered to be part of the farmer's social life and cultural heritage. Under this subsistence system, crops co-evolve with diseases, pests and weeds developing mechanisms of co-existence through time. It is also a result of continued cultivation and management of a diverse set of crop germplasm by farmers under diverse agro-ecosystems.

Farmers cultivate, select, develop and manage crop varieties in order to meet their food and livelihood needs. They depend on indigenous cultivars that were developed and maintained by their ancestors over centuries, to sustain crop production and ensure livelihoods. These subsistence farmers practice farming on fragmented patches of farmland with different types of crop mixes in order to overcome the risk of losses as a result of unexpected environmental uncertainties and ensure sustainability. The diversity developed and maintained by these subsistence farmers has immensely contributed to the country's national food security and to genetic improvement of plants, which nowadays are sources of food, fiber, medicine, etc.

Subsistence agrarian economy, in which small farmers produce the bulk of the food supplies, generally relies on household labor. In these systems, production is primarily aimed at the self-provisioning of the household (Ezra, 1997). Capital and technological inputs are low and production is largely dependent on forces of nature. Moreover, land productivity is low in these systems and the society's food security can easily be destabilized by seasonal fluctuations. In such systems the standard of living varies within communities and thus it is of significance to view food security at a lower or household level. Access to the various resources varies extremely, i.e. some households are food secure, have access to land and other resources while others do not. At times when the household's production capacity is insufficient due to lack of resources and assets, household members are often forced to migrate for wage labor or food-for-work programs in order to meet the household needs.

Irrespective of the size of their land, farm households in Ethiopia secure their food in various ways. For example, they diversify their production on the land they have by growing different crops, so that they make sure that when there is a failure in one crop, they can have harvest from the other. Diversity in farming practices (between and within crops) is indispensable for resource-poor farmers. The food security situation of Ethiopian farm households differs also by region and by farming system. The north and central part, for instance, which are characterized by a cereal based farming system cultivate annual crops, and are often at a greater risk. These regions are easily affected by seasonal variations in rainfall and often reported to be famine areas when hit by recurrent drought.

In the Southwestern part of the country, *in situ* conservation by farmers of perennial crops such as enset, root and tubers, coffee, etc., is routine. Farmers always grow different crops in their backyard, thus safeguarding their food and livelihood security. As in many parts of the world, rural women play a vital role in securing the household's food supply, being close to and taking care of the backyard crops on farm. As described by Niehof (1999b), 'women are the gateway to household food security'. Similarly, in the case of enset, if women would not process the enset plant, there would not be any food gained from it. It might have remained as an ornamental plant, as it is in other parts of Africa and Asia. Men participate at early stages of the operation i.e. land preparation, planting and transplanting, but never take part in the processing, storage and marketing of enset. According to the men 'it is a shame for the male to process or watch his wife processing or carry enset products to the market'.

1.7 Plant Genetic Resources conservation efforts in Ethiopia

National genebanks, if effectively linked into a network of community activities, would also serve as custodians of the material for the local farmers (Witt, 1985).

Proper conservation of the existing genetic resources can be achieved through a well-established institution, that can implement different conservation strategies under which the germplasm resources will be maintained and sustainably utilized for immediate use and also allow the continued evolution of the species through the dynamic force of their habitat. Within the existing efforts of establishing a sound biodiversity conservation system, the already existing Plant Genetic Resources Center of Ethiopia (PGRC/E), established in 1976, has been promoted to a national Institute of Biodiversity Conservation and Research (IBCR) in 1999. The Institute now has a broader mandate, which includes the conservation and research of plant, animal and microbial genetic resources, combining both *ex situ* and *in situ* conservation strategies.

The establishment of the Plant Genetic Resources Center, now the Institute of Biodiversity Conservation and Research, resulted in a systematic collection, conservation, evaluation and documentation of crop germplasm for national crop improvement programs. The Institute now has an assemblage of over 56,000 accessions consisting of more than one hundred crops. Collecting activities were initiated according to a well-defined priority for both crops and areas. Priorities were based on criteria such as the economic and social importance of the crops and their respective degree of genetic erosion. The Institute implements the two strategies of crop genetic resources conservation, i.e. *in situ* and *ex situ*. By far the largest proportion (more than 90%) of its collection is maintained as seeds in its cold storage facilities, while the remaining proportion, which mainly comprises the root and tubers crops, spices, coffee and enset, are maintained in field genebanks.

Apart from handling of germplasm materials conventionally, i.e. as *ex situ* in cold storage and in field genebanks, the institute has launched an *in situ* conservation strategy for cultivated crops. In this regard the institute was one of the first government institutions to engage in an *in situ* conservation program for land races. The program operates on selected sites representing the different agro-ecologies and farming systems. They are identified on the basis of the degree of occurrence of genetic diversity, degree of genetic erosion, and other criteria. Implementation is effected in close collaboration with national breeders, farming communities (selected crop conservator farmers), and community development workers, including development agents of the regional agricultural bureaus concerned. Crops such as wheat, barley, sorghum, and enset among others, are included in the on farm landrace conservation program.

The complimentarity of the two conservation strategies and the involvement of the community down to the grassroots level have been stressed as a sound way to conservation and use of crops. However, there still exists a gap for example the establishment of *in vitro* genebanks in many of the Plant Genetic Resources Centers such as Ethiopia, for many crops including enset which need an alternative means or a back up for their effective conservation and future utilization.

1.8 Enset: a multipurpose crop

Enset is an important source of carbohydrate and a staple food for large segments of the population across the regions of the south and Southwest. Actually, there is no part of the enset plant that is not used, except the root. It is used for food, fiber, construction, medicine, wrapping, storage and livestock feed. After being processed, the different products are prepared into bread, porridge, or soup. The underground stem (corm) is also eaten boiled like potato or sweet potato if not chopped and mixed with the scrapped part and let to ferment. Except for periods of famine, enset products as a staple are usually consumed with other crops or animal products. Crops such as cabbage and beans and in some cases meat, milk, cottage cheese and eggs are eaten together with enset products. The cultivation of enset is quite well integrated with animal husbandry because of food habits and more importantly to use the manure for fertilizing enset fields. Enset is a manure loving plant. No enset-growing farmer uses artificial fertilizer. This suggests that the need for manure brought enset to be cultivated around the homesteads where the livestock are kept and the women carry the manure to each plant or an outlet is dug to let the manure and urine to the fields.

Although enset is a perennial crop where full maturity takes between 4 to 12 years depending on the type of clone, it can be harvested any time of the year whenever there is food scarcity, family or social obligations or financial needs. Enset areas are characterized by a high population density and diverse ethnicity. Large numbers of enset plants are cultivated in a relatively small land area around the homesteads. Household wealth is usually assessed in terms of the number and diversity of enset plants (Pankhurst, 1996). In the better-off households, plants are not often harvested before maturity, while poorer households do not have enough mature plants as they are forced to harvest early to sustain the family (Alemu and Sandford, 1996).

1.9 Research motivation and justification for the study

Although Ethiopia is one of the Vavilovian world centers of origin and diversity in crops, it is also one of the most severely affected countries in the African region with regards to famine and other calamities, which resulted in food insecurity. However, there still exists an immense wealth of genetic resources, which could be wisely exploited. The exploitation of indigenous crops, which are adapted to the ecology and are potentially useful especially in terms of food security and sustainability, still remains an option.

Agricultural policies are largely focused on national or regional bases without due consideration of local communities (households) roles in food production. Major development programs seem to be heavily geared towards commercial crop production with little regard for food crops grown under marginal conditions. The introduction of improved seeds with high input packages distributed to farmers in order to increase food production testifies to this. However, rather than leading to a significant improvement of the life of subsistence farmers, many have lost the diversity they had. Some were left without oxen, which they had to sell in order to cover their debts. The idea that few crops feed the world does not seem realistic, especially to subsistence farmers who increase their options by diversifying the small plot of land they have rather than homogenizing their fields with high external inputs and uniform varieties. The negative lessons learnt from the green revolution is that it has accelerated genetic erosion and undermined farmers' efforts to conserve, improve and utilize their traditional varieties, endangering long-term food security.

The key actors in maintaining the bulk of genetic diversity while wisely exploiting it, namely the farm households, have not been given enough consideration in research or in the formulation of national agricultural policies. Subsistence farmers consider diversity, be it social, cultural, economic or genetic, as security. Diversity to resource-poor farmers is indispensable, as it minimizes risks by allowing a reasonable level of management flexibility to meet various socio-economic needs and to adjust to changing climatic and agro-ecological conditions. Studying the farming system along with the people, their culture, and the socio-economic environment, will give a better understanding of and insight into the role of a rural household's farming system towards efficient use for ensuring sustainability and food security.

Local crops such as enset in Ethiopia have proved to have the potential in sustaining household food security during the past famine years in the country. Rural households, which constitute 93% of the population of the Southern Nation, Nationalities and People's Regional Government (SNNPR), rely on the enset crop and increase their production from time to time, despite the threatening effects of the bacterial disease. As most of the rural areas do not have access to modern clinics or hospitals, they also maintain and use some of the landraces for medicinal purposes. Whether the household is poor or rich, enset is the most important crop for the community.

However, the knowledge and contributions made by the enset-farming households in maintaining the available diversity by considering the crop as part of their cultural heritage are yet to be recognized. Moreover, there is lack of empirical research about the different aspects of the crop such as breeding for resistance, yield, food and fiber quality, nutrition, the extent of genetic diversity, etc. It is with this point in mind that the present inter-disciplinary research was conducted, in an attempt to at least fill some of the existing gaps in enset research.

The study aims to contribute to the relations between the biological relevance of diversity and conservation of genetic resources of enset and uses at the household level. It tries to develop an understanding of the extent of biological and socio-economic linkages that exist among various components of the enset-based farming system that contribute to food and livelihood security. The findings from the research and the recommendations to be made will hopefully be of use to planners, policy makers and researchers, and enable them to formulate appropriate policies, to coordinate research efforts, and focus those efforts on research geared towards improving or solving critical problems of farmers.

Thus the following justifications for the research can be formulated:

1. Enset is one of the most important multi-purpose crops in Ethiopia. Its products are used for food, fodder, fiber, construction, and wrapping;

2. Culturally, in most parts of the South and Southwest, enset is part of the farmers' lives. It is an indicator of social status (wealth) and forms an integral part of their farming system;
3. It is a crop, which has a potential for food security as it grows in areas where there is high population pressure and where there are limitations of cultivable land;
4. Some enset clones (e.g. astara, tayo), are claimed by farmers to have medicinal values and are used by many households to cure both human and animal illnesses;
5. Women play a major role in enset cultivation, processing and marketing;

In particular, research on the development of efficient techniques for *ex situ* (*in vitro*) propagation, conservation and molecular marker analysis of enset will form a safety backup and will facilitate the efficient management of collections. This in turn will offer a system that will provide immediate access to national breeders for future crop improvement and to farmers access to the desirable genetic materials.

1.10 General approach to the problem and objectives of the study

With an effort to increase food production and changes in agricultural practice in order to meet the needs of an ever-increasing population, governments are increasingly adopting new approaches that rely on high external inputs. These high input technologies, such as the use of improved varieties, chemical fertilisers, insecticides and pesticides, have been a serious challenge to the resource-poor farmers who survive under marginal conditions. Little or no regard is given to food crops, which provide a stable source of food for domestic consumption and also serve as an income source for the household.

It is clear that enset serves as a main staple crop for millions of people living in the Southern and Southwestern parts of the country and forms an integral part of the cropping system of many farmers. The enset based farming system has been sustained through the accumulated experience of interactions of farmers with their surrounding environment, without the interference of external inputs or scientific knowledge. They are capable of maintaining the existing diversity while wisely exploiting it. However, due to the adverse effects of natural and human induced disasters, such as the introduction of high input varieties, disease, etc., the diversity they have maintained thus far is now endangered and so is their food and livelihood security.

The information that is currently available on enset is largely descriptive and anecdotal. Documentation of the use and management of the crop, its significance for rural livelihoods, and the associated indigenous knowledge is indispensable. It is crucial to understand the basic nature of enset farm households and their problems in association with the farming system. The present study aims to address issues of genetic diversity related to use and sustainability at a household level and in relation to household food security. These issues are placed in the wider context of livelihood systems.

The following are the general objectives of the study:

Meta objectives;

1. Investigate and gain insight into the indigenous enset cultivation system, the socio-economic potential and cultural aspects of its production, and its agricultural sustainability.
2. Devise applicable conservation and propagation techniques for enset that would complement the existing conservation and propagation measures.
3. Study the genetic diversity of clones and compare results with farmers' indigenous classifications.
4. Identify and explain linkages between the cultivation system, the diversity present in that system, and the socio-economic aspects of enset production.
5. Formulate sound recommendations for strengthening relations or linkages between the institutional environment (formal) and farming households (informal) in the enset farming system.

The study has the following specific objectives:

a. Socio-economic and cultural

1. Examine the role of enset in the livelihood systems of rural households in the research area.
2. Study the socio-economic profile of selected enset-producing households.
3. Examine the role of gender, in particular women's role, in the enset cultivation.
4. Document the indigenous knowledge of farmers on cultivation and utilisation of enset.

b. Technical (diversity and conservation)

1. Develop in vitro conservation techniques as a back up to farmers' maintenance of diversity.
2. Establish or develop rapid propagation techniques to provide farmers (germplasm users) with enough planting materials of the desired clones.
3. Gather germplasm and related indigenous knowledge on its use from the study area for laboratory analysis in order to investigate linkages between genetic diversity and socio-economic aspects (household uses) of the crop.
4. Study crop diversity using molecular markers to better understand current genetic variation and to compare this with the classification used by farmers.

1.11 Structure of the thesis

This thesis is organized into four major parts in order to keep the flow in perspective. Included in part I, are chapters 1, 2, 3, 4 and 5 in which mainly theoretical aspects of the research are discussed. Part II contains chapters 6, 7 and 8 dealing with procedures and findings of the technical part of the research. In part III are chapters 9 and 10, which focus on household survey results. Part IV includes chapters, 11 and 12, which deal with linkages between conservation and use, discussions and recommendations.

Chapter 1 gives a review of literature on issues of agricultural biodiversity and food security. The significance of agricultural biodiversity as a major natural resource to communities, and the factors contributing to the loss of this diversity are discussed. Global and national approaches to conservation and major conservation strategies are also detailed. A brief account is given on the issues of food security both at the macro- and micro-levels. In the context of this study, food security in relation to enset genetic diversity at the household level is given major consideration and will be dealt with in this chapter. The motivation for this research, the general approaches to the research problem and the objectives of the study are also presented.

In chapter 2, the historical background and current status regarding the cultivation of the crop enset and the enset based farming system is given. The origin, cultivation and the place of enset in the different sub-systems within the enset-based farming system are elaborated. The description of the crop, economic and socio-cultural significance is also the focus of this chapter. A literature review on research on enset is provided and the existing gaps in research are identified.

In chapter 3, the conceptual framework and the theoretical aspects of the study are presented. In the conceptual model, the linkages between use and conservation of enset are indicated. The components of the household practices, household resources and assets, strategies and the interactions with agricultural biodiversity are shown. The major concepts in the study are defined and the literature on food and livelihood security, production strategies and coping mechanisms are reviewed. The research questions in which the design and formulation of the questionnaire for the primary data depended on are also presented.

Chapter 4 presents a brief description of the research area. It includes location, agro-ecology, demographic characteristics, language, ethnicity and religion. The cropping systems existing in the area for enset and other crops are discussed. In the later part, the homestead and the residence, which can be used as a guide to understand the households in the study area, are presented.

Chapter 5 contains a presentation of the research methodology. This includes, research design, the sampling procedure, data collection, the fieldwork experience, and methods of data analysis.

Chapter 6 discusses the investigation of enset clones collected from farmers' fields for their potential for propagation and regeneration in tissue culture. It describes the findings of the laboratory-based study on the attainment of optimal conditions for clonal propagation of enset allowing both micro-propagation and rapid regeneration. The significance of this investigation for conservation of enset clones, rapid propagation of selected disease-free germplasm and more efficient breeding procedures are discussed.

In chapter 7, results of studies on the development of efficient *in vitro* conservation protocol for the conservation of enset genetic diversity are discussed. So far enset clones are maintained on farm by enset growing farmers and few research Institutes. The development of such a protocol will serve as a back up to on farm maintenance of clones and prevents the frequent loss of the germplasm from the field. This chapter therefore discusses the procedures and findings of the research in this regard.

Chapter 8 deals with the assessment of clonal diversity of enset for the efficient conservation of the crop. A molecular analysis using a technique, Amplified Fragment Length Polymorphism (AFLP) is employed to characterize enset clones collected from farmers' fields in the study area. This chapter discusses the procedures and findings from the research regarding genetic relationships among clones, identification of duplicates and regional variations. The implication of the results in relation to the conservation of genetic diversity of enset in the country is discussed.

Chapter 9 focuses on the analysis of data on demographic characteristics of the study households, which helps as a background in fitting the research objective in proper perspective. Chapter 10 provides the analysis of household resources for better understanding of the situation of household's food security and sustainable livelihoods. Brief account will be on access and availability of assets and resources such as land, livestock, genetic diversity and indigenous knowledge. The role of gender in the enset based farming system is given major consideration in this chapter. Household practices and production strategies and mechanisms of coping of households during stress periods are discussed.

Chapter 11 focuses on the linkages between the cultivation of enset and its household uses. Indicators that are selected to determine the wealth status of households surveyed would be examined. Characterization systems used by farmers and that of the molecular techniques will be examined and results will be compared. In chapter 12, the general discussions regarding the inter-disciplinary experience and recommendations both for further research and for policies aimed at food security and the conservation of enset genetic diversity are given.

Chapter 2 Genetic resource of enset: state of the art

The present chapter discusses the historical background as regards the origin and cultivation of enset and the enset-based farming system. More detailed explanations are provided on the botany, adaptation and economic and socio-cultural significance of enset cultivation. The chapter also reviews the available literature on research towards enset and tries to identify the existing gaps in research.

2.1 Introduction to the enset based farming system

Agriculture in Ethiopia is characterized by diverse farming practices. People with diverse ethnic backgrounds and great cultural diversity live in a region with the highest biological diversity while nurturing species variation. Traditional farmers living in the country's diverse agro-ecological zones have developed farming systems, which are characterized by a high degree of intra and inter-species crop diversity across time and space.

According to Braudel (1985), wheat, rice and maize, which are the three major food plants of the world, have had a deep influence on the material and spiritual cultures in their respective regions of cultivation. These include the wheat-growing civilizations of pre-modern Europe and West Asia, the rice growing civilizations of Asia, and the maize growing civilizations of the pre-Colombian America, where these crops have been historically dominant. Wheat, rice and maize can be considered "plants of civilization" rather than just food crops. Braudel also examined the characteristics of the regions in terms of dietary preferences, as well as in terms of the use of labor, the choice of technology, the nature .of social relations, and the development of markets associated with the cultivation of these crops.

Likewise, Rahmato (1996) has identified three major food crops, which can be linked with three broad cultural ecologies in Ethiopia. These crops include: teff, mainly cultivated in the Northern highlands, where it is produced as a staple and cash crop, enset, a major or co-staple in the more humid Southern and South-western, and maize and sorghum in the Eastern and Western parts of the country. Rahmato used this zoning pattern as a basis for reassessing the agro-cultural diversity of the country. However, in contrast to his suggestions, under the current conditions of farming, many crop plants have been dispersed from one cultural ecology to the other through exchange or movement of people, with the exception of enset.

Teff, for instance, is now produced and consumed in many parts of the country. However, the production of teff in areas with a different cultural background, such as the South is limited and there it is only consumed on rare occasions. In the case of enset, however, production and consumption has remained restricted to certain agro-ecological and ethnic zone.

In the Kaffa (Southwest) tradition, people express the value and the role of enset as compared to cereals or pulses in their sayings or traditional songs. An example is the following saying:

> *'Gashoye shekoye kocho kopa beshoye*
> *Gashoye shekoye kocho kopa bediye*
> *Galiye Gimiye no Kaff Shawo beshoye'*

This saying translates as: 'Any one farmer from Shoa or Jimma, who cultivates an annual crop (wheat, teff, barley, sorghum), can never harvest as much as one can get from harvesting enset which is all year round and gives high yield'.

The enset-based farming system, which is characterized by the cultivation of enset as a main staple or as a co-staple with other crops, is one of the four farming systems existing in the country. The others are the plough and cereal complex of highland Northern and Central Ethiopia; the shifting cultivation economies of sub-tropical and lowland Western and Southwestern Ethiopia; and the pastoral complex represented by the nomadic populations in the low-lying plains (Brandt, 1996).

The enset complex comprises the cultivation of various cereals, tubers, stimulants, spices, condiments and other horticultural crops in addition to enset. Enset integrates quite well with the production of other crops and livestock. The enset-based farming system is practiced by the Omotic and Eastern Cushitic speaking agriculturists of the highlands of Southwestern Ethiopia and the Ethio-Semetic speaking Gurage peoples of the Southern central part of the country. These people who belong to over 45 ethnic groups, are heavily dependent on enset primarily for food, though it is utilized for other household needs as well.

Within the enset-based farming systems, enset varies from being the major staple to a crop that is eaten only during periods of food shortage or used as an alternative for other food crops. Westphal (1975) distinguishes four subsystems within the enset- based farming system. His classifications were based on cultural, environmental, and technological criteria. These subsystems can be described as follows:

1. Enset forms the staple food and the main food source. In this subsystem, the Eastern Cushitic speakers and the Ethio-Semetic peoples, who include the Gurage and Sidama, are dominant. In these areas, population densities are as high as 200 persons per km^2 and many plants are grown on a relatively small plot of land. The population utilizes almost every part of the plant. Livestock production is also a common feature as the animals are important sources of manure for the enset fields.

2. Enset functions as a co-staple with cereals and tuber crops. This subsystem is dominant amongst the Omotic speaking tribes of North-west Sidamo (Wollamo), north and south Omo (Gamugofa) and Kaffa. However, it is also stated in Westphal that for the Kaffa people, who live in the high rainfall area, enset is used as the major staple. In this subsystem, other cereal crops (maize, sorghum, barley, teff) and root and tubers (taro, yam, oromo potato, etc.) are grown and consumed besides enset. The intercropping of cabbages, beans, and coffee with enset plants around the homesteads is a common practice. Livestock is important to use the manure for fertilizing the fields.

3. Tuber crops are dominant with enset and cereals of secondary importance. Here, tuber crops take the dominant position, with cereals and enset being of lesser importance. This type of enset cultivation is found under the Northern Omotic-speaking Gimira tribes who live west of Kaffa including the Chako. These people practice a form of shifting cultivation on a large scale, with yam being the most valuable crop followed by taro and enset. They are not familiar with the processing of enset practiced in the other subsystems and they simply cut the corm into pieces and eat it cooked.

4. Cereals dominant with enset and tuber crops of secondary importance. The Oromo of Western Kaffa practices this system, where enset is cultivated in addition to other crops, whereas cereals dominate. Enset is largely grown for security reasons in cases when cereals such as maize and teff fail.

2.2 Brief description of the enset crop

> *"Early travelers to the Wolaita area of southern Ethiopia were so impressed with the importance attached to the cultivation, harvest and preparation of enset foods that they labeled this 'the enset culture' or 'the enset people'. Certainly the presence of 20-40 magnificent 5-8 meter high enset plants framing the tukul and farmyard presents an impressive picture. Four to seven thousand years ago people in Ethiopia were largely*

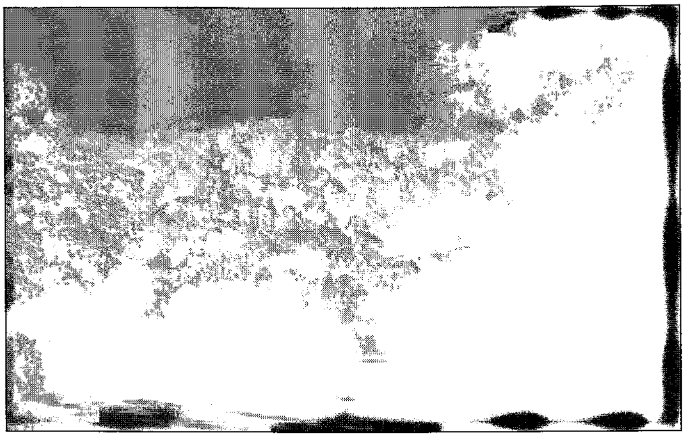
hunters and gatherers who must have learned to use the fleshy interior of enset during the dry season. About 700 years ago, with the coming of domesticated livestock, a settled culture evolved around the use of enset products as a major and co-staple food" (Shack, 1966).

Enset (*Ensete ventricosum* Welw. Cheesman) is a large tree-like and single-stemmed plant, usually growing up to 9 m or more and forming a pseudostem like that of *Musa*. It is a monocarpic and multi-year crop. Seeds are produced after four to seven or more years, depending on the type of clone and agro-ecological environment, in contrast to other perennial crops that bear fruit or seed each year. The pseudostem and the corm, which form sources of starchy food, are ready for harvesting before the onset of flowering or at the flowering stage.

Enset is usually grown in moist *woina dega* (mid-altitude) and *dega* (highland) environments. It adapts to a wide range of altitudes. Simmonds (1958) reported that enset is gown at altitudes between 1400-3100 meters above sea level while other authors (Endale *et al.*, 1996) reported altitudes ranging from 1370-3070 meters above sea level.

The cultivation of enset as food and fiber crop is restricted to Ethiopia. As a cultivated plant, it is not known elsewhere in the world. Vavilov (1951) indicated Ethiopia to be its primary center of origin and diversity. Furthermore, Kuls suggested that the natural center of distribution of enset is located in the higher areas of Kaffa, in Southern Ethiopia, where it still occurs in the forests (Westphal, 1975).

Fig. 2.1 Parts of the remaining tropical rain forests in the Kaffa area, which are sources of many wild relatives of crop species including enset and coffee.



During a survey of enset farming households of the study zone, a 70-year-old lady expressed the attachment of the Kaffa people to the crop, as we discussed the history of enset:

> *"It is difficult to separate enset from the Kaffa people. We started the production of enset ever since the crop started to be cultivated also enlightened by our ancestors. It is part of our culture. Then the Gurage took the plant from us, started cultivating it, processed it into different food types and now they have even snatched it to bigger markets such as Addis Ababa".*

Many of them in particular the elderly, have similar opinions on the history of and their fondness for enset in Kaffa areas.

However, Murdock (1959) has suggested that the Sidamo tribes of Southwestern Ethiopia, (who physically exhibit a mixture of "Negroid" and "Caucasoid" features, and who speak "Western Cushitic" (Omotic)), at some time in pre-history brought enset under domestication. According to this scholar, enset farming was later introduced from there to other areas and ethnic groups.

In areas where enset is cultivated and where forests remain, wild enset also occurs, and farmers usually have clear criteria to distinguish between cultivated and wild on the basis of directly observable attributes. However, none of the farm households use wild enset for food except for other purposes. Reasons for this given by the farmers are that after scraping, the product turns black immediately when it is exposed to the air, which makes it unattractive to eat. The people also believe that it belongs to the devil –they call it *'kocho seytana'*- and that it causes death when consumed. However, we were told by one of the household heads that wild enset can be used for food and has been practiced during villagization. Villagization was a system used during the former Derg regime. Farmers' cooperatives were formed on a large scale and farmers who once lived in scattered places were resettled in new villages. During that time, their enset plants were left in their former places. The new harvest from cereals or other crops was not ready and the family went hungry. The household head told his family that he would go to bring the wild enset from the nearby forest and he promised that he would try it first. All agreed upon this. After the wild enset was prepared and he ate it, nothing happened and the other household members followed suit. Therefore, it is only a belief. According to the farmer, the taste is bitter but it is not poisonous. The name '*Kocho seytana'* is given by enset growers perhaps only because it grows wild in the forest and it has nothing to do with the devil.

Enset covers a relatively smaller area per unit of production compared to other crops such as cereals, pulses, and oil crops, which makes it suitable for growing in densely populated areas where there is scarcity of cultivable land.

Although enset dominates the Southern Nation and Nationalities and Peoples Region (SNNPR), covering 113.520 hectares under enset, a significant amount is also grown in other regions such as Oromiya and Gambella (table 2.1).

Table 2.1 Areas under enset cultivation, total number of enset plants and harvested plants, Kocho and Bulla production and average yield per plant (national)

Details	Quantity
Area under enset in ha (x 000)	167.90
Total number of enset plants (x 000)	624,449.14
Number of plants harvested (x 000)	108,851.15
Kocho production in kg (x000)	3,281,790.71
Bulla production in kg (x000)	112,679.62
Average yield of kocho/plant (kg)	30.15
Average yield of bulla/plant (kg)	1.04

Source: enset sample survey, CSA 1997

From the 624,449.14 total enset plants (table 2.1), the SNNPR cultivates nearly 423 million, while the remaining plants are found in the other two regions of Oromiya and Gambella (CSA, 1997).

2.3 Economic and socio-cultural significance of enset

Economic importance

As mentioned above enset is the most widely used staple food crop for millions of people living in South and Southwestern Ethiopia. It is estimated that over 11 million people rely on enset for survival (Brandt, 1996). As a consequence, enset plays a central role in the economic life of the South and Southwestern people, who rely on it. It gives a higher and more dependable yield than any other known crop. A large household can be supported by enset grown on a limited area of land.

Enset can be inter-cropped with many other crops (e.g. coffee, taro, vegetables, and yam) that need canopy, while there is no demonstrable competition effect on nutrient utilization. It provides a favorable microclimate as a shade tree when used in intercropping with coffee. Enset is a manure loving plant and hence it integrates well with livestock production. It is not labor intensive compared to other crops and family labor appears to be often sufficient for planting, transplanting, weeding and harvesting. Harvesting and processing of enset is a tedious job, which is performed by women. Women sometimes invite work parties for a helping hand during processing.

Enset guarantees food security and stability to the household economy in that the processed produce can be stored for a long time. In addition, the live plant can be maintained on farm and harvested any time when the need arises. It can be harvested and consumed before it is matured and these qualities of the crop have in part contributed to the fact that enset areas are not characterized by a history of famine (Rahmato, 1996). The farmers in Sombo, Illubabor, who belong to the Oromo ethnic group form an example of people who once were cereal growers dependent on teff and maize and later switched to enset as a result of the two drought periods they experienced (Ishihara, 1993). During the drought period, many of these farmers migrated from their villages to as far away as Wolliso in search of food, and there they learned about enset production. When they came back to their homesteads, they introduced enset, and kocho has now become the major part of their diet. Since then, because of enset they have never suffered from famine even when more than half of their cereal crop was damaged by excessive rains as in 1992, and when their coffee fields were devastated by disease. They have now increased the production of enset. Enset is comparatively drought-resistant as it can withstand shortage of rainfall for a certain period and is highly productive with minimum labor input.

Enset is processed into different food types depending on the needs and preferences of the different ethnic groups. There are three main products derived from enset: *kocho, bulla*, and *amicho*.

- *Kocho (kocho* in Kaffa*)* constitutes the bulk of fermented plant material obtained from a mixture of decorticated leaf sheaths and the grated and pulverized corm. In the case of the flowering enset, the true stem will also be processed and mixed. Fermentation takes place in a pit usually dug up to 0.5 m deep and 1m in diameter, which is also covered with enset leaves. *Kocho* is eaten in the form of bread after being fermented. Sometimes it is eaten roasted.
- *Bulla (etino* in Kaffa*)* is the small amount of water insoluble starchy product that may be separated from *kocho* during processing by squeezing the scrapped leaf sheath and grated corm and decanting the liquid. The liquid starch then will be left for one or two days to dehydrate into a powder form. The product is consumed in the form of soup or porridge.

Fully matured (flowering) plants are traditionally said to be the richest source. *Bulla* is whitish in color and is considered the best enset product and so it is expensive.

- *Amicho (uchi uto* in Kaffa*)* is the fleshy inner part of the enset corm, which is eaten boiled. The taste is similar to that of potato.

In almost all enset- growing areas, compared to other root and tuber crops, enset is one of the most frequently served main meals. According to our survey results from enset-farming households in Kaffa-Shaka zone, all family members in a household are consuming enset at least twice a day, either alone or mixed with other foods such as vegetables and dairy products. Supplementation with other food depends on the wealth of the household. These results can be regarded as typical for all enset- growing areas.

Enset is not just a food crop, but is a multipurpose crop of which every part of the plant (except the roots) is utilized, for food or several non-food applications. Enset leaves are used for baking bread, for wrapping, for shade or protection from heat and rain, for production of string and rope for tying, for making mats and sheets on which to sleep and sit, and for making women's skirts. It is also used as a brewing pot during the preparation of the local beer called *shoko.* The pseudostem is the most valuable, as the basal part contains the starch, and the remaining fiber is used for making strong ropes, twines and sacks.

Farmers in the enset growing areas therefore describe the importance of enset by saying " enset is our food, our cloth, our bed, our house, our plate; it means every thing to us". The Ari people (one of the enset dependent tribes in the Southwest) are known to make their traditional beer called *agemigola* from the flowering stem of enset (Shigeta, 1990). In addition most parts of the enset plants make good for fodder for livestock. The market demand for enset nowadays is increasing as the consumption of *kocho* and *bulla* has widely expanded to even big cities such as Addis Ababa. According to the local people in enset areas, they are increasing their production as the demand and price for the products are rising, despite the increase in the severity of the bacterial wilt disease and lack of infrastructure to transport their products to the nearest market.

Enset cultivation is also spreading slowly into adjacent areas of the country. This is because of its potential to spread as a food crop into other areas, which suffer from land shortage and recurrent crop failure. In the past only few areas were reported to be major producers and users of the crop. Shank and Eritro (1996) have indicated that the cereal growing farmers in Jimma and Shewa zones grow enset, because they usually experience a shortage of food during June and July (the 'hungry gap'), when grain stocks are exhausted till the new harvest. Currently they use enset to fill in the annual gap in food supply.

Socio-cultural significance of enset

Socially, people in the south and Southwestern parts of the country not only depend on enset for food and cash, but also consider it as part of their cultural heritage. They have a strong attachment to the crop and the land. Many farming households grow enset for economic as well as non-economic purposes. According to Murdock (1959), a system of social, economic and ritual practices has developed around the cultivation of enset. The Gurage people, for example, use it for purposes such as medicine, compensation payment, and ritual offerings (Shack, 1966). Among the Gamu highlands, rituals associated with birth involve the use of a particular clone of enset (Olmstead, 1974).

According to Yentiso, (1996), enset is considered not only as the principal crop for subsistence, but also for various cultural and social functions. According to traditional knowledge of enset growers, some of the clones have medicinal value for humans and for animals. The water squeezed from the pseudostem is given to newborns before breast-feeding and also later to supplement the breast-feeding until the baby starts taking supplementary food. Moreover, a woman right after delivery will be given a product from enset for a period of three days to release the placenta and to further reduce delivery-associated stomachache and relieve pain from uterine contractions. Furthermore some clones are used for abortion or to reduce fertility both in humans and animals.

Among the Ari, the pseudostem of enset is used for *cashi* (a special blessing ceremony). The lineage leader *(babitoid)* must bless a newly bought or acquired animal before it is used, which involves feeding the animal with the pseudostem. Enset is also used during ritual occasions such as funeral ceremonies or weddings. During a funeral ceremony, people beat the pseudostems of enset or they often come crying from distant places with enset leaves in their hands as an expression of their sorrow and women wear the enset leaves as clothes during the ceremonies. When a person dies, the Ari culture requires that several enset be chopped down. Then, people step on the plant while performing a funeral dance. Relatives attending the funeral from distant places carry pseudostem of enset with them in addition to other funeral gifts such as cloths and money for the household members and close relatives of the deceased. All male relatives of the deceased person tie their head with a piece of dry stem of enset for seven days (Yentiso, 1996).

Enset serves as a status symbol. Households with many enset plants are considered to be rich. Households with many good plants feel proud and superior. The wealth of a household, particularly in highland areas, is measured partly in terms of the size and variety of enset plants grown in the garden. It can be said that the production of enset is influenced by a combination of economic, social and cultural motives.

2.4 Enset and household food security

Enset is basically an energy food, low in protein and vitamin (table 2.2). However Pijls *et al.* (1995) reported that the protein yield from enset is 50% higher than the protein yield of cereals and also higher when compared with other root and tubers such as sweet potato and Irish potato. When animal products or leguminous plants are incorporated in the diets of the enset-consuming households, the only shortage preventing a balanced diet is formed by vitamin A. This may be the reason why the cabbage (kale), which provides vitamin A is so popular and highly utilized along with enset food in most of the enset-growing households. Many resource poor households, after their grain supply is exhausted, subsist largely by consuming enset and cabbage.

Table 2.2 Nutritional value of *kocho* and *bulla* per 100gm of edible protein

nutrient	*kocho*	*bulla*
Food energy (Kcal)	200	186
Moisture (%)	48.7	53.5
Protein (gm)	0.6	0.5
Fat (gm)	0.3	0.4
Carbohydrates (gm)	49.0	44.8
Calcium (mg)	82.0	70.0
Phosphorous (mg)	36.0	45.0
Iron (mg)	3.7	7.9

Source: Food composition table for use in Ethiopia, 1975.

It is most likely that enset is so popular as it is a 'living larder' from which the family can customarily take as much food as required during any time of the season. As long as the woman has *kocho* in the pit, which is kept for fermentation, she can easily take a portion of *kocho* from the pit and bake (steam) it as required. The household is not afraid of any unexpected visitors and they are willing to offer *kocho* bread to their guests. The survey team of this research project experienced this practice when we were kindly offered *kocho* and coffee whenever we went to households for interviewing. The continuity of the household's food supply is keenly regulated by women. They guarantee the availability of *kocho* by processing a new plant and fermenting it into an additional new fermentation and storage pit before the existing one is completely exhausted.

2.5 Enset and household financial security

Not only does enset play a major role in the daily food supply of households and bridges the gap between the cropping seasons, but also plays a major role as an asset. It is a form of financial security against crop failures, as it is used to pay annual land taxes and provides a buffer in the case of illness or any unexpected expenses.

Selected enset plants, usually bigger in size, are kept as a cash reserve and are usually sold as a standing plant by the (male) head of the household before being processed. When he sells the plants, he sometimes but not always confers with his wife. The routine household financial requirements are secured by the woman (wife). She buys family supplies by selling the fermented *kocho* or *bulla* in the market. Unlike cereals or other crops where the men dominate the sale, with enset women do the selling of enset products. Women can take a portion of fermented *kocho* or *bulla* from the storage pit for sale to the nearby markets to fulfill household needs at any time.

2.6 An overview of enset research in Ethiopia and existing gaps

Enset research in the country started in the early 1970's. In Holleta, one of the research centers of the Institute of Agricultural Research, sixty clones were collected from limited enset growing areas (Chebona Gurage, Kembata, Hadiya and Sidamo areas) in 1972. This number was later increased to 103 accessions of which only 80 accessions produced suckers for propagation. In 1976 the enset project was moved to Wolaita Sodo under the Wolaita Agricultural Development Unit (WADU). WADU was closed in 1982 when the project was phased out. However, most of the valuable collection maintained under WADU was lost due to poor staffing, lack of accountability and the nature of the crop, which needs to be vegetatively propagated and maintained on farm (Gebremariam, 1996). Research at that time was focused on selecting clones for early maturity and food yield. Likewise, similar initiatives were undertaken to collect and investigate about sixty clones of enset germplasm at Debrezeit research center of the Alemaya College of Agriculture (now Alemaya University).

The research on enset at Debrezeit focused on assessing the food and fiber yields of clones, studying its agronomic and morphological characteristics, and the effect of length of fermentation on nutrition quality (Bezuneh, 1980). Research in these sites has shown yields of enset ranging between 30-50 t/ha, depending on the type of clone. This is a high yield compared to yields of cereals or pulses (Gebremariam, 1996). Apart from the yield studies at Debrezeit, Bezuneh studied the morphology of the enset embryo and the seed germination behavior, emphasizing the significance of the enset seed or embryo as an alternative means of reproduction and as a strategy to broaden the genetic base of the crop (Bezuneh, 1980).

Between the years 1988 and 1992, during establishment of the enset research center at Areka, about 195 clones were collected and maintained at the center. Now the country's total collection is said to have reached 400 accessions. Evaluations have been carried out on yields and other agronomic and morphological characters, but no breeding efforts have been recorded, using either conventional or modern techniques.

The Ethiopian Institute of Biodiversity Conservation and Research has collected and maintained over 258 accessions (only 0.5% of its total holdings) *ex situ* in the field genebank. The Institute has also initiated the *in situ* (on farm) conservation of enset in selected enset growing areas. Apart from the above-mentioned research by formal research institutions, some reports are available on agronomic and socio-economic studies by NGOs such as FARM Africa and by a few other scientists. These groups have carried out need assessments and other informal surveys (rapid rural appraisal) in some enset growing areas such as North Omo, Gurage Hadiya and Sidama.

Despite the efforts made, no substantial results have been achieved that contribute to the improvement of the crop and solve the existing problems of enset farm households. The research on the crop carried out during the last few decades was not very efficient and applicable. No improved technical packages have been promoted to farmers so far. There is lack of coordination of research, and research has not focused on identifying the acute problems of production, processing and marketing of the crop.

Chapter 3 The study design

In the earlier chapters, it was elucidated that the main objective of this research was to identify linkages between use and conservation of the genetic resource of enset. In this chapter a conceptual model is presented in which concepts related to the study are accommodated. Each concept will be defined and discussed. Furthermore, research questions on which the design and formulation of the questionnaire for primary data collection was based, are also presented.

3.1 Conceptual framework

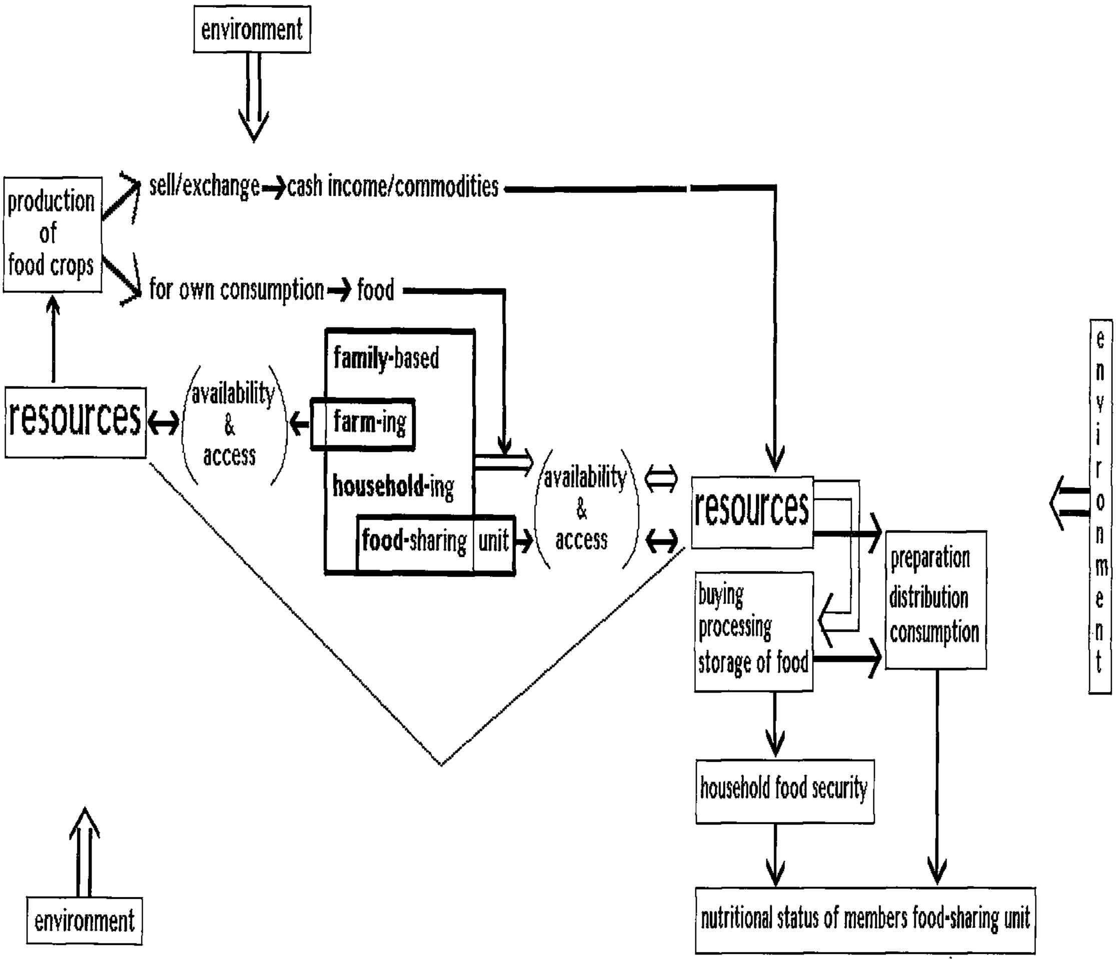
The household is an important socio-economic unit that generates food and livelihood security for its members (Niehof, 1998). It is a dynamic system and its food and livelihood security can be altered and affected by changes in the household composition, genetic diversity maintained, the production situations, or by changes in the environment. In the framework of Hardon-Baars (1994), the elements of the household system are represented in a model. A household uses inputs (human and non-human resources and assets) in which those inputs through processing will be transformed into the final outputs (food situation, nutrition, livelihood of members). These transformation processes involving resources are termed as throughputs (the household practices and strategies).

The relationship between households and the food chain has been presented in the model developed by Niehof (1998). In her model (Fig. 3.1), householding and farming are connected in several ways. It also shows how outputs resulting from agrarian production, enter into the farming household in the form of food, money or commodity exchanged for food. In this case resources necessary for these activities are shared and in doing so, a particular farming practice will have an impact on the functioning of the household and ultimately on its food and nutrition security (Niehof,1998). However, in the model the production side has not been much worked out. In order to fill this gap, my model shows the integration (Fig. 3.2). Using Niehof's model as a point of departure, the new model has been composed to show a complete picture of the farming-household-food system including production, maintenance, preparation, distribution and consumption. The model also shows how the conservation of agro-biodiversity of food crops (the crop enset in this case) relates to household food security. In the processes going on in household livelihood systems, there is a continuous interaction between the components of factors in the system, which in the end influences the well being of household members.

The components of household practices and strategies, household resources and assets, and the interactions with agricultural biodiversity in order to attain food security in farming households, are shown in the model (fig. 3.2). These interactions of the natural environment, genetic diversity resource base (*in situ* and *ex situ* systems) and the household system are interrelated in a given agro-ecological context. Agricultural biodiversity in general is regarded as holistic (it results from social and ecological systems), integrative (it brings together the economic, cultural and ecological functions), and hierarchical (biodiversity is manifested and is affected by factors occurring at all levels of the society (SEARCA, 1997).

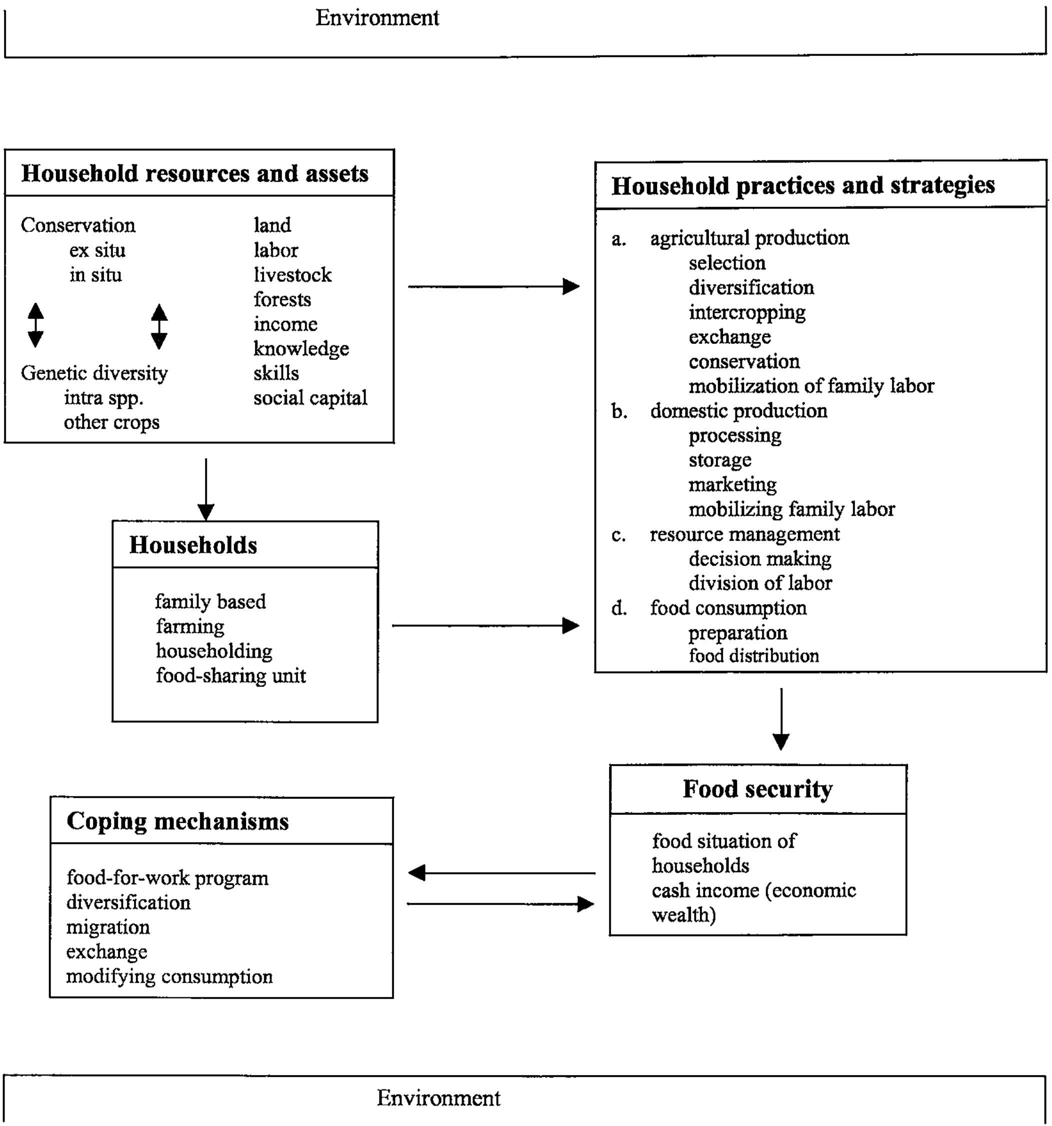
In a specific agro-ecological context, a given farming system has an impact on the functioning of the household and on its food and nutritional security. Sustainable management of the available resources is a dynamic process and is done through maintaining as much diversity as desirable under a given set of circumstances. It is stated in Frankenberger *et al.* (1993), that sustainable management of natural resources is a basic requirement for food security at the household level of rural households, that depend on autonomous farming systems characterized by low external inputs. Rural households acquire food through farming of their lands and cultivating crops. There are situations, however, where a farm household buys additional food substitutes to fulfill the needs of its members. Obviously only farming households that are well off can sustainably feed their members all year round from own production. When land is scarce, and only little is produced, some members perform off-farm activities, or seasonally migrate to earn extra income in order to be able to procure enough food. Given the limited natural resource base, decisions made within the household will determine the allocation and distribution of resources such as land, labor, plant genetic resources or income to ensure food security at the household level. Farm households, therefore, depending on the available resources (land, capital, labor, genetic resources, etc.), perform various activities to produce food and income. Intra-household decision-making, division of labor and access to and control over the resources, are all relevant variables in this respect (Maxwell and Frankenberger, 1992, Hardon Baars, 1990). As resources are limited, access is unequal among household members and the distribution (share) of food within the household also varies.

Fig.3.1 Linkage between household and the food chain



Source: Niehof, 1998

Fig. 3.2 Linkages between diversity, conservation and food security



In the context of this study, gender is an important variable, as it influences the functioning of farm households and the patterns of preparation, distribution and consumption of food in the household's food system. It refers to the socially defined roles and responsibilities between men and women. The social division of labour is usually gender based, as there are farm activities, which require either male labour or female labour. At the household level, major decisions are also made about the management and use of genetic resources as part of their livelihood strategies. According to Moser (1993:27), most women especially in low-income countries have triple roles. The first is their reproductive role, which comprises childbearing, child rearing, and domestic tasks required in guaranteeing the maintenance and reproduction of the labour force in the household. The second is the productive role that women play as income earners, which in most rural settings usually comprises the agricultural work. The third is the '*community managing*' work that they undertake for the provision of community needs. Boserup (1970) has described African women as farmers "par excellence". Women contribute in their capacity as farm partners and farm labourers. They are involved in crop production, processing and storage to feed the family and generate income for the household. While women are the mainstay of small-scale agriculture, the farm labour force and day-to-day family subsistence, they have more difficulties than men in gaining access to resources such as land, credit and productivity-enhancing inputs and services (FAO, 1996).

3.2 Definition of concepts

The major concepts in which the study will focus are: household, genetic diversity, conservation (*ex situ, in situ*), coping strategies and food and livelihood security. These key concepts will be defined as they are applied in the study.

The household

Households in this study will be seen as the unit of analysis. The household is a social group so ubiquitous in human society that it is easy to take it for granted. Its form varies: monogamous and polygamous, patrilocal and matrilocal, nuclear and extended, with and without servants, however no universal common functions or activities seem to exist (Netting, 1993). Though the household is a universal phenomenon, there is no standard definition for it. However, in all instances, domestic groupings of kin can be recognized with a corporate character and identity reflected in the use of terms such as family, house, hearth, or those who eat from a common pot. The household is seen as the next biggest unit on the social map after the individual (Hammel, 1980). In many literature entries, dealing with household food security, households and its practices are given due attention, though this unit of analysis is yet to be investigated systematically.

According to the Ethiopian Statistical Office (1995), a household or an agricultural household is defined as:

A one person household-a person who makes provision for his own food or other essentials for living without combining with any other person to form part of a multi-person household or;

A multi-person household- a group of two or more persons, who live together and make common provision for food or other essentials for living. The persons in the group may pool their incomes and have a common budget to a greater or lesser extent. They may be related or unrelated persons or a combination of both.

Agricultural household- household is considered to be an agricultural household when at least one member of the household is engaged in growing crops and/or breeding and raising livestock in private or in partnership with others.

Farming households according to Niehof (1998) are distinguished as having two domains: the farm and the household, the first dealing with agricultural production and the second one intended for domestic production (see model). A farming household with respect to this study can be defined as a family-based group of people, that form a household, share farm or farming resources and assets and consume or sell their farm produce. Moreover, a farm household may own land obtained either by inheritance or land distribution, is composed of a group of related people (by blood, marriage, or adoption), usually an extended family, and pool labor and other necessary inputs for the production of crops and livestock. The man (husband) by tradition is the head of the household who controls the resources and makes most of the household decisions. A female (wife) is considered as a head (*de jure*) only when the husband is deceased, gone permanently or when she is divorced. In some areas, where polygamy prevails, the man still continues to be the head for all his wives who live in separate houses in the same premises or in different locations. Although the functioning of a household is dependent on the patterns of sharing resources and expenses between the household members in order to fulfill the primary needs of the members, kinship plays the major role in the household formation or composition.

Among many definitions of a household given in literature, Rudie's (1995:228), definition: 'a co-residential unit, usually family-based in some way, which takes care of resource management and the primary needs of its members' has been considered most relevant in the context of this study (see Fig. 3.1).

In neo-classical models, the household is seen as the smallest unit of analysis and the different positions of individual members of the household were not given attention. Those models assumed that among household members consensus exists on goals, and on allocation of resources. However, research done in households of various cultures have shown that members of households can have different goals of production, have varying degree of access to resources, and uneven distribution of welfare. It is also stated in Niehof (1998) that theorising the household as an undifferentiated unit leads to underestimating gender related power inequities.

Hardon-Baars (1990) states that the household has a buffer function in any given society. She further noted that, when the formal money-based economy is growing, certain activities of the household could, if resources like money permit, be transferred to the formal economy. When the formal economy is decreasing as a result of economic decline, the household will take up such activities again. As has been mentioned above, different members of households play varying roles in sustaining the household. In most of the cases, the degree of the allocation or the division of labour is unequal.

In most African countries, the labor of women is more important in all aspects of food production than that of men. In the enset culture in Ethiopia for instance, men are involved only during the early stages i.e. land preparation, planting and transplanting. Otherwise, the weeding, harvesting, processing and marketing of enset are the sole responsibility of the women. Women also have to perform other duties in the house such as collecting fuel wood, fetching water, cooking, caring for children, etc. Therefore in many ways women play a significant role in the food supply system of the household through their productive labour, and their income is used to fulfil the needs of the household members. A World Bank perspective study estimated that women are responsible for about 70% of the staple food production in Africa. Their labour contribution to export crop and informal trade is also highly significant (World Bank Guide, 1989).

In general, the role of women in the household should be given special attention as they often have different management objectives and tasks and responsibilities distinct from those of men. In situations where they are said to play minor roles in field production directly, women still play a crucial role in maintaining food security (Niehof, 1999b). Children also take part in household activities either directly or indirectly, by looking after the cattle, protecting the farm from attack by wild animals, or by taking part in the farm activities (planting, weeding, etc.). They often are the main work force in various activities in the house i.e. fuel wood collection, looking after their younger brothers and sisters, and collecting water.

The functioning of the families and households is critical to the development of any community. The study of households will therefore, help to gain more insight into their functioning and contribution to development. It is imperative to view the dynamics of a household and examine the various processes and activities pursued by the household members, in order to be able to address the issues.

Genetic diversity

Genetic diversity in scientific terms is defined as: variation in the genetic composition of individuals within or among species, the heritable variation within and among populations. Genetic diversity forms the basis of domestication of crops and animals and the development of cultivars and races since the beginning of agriculture. It has been maintained *in situ* in a natural process of co-evolution in the various farming systems by farmers or in the natural environment. Variation within crop species is created as a result of genotype differences and interactions.

In traditional farming practices, farmers have played a major role in maintaining and improving the diversity existing in their habitats. In these traditional farming systems, farmers maintained whatever new and attractive form they observed as a result of either natural or artificial selection. Many new varieties were developed in the process, which are productive and highly adapted to the local situation.

Through accumulated experience, farmers have developed criteria for identifying, classifying and characterising their varieties. In every farming system in Ethiopia for instance, farmers are breeders of their own materials and they have a socially and culturally constructed classification system for every crop species. In the enset-based farming system, farmers have set criteria for classification of enset such as colour of leaf and pseudostem, leaf width, pseudostem length and width, growth period etc. based on which they have named several hundred enset landraces across the various ethnic groups. This phenotypic classification has now been used as a basis for scientific work on the crop. However, when modern breeding programmes progressed, the role of farmers in maintaining diversity and crop improvement was gradually taken over and farmers tended to loose the diversity they had developed. This is attributed to the fact that breeders are more interested in uniformity for a desired characteristic, while farmers are interested in diversity as a mechanism for minimising risk against any environmental uncertainties.

In situ conservation

In situ conservation is a conservation method that attempts to preserve the genetic integrity of germplasm resources by conserving them within the dynamic ecosystems of their original habitat or natural environment. It is a strategy for maintaining diversity under a condition where the variation is inherently maintained. It involves the maintenance of genetic resources with due regard to the natural ecosystem and allows evolution to continue. Both wild and domesticated plants can be conserved *in situ*.

For crops, *in situ* conservation includes the continuing cultivation of crops, in particular in a farming system in which those crops have evolved. Crops co-evolve with pests, diseases and weeds existing in a given environment. The diversity of crops maintained *in situ* is a security mechanism and also serves as a source of desirable genes for several characteristics in crop improvement programmes.

On-farm (*in situ*) conservation, as a subcategory of *in situ* conservation, has been defined as conservation by farmers who continue cultivation and management of plant populations in the agro ecosystems where the crops have evolved (Bellon *et al.*, 1998). It is dynamic as the varieties that farmers manage continue to evolve in response to selection pressure. On-farm conservation emphasises the role of farmers indicating that crops are not only the result of natural selection but also of human selection and management. It also signifies that farmers' decisions determine which germplasm materials are maintained. On-farm conservation therefore depends on the active management of farmers, and on their reasoning behind the management practices.

A formal *in situ* conservation program for cultivated crops was initiated in Ethiopia in 1988 (Worede and Mekbib, 1993). It is complimentary to the informal *in situ* (on farm) maintenance of crop landraces by farmers with the major objective to support the farming communities in their efforts of maintaining crop diversity and producing food for their household as well as for the whole country. Landraces maintained *in situ* are believed to have a wide range of adaptation and serve as a source of breeding materials for resistance to drought and other stress conditions. Farmers can also select special lines to meet their changing needs and demands.

The Ethiopian *in situ* conservation efforts are designed considering the diversity in crop species, cropping patterns, and cultural practices and factors contributing to the disturbance of the traditional way of maintaining diversity. These efforts have been decentralised and there is broader participation of farmers and other groups (FAO, 1996).

Ex situ conservation

Ex situ conservation is a conservation method that entails removal of germplasm resources (seed, pollen, individual organisms, etc.) from their original habitat or natural environment, and keeping these components of biodiversity alive outside of their original habitat or natural environment. It may involve various means to maintain the germplasm such as community and botanical gardens, field gene banks, traditional and modern refrigerated storage facilities, arboreta, community seed banks, etc. and is often implemented without direct linkages to the natural ecosystem.

The *ex situ* conserved materials are highly dependent on human interference. Further more, materials stored under controlled storage facilities have their evolution arrested and loss of viability, which results in genetic erosion, is also prevalent. However, these materials, which are maintained either in the form of seed or *in vitro* are used as backup collections and are accessible for immediate use in breeding and research. They are also used for restoration of types into their original habitat where the germplasm has been lost due to man-made and/or natural factors.

Household Food security

Although the concept of food security has been highlighted in the early 1970's i.e. during the world food conference in Rome (RAWOO, 1986), most of the definitions or concepts until very recently have focused on global or regional levels. Little attention was paid to the national, or community level, which has a major role to play in any country's food and livelihood situation. The national economy or GDP of a given country that is dependent on agriculture can grow if and only if there is enough labour and production or if the level of income of that community is growing, though the strata and levels of income may vary.

In the literature (Maxwell and Frankenberger, 1992), quite a number of definitions are presented which may be influential and summarising agency views. In general, many of the definitions and conceptual models agree with the key defining characteristics of household food security. Despite the arguments that operationalizing the concept at the household level is different from the national level, a definition by the World Bank is deemed relevant in this study as it is the most common and frequently used definition. It states that it is a condition in which all people at all times have access to the food they need for a healthy, and active life (World Bank, 1986). Food security has four dimensions: availability, accessibility, safety and reliability. A country and people are food secure when their food system operates in such a way to remove the fear that there will not be enough to eat. In particular, food security will be achieved when the poor and vulnerable, particularly women and children and those living in marginal areas, have secure access to the food they want (Maxwell, 1988). It is also stated (Maxwell, 1991) that food security will be achieved when equitable growth ensures that the poor and vulnerable have sustainable livelihoods. Rural food security can be best met by local measures to raise farm output of locally consumed basic foodstuffs. Production of a food surplus, in response to guaranteed markets, will provide additional income for the producers through increased food products, which can be supplied to urban areas or markets.

Food security at the household level refers to the ability of the household to secure adequate food either by producing it or through purchase in order to meet the dietary requirements of its members. Food should be available throughout the year to sustain household energy and health, and to meet nutritional requirements. The availability of food must be coupled with the ability of every household to acquire it i.e. it must be affordable by the poor (FAO, 1999b). Access to food can be gained at a micro- level (household) through entitlements, assets and strategies. Households have different entitlements to these resources and assets, that enable them to produce food and hence it is imperative to view food security at a household level. In literature, household food security as a concept is in most cases not explicitly discussed.

If a country is food secure, this should imply to the availability of and access to adequate food both in terms of quantity and quality for its entire nation. A food secure country should be able to generate a sufficient level of production to feed its citizens. However, in some countries such as Ethiopia, this is not the case, as income and living conditions among communities are unequally distributed. Access to the different resources varies significantly, i.e. some households are food secure, have access to land and other resources, while others have not. Food security should be seen to have three specific elements: ensuring production of adequate food supplies; maximising stability in the flow of supplies; and securing access to available supplies on the part of those who need them (Dey, 1984). Moreover, setting national and international goals to achieve food security becomes even more difficult for two reasons. First, rural food consumption patterns are diverse involving the consumption of different crops and second, their diversity aggravates the problem of ensuring rural food security through formal channels.

The concepts of household food security as well as the risk of food insecurity to a household have also been explained by an equation (Foster, 1992).

$$\left\{\begin{array}{l}\text{HH food}\\\text{consumption}\\\text{requirement}\end{array}\right. - \left.\begin{array}{l}\text{HH food}\\\text{production}\end{array}\right\} \times \begin{array}{l}\text{price of}\\\text{food}\end{array} \leq \begin{array}{l}\text{income and liquid}\\\text{assets available to}\\\text{purchase food}\end{array}$$

The equation compares the deficits in the value of food production in a household with the income and liquid assets that are available in the household in order to purchase food. In practice, households can produce food which sometimes is not enough depending on the available resources such as land. Therefore their food production deficits have to be compensated for by the purchase of food. Moreover, the imbalance between the variables in the equation can be influenced by the size and composition of the household, which determine the consumption requirement. The differences between the household food consumption requirements and the amount of food production, as well as the existing market prices for food may cause food insecurity. When the household food production capacity is greater, then the need to purchase food for consumption will be lower. The imbalance between the variables on the two sides in the equation can provide explanations for household food security problems.

The ability of a household to command adequate food resources through self-production or market transactions is primarily dependent upon assets and/or income (Berck *et al.,* 1993). In some of the agrarian societies, land ownership has been shown to be a sensitive indicator of wealth, and many studies have indicated that under-nutrition is associated with lack of such a productive asset and/or low effective income.

Benson *et al.* (1986) define household food security as a household having assured sets of entitlements from food production, cash income, reserves of food or assets and or government assistance programmes, such that in times of need the household will be able to secure sufficient nutritional intake for the physical well-being of its members. Such a situation implies that a household has the capacity to procure adequate food supplies on a stable basis and in a sustainable manner. Thus a state of household food security also satisfies three essential conditions; a capacity to procure adequate food supplies, the stability, and the sustainability of these supplies (Frankenberger *et al.,* 1993).

However, there are cases where the household's production capacity is limited to hand to mouth provision, and conditions, which do not allow for government assistance (food aid). Hence, households are forced to migrate for wage labour or food for work programmes. In communities marked by land holding and income inequalities, household responses to food shortages occur differently along the lines of wealth and access to resources (Longhurst, 1987). Therefore, communities or households depending on their status, always develop a strategy for coping with temporary or permanent food shortages in various ways. This fact is exemplified in a model defined by Watts (1988). The model shows how households respond to food shortages, the sequence of responses that the farming household employs when they are faced with severe food shortage, as well as the level of commitment of the household resources.

Livelihood security

Chambers (1989:7) defines livelihood as "adequate stocks and flows of food and cash to meet basic needs" and security as 'to secure ownership of, or access to, resources and income-earning activities, including reserves and assets to offset risks, ease shocks and meet contingencies'. Livelihood is more directed towards seeking to assure command over flows of food, over productive assets such as land, water and forests, and over common property resources. It is also aimed towards assets, which can be used, as a buffer against impoverishment by enabling the poor people to meet major needs. When analysing livelihoods, Chen (1990) stresses that gender is the basic variable in understanding household behaviour, as women's roles are central to the generation of these livelihoods. Livelihood generation according to Niehof and Price (2001) refers to the cluster of interrelated activities that people (households) undertake with the resources and assets at their disposal in order to meet their basic needs.

According to Maxwell and Frankenberger (1992), the achievement of food security corresponds to a sub-set of livelihood objectives and food is one of a whole range of factors, which determine why the poor make decisions to spread risk. It also refers to how they smoothly balance competing interests in order to subsist both in the short and long term. Livelihood opportunities are the key to long-term stability of the households food supply system. Livelihood security is seen as a more encompassing concept than food security although overlap exists between the two concepts (Niehof and Price, 2001). This implies that households with secure and sustainable livelihoods are also food secure. However, food secure households are not always livelihood secure.

Livelihood security also goes beyond the food security concept and nowadays has been acknowledged as a concept that better captures how the poor live and which diverse strategies they employ in order to survive. De Waal (1989) reported that people chose to go hungry in order to preserve their assets and future livelihoods during the 1984/85 famines in Sudan. He further argued that "people are quite prepared to put up with a considerable degrees of hunger, in order to preserve seed for planting, cultivate their own fields, or avoid having to sell an animal". Similarly, in Ethiopia, farmers always retain some seed stock of several crops and store them in clay pots, rock-hewn mortars, or underground pits, which are sealed, buried or stored in other secure places as a reserve for planting (Worede, 1990).

For most of the rural poor the concept of livelihood security may better suit their circumstances, as it considers the stocks and flows of food and cash that provide the physical and social well-being and security against impoverishment. Chen (1990), in his framework for livelihood systems, discusses the mix of individual and household survival strategies that are used to mobilise the available resources. Livelihood systems are dynamic and provide a fuller understanding of the activities of the members of the household. All the available resources and opportunities are mobilised to generate livelihoods. Resources include the physical assets (land, capital, etc.), human assets (time skills) and the social capital. Opportunities (social resources) include kin and friendship, and partnership relations. Resources are significant in understanding the dynamics of the household and are the means to attaining food and livelihood security.

3.3 Coping mechanisms and production strategies aimed at minimising risk

Niehof and Price (2001:16) state that, "In the livelihood strategies employed by rural households, coping strategies are a particular kind of strategy which are aimed at dealing with recurrent, hence foreseeable, situations of stress". According to Anderson *et al.* (1994:20), a strategy is "the overall way in which individuals, and possible collectivities, consciously seek to structure, in a coherent way, actions within a relatively long-term perspective". When distinguishing coping strategies from coping, Davies (1993:60) also defines coping as a short-term response to an immediate and irregular decline in access to food. Coping strategies are therefore the package of poor people's responses to declining food availability and entitlements in irregular seasons during the years.

Households do not respond arbitrarily to variability in food supply and as a result, people living in conditions where their main sources of income and food are under recurrent threat develop strategies to minimise risk to their immediate food security and to the long-term livelihood security (Frankenberger and Goldstein, 1990).

While coping strategies may be useful in the short-term, they may not be sound for long-term development and are not necessarily sustainable either environmentally or economically. A focus on coping strategies also hides the (increasing) need of rural producers to develop livelihood strategies, which will provide for greater number of people in the future (Davies, 1993). Poor people may have pre-planned strategies in their livelihood system to overcome an exceptionally severe event of food insecurity. There are circumstances, for instance when famine risks are endemic, in which farming households may need to alter their livelihood strategies to survive.

Farm households develop strategies in which they structure their farm activities based on their intended plan. These livelihood strategies are part of the system's throughput, which are the household practices and strategies aimed at agricultural and domestic production, and food consumption, while decision-making and management are needed for the implementation of the strategy (Niehof and Price, 2001). Within the household, in most of the cases, strategies are designed jointly by the household members. However, when there are specific budget responsibilities assigned to male and female, different individuals may adopt different strategies both for the benefit of securing the livelihood of themselves as well as other members. The range of means and sequence of responses to food insecurity is diverse and also complex. It varies by region, community, social group, gender, age and season (Chambers, 1989). The pattern and types of strategies employed by households also varies depending on the intensity and the duration of food insecurity.

The need to identify and analyse the various sources of farm risk and how households cope with them has became increasingly important as a result of the continuing food crises in sub-Saharan Africa (Taal, 1989). Studies done in the Gambia have indicated the range of sources of risk faced by farmers, their seasonal exposure to risks and stresses, and their strategies for coping and how this has changed over time. Farmers tend to allocate their resources in order to assure survival, especially in difficult years of low rainfall, crop failure and food shortage. Reduced food consumption as a resource management strategy becomes also more pronounced when food stocks are low and minimum harvest is expected due to environmental uncertainties.

The range of household coping strategies both in drought situations or seasonal variations includes adapting or diversifying activities in the households, seeking employment, or drawing on inventories. It further includes modifying or reducing consumption, borrowing money or goods, disposing of assets and migration. Farm households constantly develop strategies to cope with changing situations through time. The mechanisms by which farmers can reduce the risk of crop failure or cope with food insecurity vary from place to place and depend also on the levels of distress involved. But some general patterns of coping with such problems have been identified.

Corbett (1988) found that preservation of assets takes priority over meeting immediate food needs until the point of destitution, when all options have been exhausted. He has summarised a sequence of responses that households employ to deal with food insecurity, and divided these into three broad stages: a. insurance mechanisms, e.g. changes in cropping patterns and planting practices, reduced consumption, inter-household transfers, etc. b. disposal of productive assets (divestment), e.g. sale of large livestock, agricultural tools, mortgaging of land or obtaining credit, and c. destitution, e.g. distress, migration (of household members for wage labour and sending of remittances) and starvation. In addition, even within the same community strategies vary sharply between rich and poor households, and in general those whose main source of income is at risk will develop self-insurance coping strategies to minimise risks to household food and livelihood security. Under subsistence agriculture, in the Ethiopian context, farm households use the following strategies in order to overcome food insecurity:

- Diversification of farming systems (in cases where enough land is available), i.e. growing of different crops considering the fact that the failure of one crop will be compensated by the other and hence risk will be minimised.
- Exchange or borrowing of food grain or planting materials from neighbours, kin or relatives (based on certain agreements) to overcome seasonal food shortages.
- Inter-cropping early maturing legumes or vegetables with a perennial crop such as enset and coffee.

- Migration to cities, state farms, food for work programs (usually men) and wage labour to send remittances while women take all the responsibility of the household.
- Polygamous marriages as a means to expand land holdings and to increase household labour

3.4 Research Questions and hypothesis

In this study the emphasis has been laid on how the farm households are faced with food insecurity and how they overcome food insecurity in the context of the existing farming systems.

Questions Raised

It is clear that enset is a major food crop in some regions of Ethiopia and that it forms an integral part of the cropping system of many farmers. However, the available information on enset is largely descriptive and anecdotal. The present study aims to address issues of genetic diversity related to use and sustainability.

These issues are placed in the wider context of livelihood systems and this has raised a number of research questions. Furthermore, the design and formulation of the questionnaire, on which the primary data have been gathered, depended on these questions, listed below.

Research questions

1. Farmers in the Southern region of Ethiopia are said to be dependent on enset as their staple food and several clones are conserved by every household in their backyard. Therefore, does maintenance of diversity of the enset crop contribute to food security and livelihoods of the farming households?
2. How do farmers characterise the different enset clones? Do they have specific preferences for the different clones? What are their selection and classification criteria and who takes part in the selection of clones?
3. Gender roles: How is the division of labour and decision making in enset production, processing, and marketing in the household organised?
4. Are there any changes in the production of enset now and several years' back? Does the change in population bring a change in the cultivation of enset?

5. Will tissue culture techniques such as micro-propagation and *in vitro* conservation solve some of the farmers' conservation and propagation problems?
6. How does farmer's classification of clones correlate to the results of scientific methods making use of molecular markers?

In general, the conceptual framework emanates from the idea of investigating the relationship between maintaining diversity and household food security in the farming households of the study area. Therefore, a hypothesis around which the data analysis converges has been formulated as follows:

By maintaining enset diversity, a subsistence farmer can secure food self-sufficiency and therefore, a positive relationship exists between conserving the diversity of genetic resources of enset and household food security.

The major factors contributing to food security at the household level including crop diversity will be considered. Households are the unit of analysis and, during the process of data collection, the main focus was on household heads (both men-headed and women-headed households) and wives (in the case of men-headed households) because of the accumulated knowledge on their crops and on traditional farming systems.

The following points suggest the linkages or relationships between conserving the genetic diversity of enset and household uses, which will be further, elaborated upon in the forthcoming chapters.

1. Farmers maintain enset landraces for different purposes i.e. some clones are maintained for consumption, some for sale in order to generate household income, some for their medicinal uses, etc. If that variation can be verified and/or be correlated at the genetic level, then conservation strategies are related to use.

2. Traditionally or according to some literature entries, (e.g. Brandt *et al.* 1997), in the enset based farming system, farmers having many clones are said to be wealthier than those having few clones (both in terms of number and variability). Therefore, if the standard of living of households having many diverse clones can really be distinguished from the others by analysing the various socio-economic data collected from the different household strata using various indicators of wealth including

diversity, then we can rightly say that maintaining clonal diversity contributes to food security and income generation.

3. Farmers have set certain criteria for classifying clones, and women farmers especially are said to be experts in selection of clones for quality, taste, yield, etc. If the different clones classified by farmers can be distinguished scientifically using molecular markers then we can say that indigenous knowledge plays a major role in the conservation and use of plant genetic resources.

4. Knowing the farmers' propagation problems and assisting or backing them by providing them with sufficient desirable planting materials means enabling them to produce more, and to increase their selection options (for food, income, medicine, etc.). If materials are maintained *ex situ (in vitro)*, it is possible to introduce or reintroduce it to the farmers whenever the need arises and this increases the possibility for farmers to get insurance against any natural or man-made erosion which might threaten their production. This creates/strengthens the link between the formal (institutional) and informal (farmers) conservation strategies and bridges the so far existing gaps.

Chapter 4 Introducing the Research area

This chapter provides information on the description of the Southern region of Ethiopia and that of the study sites including climate and agro-ecological zonation. Secondary data on demographic characteristics such as size and composition of households, male-female population, etc. are presented. As the Southern region is characterized by multi ethnicity, several languages, and religious denominations, these issues are also addressed. Likewise, cropping patterns both for enset and other crops are presented.

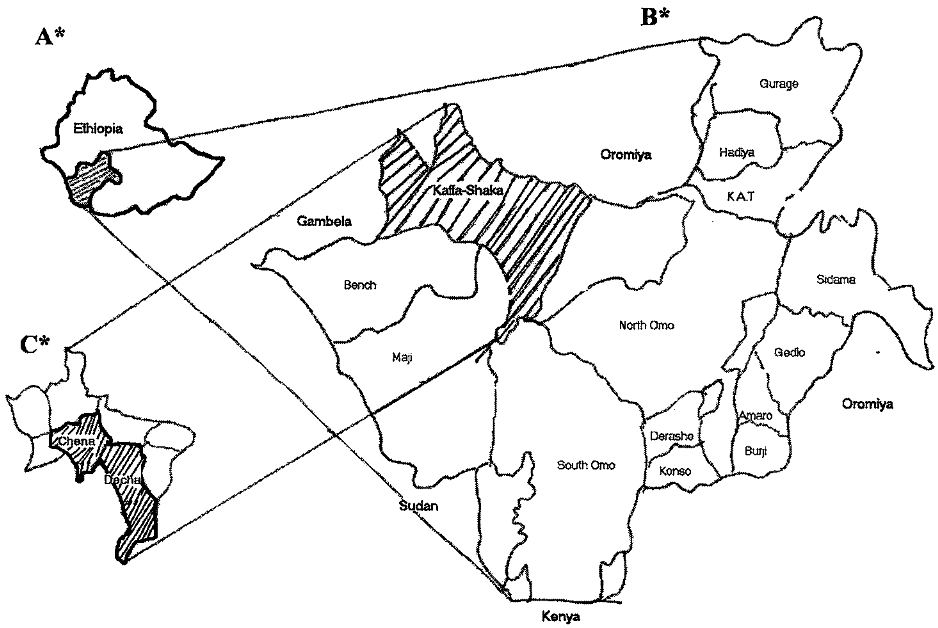
4.1 Location

Ethiopia is a federal republic consisting of nine ethnically based administrative regions with the federal capital being Addis Ababa. The regional states include Amara, Tigrai, Oromya, Afar, Southern Nation and Nationalities Peoples Region (SNNPR), Benshangul Gumz, Gambella, Somali and Hareri.

This study was conducted in the Kaffa Shaka administrative zone of the Southern Nation, Nationalities and Peoples Region (SNNPR) of Ethiopia. SNNPR is located in the Southwestern part of the country (fig. 4.1), within the tropics of cancer and close to the equatorial region. It borders with Kenya in the south, the Sudan Republic in the southwest, Gambella region in the northwest and Oromya region in the north and east.

The SNNPR covers an area of approximately 118,000 km^2 and accounts for 10% of the total area of the country. It is divided into nine administrative zones and five special *woredas*, which are based on ethnic and language identities. The Kaffa Shaka is one of the nine administrative zones, with the principal town Bonga. It has eight districts (*woredas*) with a total area of 13,198.4 km^2. It accounts for 11.2 percent of the total area of SNNPR. Decha and Chena are the two *woredas* of the zone in which the present study was carried out.

Fig. 4.1 Map showing locations of the study zone and study *woredas* in the Southern Nation Nationalities and Peoples Region



A* Map of Ethiopia

B* Map of the Southern Nation Nationalities and Peoples Region

C* Map of the study zone (Kaffa-Shaka) and the two study *woredas* (Chena and Decha).

4.2 Climate and topography

Kaffa Shaka is characterized by slopped and ragged areas interrupted by rare plain lands. It enjoys a tropical climate. The landscape is rugged with narrow plateau often on water shades, full of gorges, smaller valleys and streams. The altitude of the zone varies considerably as one travels from one administrative *woreda* to the other. It ranges between 700 and 3400 meters above sea level.

The zone receives an adequate amount of rainfall annually, i.e. 1400-1600 mm per annum with only short dry periods. The average annual temperature ranges from 15-26°C. Over fifty percent of the soil is red brown, while black brown and black soil make up thirty and twenty percent of the area respectively. During the rainy season ploughing and cultivation of these soils becomes heavy as a result of water logging.

Kaffa Shaka consists of three agro-ecological zones:

a. High land *(dega)*: 2500-3500 meters above sea level and accounting for 10 percent of the total area;
b. Mid high land (*woinadega*): 1500-2500 meters above sea level and accounting for 70 percent of the total area and
c. Low land (*kolla*): 500-1500 meters above sea level and covering 20 percent of the total area.

All farmers in the zonal administration depend on rainfall for cultivation of their crops. There are two cropping seasons depending on the annual distribution of the rainfall, *meher* (June-mid September), the long rainy season and main cropping season and *belg* (February-June), *the* short rainy season.

The SNNPR is endowed with a variety of natural resources, and it has a large forested area. Some of the registered and protected state forest areas of the region, of which 90 percent consists of natural forest, are found in the Kaffa Shaka zone. A dense natural forest, which dates at least several hundred years back, forms a living reminder of the threatened tropical vegetation. The forests contain a tremendous diversity in species. The Kaffa forest is the source and home for many species including wild enset and *Coffea arabica.*

The zone does not have a well-developed infrastructure such as roads, electricity, etc. Most of the places in the zone are difficult to reach. There are not enough roads to connect the different *woredas* with each other. For the study, this had the implication that poorly accessible areas could not be included in the survey. This is unfortunate because these more remote areas might have been equally interesting in terms of enset genetic diversity.

4.3 Demographic characteristics

The SNNPR is one of the most densely populated areas of the country. It has a higher population density (96.3/km^2) compared to the national average (48 people/km^2). According to the 1994 census, the population of the SNNPR was estimated to be 11.3 million, which accounts for 20 percent of the total population of Ethiopia.

Table 4.1 Population densities of zones and special *woredas* in the SNNPR

Zone/special woreda	Area (km^2)	Population	Density per km^2
Gedeo	4180.4	817163	195.5
Sidama	6793.6	2037752	299.9
North Omo	24541.4	3109167	126.6
South Omo	22146.7	270929	12.2
K.A.T.	3083.9	854357	277.0
Hadya	3404.4	931720	273.7
Gurage	8216.9	1717193	209.0
Kaffa Shaka	13198.4	779659	59.1
Bench Maji	23420.0	379686	16.2
Burji	1783.3	46271	25.9
Amaro	1778.4	84474	47.5
Konso	2657.0	134657	50.7
Derashe	1917.6	113398	59.1
Yem	383.9	43891	114.3
Total	117506.1	11320117	96.3

Source: SNNPR planning bureau, 1996

The Kaffa Shaka zone has a total population of 779, 659 of which 91.3% (711,971) is classified as rural and 8.7% (67,688) as urban population. Moreover, the number of women is 395,039 (50.7%), while that of the men is 384,620 (49.3%) (see Table 4.2). Kaffa Shaka occupies the 7th

place in population after North Omo, Sidama, Gurage, Hadya, Kambata and Gedeo zones of the SNNPR.

In the tables below population profiles and densities from a recent population census for the two study woredas and that of the entire zone are presented in order to demonstrate the changes in population over time. This is the population from which the sample population has been drawn.

Table 4.2 Population size of the study area by sex and rate of annual population growth

	1994/95				1995/96			
	male	female	total	r (%)	male	female	total	r (%)
Decha	36,964	37,828	74,792	2.30	37,812	38,699	76,511	2.31
Chena	75,745	77,901	153,646	2.42	77,570	79,791	157,361	2.42
K.S zone	357,737	367,349	725,086	2.41	366,320	376,233	742,553	2.47

r = rate of annual population growth

	1996/97				1997/98		
	male	female	total	r (%)	male	female	total
Decha	38,680	39,690	78,270	2.42	39,617	40,551	80,168
Chena	79,440	81,730	161,170	2.52	81,440	83,798	165,238
K.S zone	375,638	385,281	760,919	2.50	384,620	395,039	779,659

K.S = Kaffa shaka

Source: Zonal planning bureau, 1998

Table 4.3 Total area and population density of the study area

		Density/km^2			
	Area km^2	1994/95	1995/96	1996/97	1997/98
Decha	2998.88	24.9	25.5	26.1	26.7
Chena	1831.04	83.9	85.9	88.0	90.2
Kaffa-Shaka zone	13,289.24	54.6	55.9	57.3	59.1

Source: Zonal planning bureau, 1998

As can be seen from Table 4.3, the Chena *woreda* has a higher population density with more concentrated human settlements than the zonal average. It is logical that the Decha *woreda* has a lower than average density as much of the area is still covered by forest and therefore, there are less inhabitants than in Chena. In general, the reason that the SNNPR is so densely populated might also be attributed to the share of low-lying sparsely populated nomadic zones and pasturelands in the other parts of the country, which contributed to lower national densities.

Enset-growing areas of the country are reported to accommodate a relatively higher number of people per unit area and hence a relatively high population pressure is a notable feature of the enset-growing regions.

Table 4.4 Number of households of the study woredas and zone by urban and rural population

	1994/95			1995/96		
	Urban	Rural	total	urban	rural	total
Decha	415	16,231	16,646	432	16,595	17,027
Chena	2,805	32,118	34,923	2,923	38,842	35,765
Kaffa Shaka zone	13,686	150,296	163,982	14,231	153,768	167,999

	1996/97			1997/98		
	urban	rural	total	urban	rural	total
Decha	451	16,971	17,422	468	17,377	17,845
Chena	3,045	33,583	36,628	3,165	34,386	37,551
Kaffa shaka zone	14,742	157,260	172,002	15,324	160,906	176,230

Source: Zonal planning bureau, 1998.

In the two study *woredas* of the zone, the average household size is 4.5 for Decha and 4.4 for Chena, according to the zonal planning bureau. From a recent household-level socio-economic survey for the entire region, however, it is reported that the mean household size for SNNPR is 7.0. Data obtained from our survey of the households from the two *woredas* shows that the average size of surveyed households is larger than that of the data given in Table 4.3 and similar to that reported by the UNDP/ECA.

4.4 Ethnicity, language and religion

Basically, the SNNPR is characterized by its multi-ethnic composition. There are over 45 indigenous ethnic groups inhabiting the area, distinguished by distinct languages, cultures and religions. In Kaffa-Shaka, over five different ethnic groups exist including *Kaffecho, Chara, Nao, Zilmamo* and *Shekecho.* In addition, there are other ethnic groups, i.e. *Amara, Oromo, Bench, Dawero*, which have moved from other communities and settled in this region because of socio-economic factors and government policies (villagization).

The languages spoken in the Southern region can be classified into four major linguistic groups, namely *Omotic, Cushitic, Semetic* and *Nilotic.* The majority of the ethnic groups speak the *Omotic* language although Ethio-*semetic* speaking Gurage people occupy south central Ethiopia. The *Omotic* language is sub-divided into the northern and the southern *Omotic* because of slight differences in the language family. The Kaffa Shaka zone belongs to groups speaking the northern *Omotic* language.

As diverse is the ethnicity and language, there are also different religions followed by the inhabitants of the Kaffa-Shaka zone. The religious groups include Orthodox, Protestants, Catholics, and Muslims. Originally, the majority of the villagers adhered to the Orthodox religion, with few Moslem followers present. Nowadays, due to the work of missionaries and non-governmental organizations, which have come to the area in the framework of development aid, the Protestant and Catholic religions seem to have spread significantly.

4.5 Crop Production and land use patterns

The enset regions are among the densest populated areas in the whole of Ethiopia (Westphal, 1975). Although the extent to which the staple crop is supplemented by other crops varies from tribe to tribe, all have a vital interest in enset cultivation.

In Kaffa Shaka, enset is grown as the main staple crop and forms the major food source for 90-95% of the farm households. Its highly developed cultivation is mainly concentrated around the house. Farmers practice mixed farming, cultivating crops and raising livestock. Livestock are kept in the house for safekeeping and for protection against pests. Many other crops are cultivated besides enset. Crops such as coffee, roots and tubers (taro, oromo potato, potato and yam), vegetables and spices are grown in mixture or are intercropped with enset in the same field. Other annual crops such as cereals (teff, maize, barley, wheat, and sorghum), pulses and oil crops (various beans, pea, lentil, niger seed, etc.) are also important and are cultivated on separate fields each year. The spice crop korarima (*Aframomum korarima*), is a very important cash source for farmers, especially in the Decha *woreda.* It is collected mostly from the forest.

The Kaffa people follow a system of shifting cultivation for annual crops although shifting does not occur each year. In gardens, and on small plots, which are close to the house, the hoe is used besides the plough. Furthermore, livestock production is an important aspect of the enset farming system. The manure is used for fertilizing enset fields, whereas farmers in that area never use artificial fertilizers in their enset fields. The animal products are consumed together with enset. Farmers are keen on using cabbage and animal products in combination with enset foods in their daily diet, although this depends on the status of the household. Furthermore, livestock form the main source of income for the household, as they are readily convertible to cash whenever the household is in need of money to pay annual land taxes, fertilizer debt, or medication of household members.

Every household in the study area prefers the use of diverse crop types in the same field and in integrating livestock in their cropping systems. This practice of mixed farming and intercropping is a system, which has been used by farmers for ages. Farmers usually spread risks in this way and simultaneously secure two or more harvests in a year by growing early maturing with those late maturing ones, and annual crops with perennials.

Fig. 4.2 Area devoted to different crops: Decha *woreda*

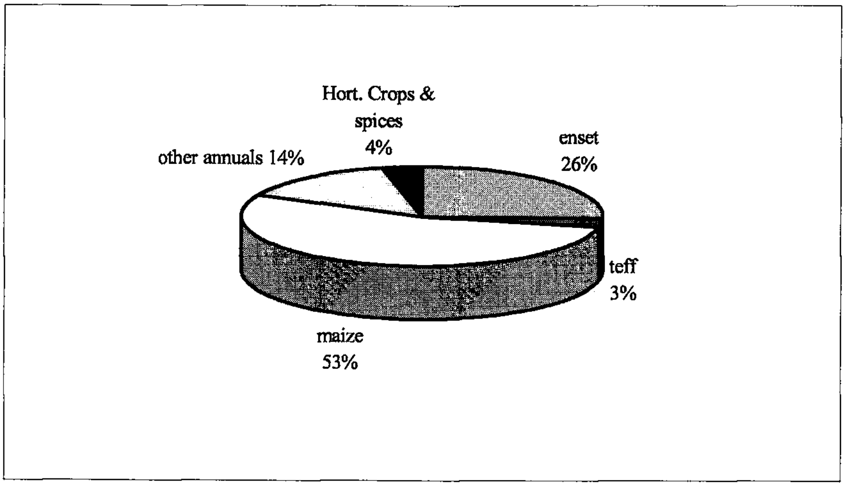
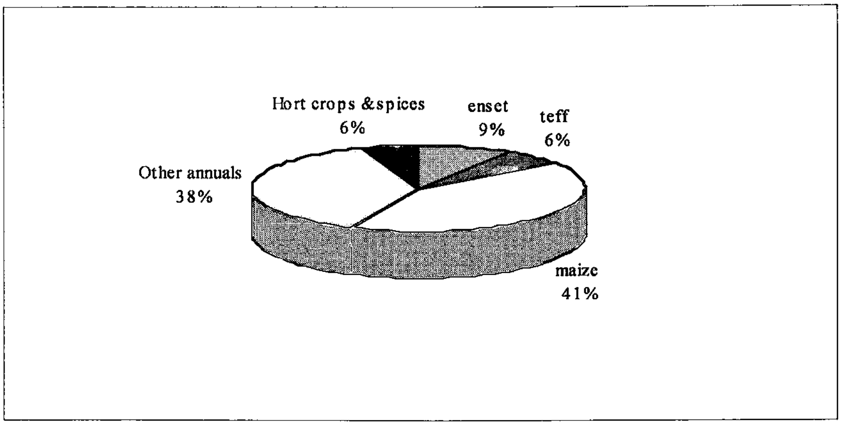


Fig.4.3 Area devoted to different crops: Chena *woreda*



Agricultural land is one of the basic resources or socio-economic assets for farmers' of the SNNPR where the economic strength of any farm family is related to the agricultural land the household possesses. Ownership of land implies regular food supplies for the household and income when crops are sold. Due to population pressure and other factors, the land holdings per family have become very small in Kaffa Shaka as well as other administrative zones of the Southwestern region. This might be the reason why forests are set fire in many places in the Kaffa Shaka area, as farmers are looking for more farmland at the expense of natural forests. These forests however, are assets for farmers as they are sources of cash in terms of collecting and selling wild spices from the forest such as aframomum. They are also sources of many wild herbs and medicinal plants, which are routinely used by farm households.

From the total area of the zone (13,199 km^2) the cultivated land is only 4,281 km^2. The remaining land is either cultivable, grazing, shrub, bushland or forest. The distribution of households by size of agricultural land holding is given as; 0-0.5 ha for 2.02%, 0.5-1 ha for 19.05%, 1-1.5 ha for 29.9% and 1.5-2 ha for 49.03% of the households. These figures, which are reported by the zonal bureau of agriculture, however, vary significantly between *woredas,* as we noticed during a survey of individual households in both *woredas.*

The cropping calendar for enset and other major agricultural crops

Field preparation for enset with the plough or the hoe is conducted in the months October to December. Farmers use different plots for the production of suckers and practice several transplantings till enset plants are brought to the final place of establishment. The production cycle is maintained in such a way that each household plants new seedlings every year in his plot in order to compensate for plants harvested throughout the year. In this case every household will have enset plants of various age groups, which ensures harvesting in any time of the year. According to Bezuneh and Feleke (1966), in the enset based farming system, an average family of 5-6 persons cultivates about 200-400 plants with the annual consumption ranging between 50 to 60 plants. Farmers in Kaffa Shaka as well as most of the enset-producing farmers generally use vegetative propagation and enset seeds are not used for planting.

Between December and February, the corm, which is selected from two-year-old plants, may be uprooted and after cutting of the pseudostem, is then reburied to produce suckers. Following are the different stages of transplanting for the propagation of enset in Kaffa Shaka and the names to indicate these stages;

a. Sucker stage called *uko* in Kaffa language: is the stage where suckers sprout from the mother corm while still attached to it. It lasts about twelve months before they are separated and planted in a different field. The first emerged suckers may be called *dusho.*
b. The second stage is when the suckers are split not in a single plant but in batches of two or three and this is called *buchicho*. This stage also lasts for 12 months.
c. During the third year, seedlings are split into individual plants and these are transferred to their permanent places. This stage is called *gedo* and lasts for over two years.
d. The fourth stage is called *uto* and plants here are over four years old and some early maturing ones depending on the type of clone are ready to be harvested.
e. The last stage is called *udo* or *gameto* and is the stage where the enset plant starts to flower and inflorescence emerges.

When individual enset plants are transplanted to their permanent fields, it can be either to a newly prepared field or to an already existing field with enset plants whereby the new plants are planted next to the existing ones. They usually refill the empty places or holes of plants, which were harvested upon maturity or died after transplantation. Before the final stage, transplanting is done to obtain more closely spaced plants. In general, suckers are transplanted from two to three different places, depending on the availability of land, before the final place is reached.

Weeding of enset fields is done whenever necessary by all family members while women and children apply organic manure on individual plants once or twice a year.

Harvesting of enset is carried out all year round. However, farmers prefer the dry period, as *kocho* quality will be superior. Farmers say that in the dry periods, although the yield on a wet weight basis might be lower, plants do not take up much water and hence the *kocho* tastes better. The rainy season is preferred for preparation of the yeast when there is enough moisture, which will be absorbed by the trunk of the cut pseudostem. This is to prepare and store the yeast for the fermentation of *kocho.*

For annual crops i.e. cereals, pulses and oil crops, cultivation activities follow the distribution of rains. During the main rainy season *(meher)* these crops are produced and usually they are harvested between December and January. Similarly, harvests from the small rainy season fall between April and May. In the following Table 4.5, the seasonal calendar for the major annual crops is presented.

Table 4.5 Seasonal calendar for major agricultural crops

Crops	land preparation	planting	weeding	harvesting
Maize	September	Nov.-Dec.	Jan.-Feb.	April-May
Teff	May	July-Augest	Oct.-Nov.	Dec.-Jan.
Sorghum	February	March-April	June-July	Oct.-Nov.
Barley	June-July	July-Augest	Sept.-Oct	Dec.-Jan.
Fababean	June	July-Augest	Sept.-Oct	Dec.-Jan.
Field pea	June	July-Augest	Sept.-Oct	Dec.-Jan.

Source: Zonal agricultural bureau, 1998

Yields for the major cereal and pulse crops are generally low. Some farmers use improved seeds (hybrid seeds) for maize, which are distributed through the extension program of the Ministry of Agriculture. However, there appears to be no significant yield increase resulting from the use of high-input seeds in the area. One of the reasons might be attributed to the poor accessibility of the region so that high-input packages arrive late in the planting season. Moreover, since households prefer the use of green maize cobs either for consumption or immediate sale, yields at final harvest are relatively low. Teff is also another low yielding crop in the area. Kaffa Shaka is a high rainfall area and as a result the small seeded teff grain is usually overgrown by weeds, which results in a very low yield per hectare.

For other root crops such as taro and yam, which are intercropped with enset, planting activities are usually carried out in February-March while harvesting is done between September and November.

Fig. 4.4 Intercropping of enset with coffee, taro, kale and other horticultural crops in the backyard

4.6 Description of the homestead

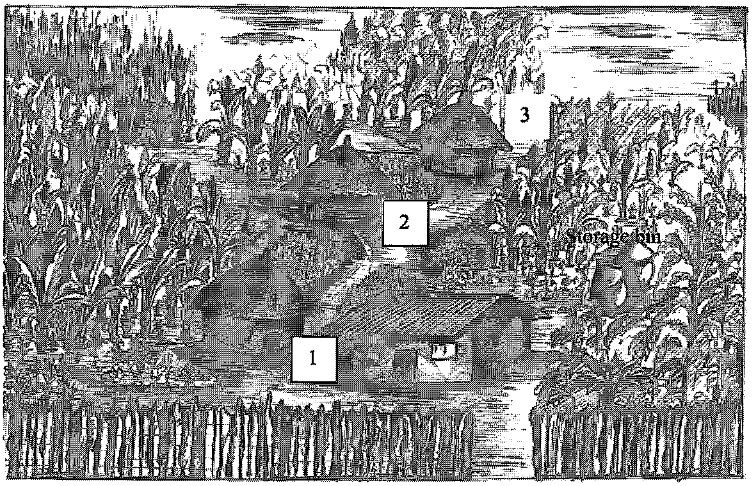
As it has been stated in the previous chapter, the boundaries of the households in the study area are permeable and there is always some overlapping of domestic groups. A working definition of the domestic group was given as: a family-based group of people (related by lood, marriage or adoption), that form a household, share a farm or farming resources and assets and consume or sell their farm produce. The household may own land obtained either by inheritance or land distribution and mobilizes labor and other necessary inputs for the production of crops and livestock.

In the area studied, a patrilineal landholding system prevails and hence the men are usually the owners of and responsible for the homestead (Fig. 4.5), except in the case of a widowed woman. The boundaries of the household occupying the homestead are permeable and any relative, usually from the (male) head, is welcome for as long as they want to stay and contribute labor to the household. As shown in Figure 4.5, there are two types of households, polygamous and monogamous ones. In a household, there will be a head (usually male), the wife and other members. It is often based on an extended family. Members can be children, grandchildren, adopted children or hired farm hands. It is also customary that parents of the household head reside in their son's household when they get old and become helpless. In polygamous households, there are at least two houses in the homestead, while there is only one household head. Basically, the land belongs to the man but each wife will be given her own plot for growing of enset and other crops in the backyard and also her share of domestic animals. The different houses within the homestead do not have borders drawn around them. Although these houses are located in one premise and are under one headship, food is not always shared between the occupants of the different houses, except at special occasions. The husband decides whether and when to share the meal with either of the wives. The labor of all members from the different houses can be pooled whenever there is a need to carry out farm activities, construction activities, harvesting or processing.

There is a well-established and kin-based relationship between the members of one homestead, which usually extends beyond the nuclear family. When the elder son in the family gets married, he and his wife stays with his parents until he is able to secures his own homestead or they live on his parents' homestead for good. The parents usually prefer their married son to stay close to them to facilitate mutual support. As the parents get older and become unable to carry out farm activities, the son ploughs for them and also he and his wife represent the parents in community activities in the village. In addition, the wife assists her mother-in-law in enset harvesting, processing, and in manuring the plots. The grandchildren to his parents, are taken care of by their paternal grandparents. The system continues and the labor of the whole extended family will be mobilized for the production of crops and other household activities. Later when the old man dies, the son takes responsibility for and control over all the resources in the homestead.

Fig. 4.5 The homestead: polygamous (A) and monogamous (B) households

A



In the layout of the homestead presented above, the household head has three wives located in the same premises. The first (senior) wife lives in the corrugated iron roofed house. She has an additional tukul (hut) part of which is a kitchen and the other part a stable. The other two wives have only one house each. Each of the wives has a separate plot for enset and other crops intercropped with enset in the backyard. During harvesting and processing of enset, all the wives work in groups on each other's plots.

B

A typical homestead of a monogamous household with the living room, the bedroom, the kitchen and the stable found in the same hut, sometimes separated by a wall. In the backyard, there are plots for enset and few other crops such as cabbage and root and tubers (taro, yam, etc.).

Chapter 5 The set-up of the research

In this chapter, the research design, the general scope and contents of the questionnaire, the employment of field assistants, the procedures followed in selecting the study sites and respondents will be presented briefly. In order to allow for careful interpretation of the fieldwork, the overall circumstances in the field, data collection methods and interviewing procedures will be described in more detail. Furthermore, the methods employed in data analysis and the experimental procedures for the laboratory-based research will be discussed.

5.1 Research design

The research design aims at the organization of the research in such a way that it allows for collection and analysis of research data and plant samples in a manner that these optimally contribute to answering the research questions, taking time and cost effectiveness into consideration. As stated earlier, this study comprises an integration of biodiversity research and socio-economic research. Its main purpose was to assess and identify relationships between the major components i.e. crop diversity within and between species, conservation strategies employed and household uses of crop diversity in the enset based farming system. In order to fulfill the objective of the study and to adequately answer the research questions, an explorative type of research, which employed both qualitative and quantitative methods of data collection, was applied. Secondary data was obtained from regional and zonal agricultural bureaus and the central statistical office as deemed necessary to support the primary data.

The research methodology consisted of both biodiversity components (conservation strategies and genetic relationships) and a socio-economic part. Prior to the actual survey, a preliminary phase was planned in order to obtain a better understanding of the area, the people, their culture and traditions, and the farming systems. The information obtained during the preliminary survey was helpful in the selection and design of the research instruments. This phase also enabled the researcher to develop trust and contact with farmers in most of the cases. One of the most important conditions for conducting household surveys is to develop a trusting relationship with the community, which allows for greater interaction between the researcher and the community.

In most cases, farmers appeared cautious and were not willing to disclose any information to a new face around their backyard. As the investigator totally relied on the information obtained from them, care should be taken that they would not tell only part of the story. However, since I already had some exposure to the area and to some of the farm households, I was not regarded as a stranger, and with the help of the development agents working for the Biodiversity Institute on site, extension agents, and the experts from the zonal agricultural bureau, it was possible to get acquainted with most of the villages and its household members. This resulted in easy access to the required information from the respondents.

The questionnaire for the household survey was pre-tested on a few selected households and amended based on the responses. Existing gaps were filled before the start of the actual survey. The pre-testing procedure also helped the researcher to estimate the time needed for each interview. The actual survey consisted of a single exercise, in which all selected households were asked identical types of questions mainly on social and economic topics. In addition to the survey, based on the formal structured questionnaire, focus group discussions and key informant interviews were carried out to gain more insight into the culture, farming systems, the institutional infrastructure and other relevant issues.

As indicated in the earlier chapter, households formed the unit of analysis. Primary data was obtained mainly from household heads', and wives (in case of male-headed households). Elderly persons and older children in the household also participated actively in responding to the questionnaire.

While conducting the household survey, planting materials (corm tissues) and seeds of enset landraces available in the surveyed districts were collected and were planted on the premises of the two community seed banks built by the Biodiversity Institute in these districts. This was done in order to establish a back-up collection of cultivated germplasm and to make suckers available for laboratory analysis upon return to The Netherlands after completion of the survey. The samples were collected for the experiments aimed at developing appropriate techniques and protocols for propagation and *in vitro* conservation of enset and for studying the genetic diversity of enset landraces using molecular marker techniques.

5.2 Household survey

Both quantitative and qualitative data were gathered from the fieldwork depending on the needs of the researcher. The field research was designed in such a way that formal/structured and informal/unstructured interviews with closed and open-ended questions, respectively, were asked.

The questionnaire

Several issues were covered in the household survey including: data on identification of household members; demographic characteristics and behaviors of the study households; data on socioeconomic characteristics; food consumption patterns; data on household resources; cropping systems; ethnobotanical data and coping mechanisms employed in times of drought and other calamities. Several pertinent questions were designed for each of the categories given below, with the aim of getting appropriate answers in relation to the objectives of the study and the research questions provided in the earlier chapters.

The topics of the questionnaire of the household survey included:

- Identification data: respondent's name; language, religion, ethnicity and polygamy
- Demographic characteristics: household composition and migration patterns
- Household resources: land, livestock resources, other assets and household division of labor, household income
- Access to and control over resources: access to land, other resources, decision making,
- Food consumption: food availability, food distribution, buying and/or producing of food, household expenditure
- Storage and marketing: traditional storage techniques, access to market, marketing of products
- Cropping system: cropping calendar, cultivation practices
- Ethno botanical data: indigenous knowledge on crops, traditional exchange of plants, use of additional inputs,
- Coping mechanisms: strategies employed in the past and expectations for the future

On each of the topics and subtopics, a wide range of questions was covered, which are detailed in the survey's questionnaire (see Appendix 1).

The questionnaire was initially prepared in the English language. It was then translated into the local language so that the interviewer and interviewee would comprehend it clearly. The answers were translated back into English to facilitate data entry and analysis.

Selection of survey site and sampling of households

The Southern Nations Nationalities and Peoples Region, which is the main enset-growing region, was the region selected for the present study. Kaffa Shaka is the administrative zone, which is part of the region composed of eight administrative *woredas* of which two were selected for the study.

The selection of *woredas* was based on the secondary data and information from consultation with the regional agricultural bureau in addition to the criteria set by the researcher. The criteria considered for selecting the study *woredas,* among others, were based on where the following could be found; households in different socio-economic groups (in terms of land, livestock and other household resources); a high level of diversity in enset landraces; infrastructure (roads, school, clinics, etc.); and access to markets. *Woredas* in more extreme situations such as those with accessibility problems were excluded from the survey.

Three peasant associations from each of the two *woredas* and three villages from each peasant association were selected making a total of six peasant associations and 18 villages. Until this stage selection followed purposive sampling with the criteria mentioned above and in consultation with the relevant experts from the zonal and *woreda* agricultural bureaus.

All households in the 18 villages were enumerated and a random sampling was applied from the list of all households to constitute the number of households for the interview. Random sampling gave an equal probability to every individual in the population to be selected following the procedures of Bernard (1995). The total number of households interviewed was thus 240 for the two *woredas,* 120 households being included per *woreda* (Decha and Chena).

Composition of the survey team

A total of seven people (including the principal investigator) participated in the interviewing including the principal investigater. Four assistants were provided by the Institute of Biodiversity Conservation and Research. Two of these were natives and were stationed in the study area, working for the Institute as development agents for the on-farm conservation project. Two field assistants were employed for the duration of the survey period.

During the course of hiring the two assistants, the zonal and *woreda* agricultural bureaus were highly cooperative in posting our advertisements and registering those who wanted to take the job on the basis of a short-term contract. We set the criteria for hiring, as the candidate must be a native to the area and with fluent speaking ability in the language of the ethnic group. Knowledge of the language of the ethnic group was considered essential, as all the interview questions had to be interpreted for the fact that not all the interviewees were capable of responding to the questionnaire which was prepared in *amharic* (the national language). The candidates were also expected to have had completed at least 12 years of formal education and have had experience in the field of agriculture or socio-economics. All registered candidates were given both written and oral examinations and finally the two assistants were recruited based on their performances.

The next step was training of the entire survey team. During this time they were given detailed instructions on the objective of the survey and all the questions were carefully explained, variables and terms clearly defined and then translated into the local vernacular. Care was taken not to misinterpret the words and in this regard having four people fluent in the local vernacular gave assurance to the accuracy of the translation. At times there were arguments over unclear terms where it has a different meaning at least for them, but then finally a consensus was reached on an appropriate meaning.

Field organization and data collection

Prior to the operationalization of the actual survey, preliminary visits were made to pre-test the questionnaire and get used to the area. Discussions with the respective staff of the agricultural bureau were made to facilitate the survey. It was also vital to get to know the extension/development agents of the respective study *woredas* in order to have some idea about the farm communities in which the investigation was carried out. Furthermore, the preliminary visit enabled the planning of the logistics and all the necessary survey equipment required for the actual survey as the sites were distant from the Institute and at times communication was ineffective.

After the first visit, the questionnaire was finalized and the actual survey was conducted from October 1998 to February 1999. During the course of the interview, every evening, the survey team spent time discussing events and problems encountered during the day. Every questionnaire was reviewed and edited by the interviewer so that confusion during data entry was avoided.

During the interview, some respondents were sometimes taken up by the subject and spent much time in sharing their views, which made the interview time longer than expected. However, the interviewers were repeatedly made aware to keep checking the consistency of the respondents' answers and to clearly explain the contents of each question.

For some of the variables, such as landholding, livestock, and annual income, it was sometimes difficult to get the exact figure from the respondent. While sincere farmers told the truth, others were skeptical as they thought that giving information about the actual property they own might result in having to pay more taxes. In such cases, we had to convince respondents of our intentions, in order to reassure them. Prior to the interviewing of each household, it was vital to spend some time introducing ourselves, explaining where we came from and about the purpose of our survey. Maximum efforts were thus made to extract the most reliable information from the respondents. At times, we had to cross check the information we got from the farmers with the secondary data from the *woreda* agricultural bureau on some aspects such as household resources especially of individual land holdings. We did these, as some respondents did not feel comfortable disclosing all information about their land ownership for reasons mentioned above.

5.3 Focus group discussion and key informant interviews

Apart from the formal questionnaire survey, focus group discussions and key informant interviews were also carried out, to complement the survey method. For the focus group discussions, about six farmers per *woreda* were invited for a joint interview session. Several topics were brought up for discussion, including thoughts, perceptions, beliefs, attitudes and practices with regard to the role of enset in the farming system, farmers' selection criteria of clones, food security of households, land acquisition, wealth status, social/cultural events, and so forth. This method assumes that there exists variation in opinion, experiences and knowledge among informants. The discussions were very lively, where comments given by one participant were amended and further elaborated upon by another. For instance, issues such as 'what is your perception about a poor, better and wealthy farmer' were hotly debated and thoroughly discussed, to the extent of determining criteria for ranking farmers according to wealth.

Key informant interviews are done with individuals who can be easily accessed, and who have good knowledge of a given topic (such as information on an area, culture, infrastructure, cropping system and other related subjects). Thus key informants were identified based on the above criteria. They included: community leaders, agricultural bureau heads (head of the zonal agricultural bureau and head of the extension department), representatives of the NGO SUPAK (sustainable poverty alleviation for Kaffa Shaka) working in the area, and individuals from other relevant organizations. The information obtained from these individuals greatly helped in selecting the research area and in the implementation of the survey research.

5.4 Data entry and analysis

Editing, coding and verification procedures were implemented in order to ensure the quality of the collected data. A statistical framework was prepared, i.e. variable names, labels and their corresponding descriptions were put in the appropriate rows and columns. In general, the process of data entry and analysis included coding of the interview responses or observations, tabulation of the data and performing statistical computations.

All the data gathered was transferred to a codebook and observations were transformed into numbers that could be used statistically. Open-ended questions were also investigated and given codes whenever applicable. In order to avoid error during coding and data entry, all the variables were checked and at this stage the data was ready for input. The data were entered in personal computers using SPSS (Statistical Products and Service Solutions) software. As indicated in an earlier chapter, this research is exploratory and descriptive in nature, and hence the methods of data analysis and the presentation of findings use the standard approaches to describing qualitative and quantitative data.

Data analysis was carried out using several statistical measurements, which includes frequency distributions, cross tabulations, chi-square and correlation tests. In the case of nominal variables, such as religion or ethnicity, frequency distributions were computed. Likewise, measurements such as correlation, and chi square test were applied for both ordinal and nominal variables. Cross tabulations were also employed in order to reveal likely differences between households across the two study *woredas*. Qualitative data were attached to various topics of the different chapters of this thesis to enhance understanding of the other data. Selected anecdotes and comments from informants, which were kept in individual field diaries/jottings by the principal investigator and the field assistants during the focus group or informal discussions, were selected and are presented in the various chapters.

5.5 Biodiversity components (Field and laboratory based research)

Three types of laboratory research were conducted, i.e. studies on *in vitro* micro-propagation, on *in vitro* conservation under slow-growth conditions, and on genetic diversity using molecular marker techniques. The establishment of efficient protocols for micro-propagation and *in vitro* conservation was considered vital as this technology may serve as a backup system to the existing traditional propagation and on-farm conservation of the crop. Studying the genetic diversity using molecular markers helped to assess genetic relationships among clones, identification of duplicates and allowed the selection of germplasm for effective conservation of genetic resources of enset. During the first year of the PhD studies, a series of experiments regarding germination of seeds and embryos, micro-propagation and *in vitro* conservation were conducted using seed samples collected from farmers' fields. While the germination and micro-propagation experiments were completed at the end of the first year, the *in vitro* slow growth experiment continued into the second year. Studies on genetic diversity of enset landraces using molecular marker techniques were conducted during the third year using suckers obtained from corm tissues planted in the field genebanks during the household survey. Detailed experimental procedures and methods used for analysis of the data for the technical part of the research are given in chapters 6, 7 and 8. Characterization data on phenotypic characters and specific uses were collected using farmers' indigenous knowledge of all clones, which were analyzed using molecular markers (see Chapter 11). This allowed a comparison of the results of the two methods (farmers' vs. molecular).

5.6 Time frame of the research

Time (year)	Activities
Year I (1997/98)	a. writing of the research proposal b. attending of relevant courses c. laboratory and green house experiments on seed and embryo germination d. micro-propagation experiment e. *in vitro* conservation experiment f. preparation of the survey questionnaire
Year II (1998/99)	a. translation, pre-test and further improvement of the questionnaire b. household survey and data collection c. collection and planting of enset samples (on site) d. coding and data entry e. *In vitro* conservation experiment (continued)
Year III 1999/2000	a. molecular genetic analysis of enset landraces b. analysis of both laboratory and field data c. field characterization of enset landraces
Year IV 2000/2001	a. finalization of all laboratory experiments and data analysis b. analysis of survey data c. thesis write-up

PART II

Chapter 6 *In vitro* regeneration and micro-propagation of enset from Southwestern Ethiopia*

6.1 Abstract

Three clones of enset (*Ensete ventricosum* Welw. Cheesman) collected from farmers' fields in Southwestern Ethiopia (Keffa-Shaka zone) were investigated for their potential for micro-propagation and regeneration in tissue culture. Greenhouse-grown plants as well as *in vitro* germinated zygotic embryos were used as starting material for micro-propagation and regeneration studies. Corm and leaf tissue was used as a source for *in vivo* explants. Embryos were excised from disinfected seeds and cultured *in vitro*. Multiple shoots from both embryo- and corm-explants were obtained using regeneration medium supplemented with 10 μM or 20 μM BAP. Rooting of shoots was achieved using medium with 5μM IBA, 1μM BAP and 1 g/l activated charcoal. Plantlets obtained by this process were transferred to soil under greenhouse conditions. Optimal conditions, which were determined for clonal propagation of three different genotypes of enset, allowing both *in vitro* micro-propagation and regeneration, are described. This protocol makes for conservation of enset clones, rapid propagation of selected disease-free germplasm and more efficient breeding procedures.

6.2 Introduction

Enset (*Ensete ventricosum* Welw. Cheesman) is a major food crop, which is indigenous to Ethiopia. It is a large, diploid (2N=18) perennial plant which resembles the banana plant and for this reason is sometimes called the false banana. Smeds (1955) reported that enset cultivation originated in the highlands of Ethiopia, a region of Africa possessing a well developed agricultural and pastoral economy. The enset crop is adapted to a wide range of altitudes from 1200 to 3100 meters above sea level. It is mainly cultivated in densely populated areas in the Southern and Southwestern parts of the country inhabited by over 45 different ethnic groups. Enset has several uses including food and non-food applications, and is highly integrated in the economic, social and cultural life of enset-growing societies. It is a major staple or co-staple crop for over 15 million people (20% of the Ethiopian population) (Brandt *et al.*, 1997).

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Enset is mainly propagated by vegetative means. Although it can also be propagated by seeds, seed production is not a common practice, as farmers do not usually postpone harvesting until maturity of the crop. Unlike banana, the plant seldom produces suckers unless induced to do so. In Southwestern Ethiopia, vegetative propagation is effected by farmers using the corm, a tissue found in the underground central part of the plant, although sexual reproduction has been reported in a few cases. The corm of a two-year-old plant will be pulled out of the soil after cutting away the pseudostem at approximately 10 cm. above the ground, then be exposed to sunlight for a period of two days and subsequently buried again in the soil after removal of the apical meristem area, located at the central part of the corm. After 2-3 months new suckers will emerge. This traditional method, however, is very tedious and laborious, results in a poor propagation rate, and requires a large land area.

Despite the importance of enset as a food crop, very little research has been carried out to improve cultivation of the crop, and the traditional inefficient mode of propagation has continued unchanged. Besides, a fairly large number of clones are lost in cultivation owing to diseases, abiotic selection pressures, or changes in land use systems. Hence, enset-growing farmers may profit from a backup system for the existing traditional methods of propagation and on-farm maintenance of their enset landraces, a backup system based on by *in vitro* rapid micro-propagation and storage methods. The development of an efficient *in vitro* propagation protocol aims to secure conservation of the existing diversity of enset germplasm, and to facilitate rapid propagation for large-scale production of desired clones. Moreover, *in vitro* propagation may help produce of healthy plantlets free from bacterial or viral diseases that are easily transmitted when suckers are used as a source of new planting material.

6.3 Materials and Methods

Plant materials

To obtain optimal conditions for regeneration and micro-propagation, alternative procedures were followed to germinate seeds under *in vivo* as well as *in vitro* conditions, including the isolation and culturing of embryos under *in vitro* conditions.

Germination of seeds in vivo and in vitro

Mature seeds of three clones of enset, named Nobo, Ketano and Choro, were collected from farmers' fields. For *in vivo* germination, seeds were soaked overnight in a water bath at 40 °C.

Subsequently, these were planted in pots containing soil and maintained in the dark in a growth chamber at 22 °C for germination.

For *in vitro* germination, seeds were surface sterilized using 70% ethanol for 30 seconds, followed by a 1 hr incubation in 1% (w/v) NaOCl and 20 mg/l nystatin, then scarified using a needle (around the micropylar plug), rinsed three times with sterile milli-Q water and soaked overnight in sterile water in a 40 °C water bath. Seeds were subsequently placed onto germination medium. Germination medium was Murashige and Skoog (MS) medium supplemented with 30 g sucrose, 2 g gelrite, 2 μM BAP and 1μM IAA per liter and kept at 25 °C in the dark. Subculturing to fresh medium was carried out at two weeks intervals.

In vitro germination of excised embryos

Seeds of the same three clones were soaked in sterile water overnight at 40 °C in a water bath. They were mildly scarified around the micropylar plug using a needle and surface-sterilized as described above. After seed coats were ruptured using pliers, embryos were excised, and cultured on the same germination medium as used for the germination of intact seeds.

Shoot induction and micro-propagation

Corm and leaf tissues derived from five month old greenhouse grown plants were used to prepare explants. The *in vitro* explants were surface-sterilized in 2% (w/v) NaOCl for 10 minutes, and rinsed three times with sterile water. Corms were cut in 5 mm pieces and leaves were cut in 2-cm pieces with a scalpel. All plant explants were subsequently inoculated on MS medium, supplemented with cystein HCl (50 mg/l), sucrose (30 g/l), gelrite (1 g/l), daishin agar (5 g/l), IAA (1μM) and BAP (10μM) to allow shoot regeneration. Transfer to fresh medium was carried out at two weeks intervals until shoots were produced. Germinated excised embryos were also cultured on this medium to allow shoot generation.

Regenerated shoots were then subcultured for micro-propagation on MS medium supplemented with 30 g/l sucrose, 2 g/l gelrite, 125 mg/l ascorbic acid, 1μM IAA and 250 mg/l cefotaxime and two different concentration of BAP, i.e. 10μM or 20μM per liter (EN2.25 and EN5.0 propagation medium respectively). Cultured plant materials were maintained at 25 °C and with a 16 hours photoperiod at 3000 lux. Separation and transfer to fresh medium of individual shoots was performed.every two weeks.

Rooting and transfer to soil

After 16 weeks in culture, individual shoots were transferred to a root induction medium, consisting of half strength MS medium supplemented with 5μM IBA, 1 g/l activated charcoal, and 1μM BAP. Upon root formation, individual containers with individual rooted plants were covered with plastic caps to maintain the humidity and kept at 26 °C for four days after removal from the culture room. Subsequently, the cover was removed and plantlets were kept under the same conditions for two weeks. Established plants were transferred to a 22 °C greenhouse.

6.4 Results

In vivo* and *in vitro germination of seeds

To obtain optimal conditions for regeneration and micro-propagation, alternative procedures were followed to germinate seeds under *in vivo* as well as *in vitro* conditions, including the isolation and culturing of embryos under *in vitro* conditions.

A small number of seeds germinated after a maximum of forty days of incubation in soil in the greenhouse, while no germination was observed from *in vitro* cultured seeds, albeit that here the number of seeds that could be treated were extremely low (Table 6.1).

Table 6.1 Germination of *Ensete ventricosum* seeds *in vivo*

Clone	No. of seeds used	No. germinated (%)
Choro	30	1 (3)
Nobo	30	4 (13)
Ketano	30	2 (6)

The results on *in vitro* germination represent the pooled data from two independent experiments. The rate of germination varied from 21 days when the first emergence of seedlings was observed in clone Nobo to 40 days. Considerable differences in germination rates between these three clones are apparent, but germination could be obtained for all. No further germination of seeds *in vivo* was observed after this period over a total observation period of 70 days. Germinated seedlings were maintained further in the greenhouse at 25 °C. Leaves and corms were taken from these plants for subsequent *in vitro* ex plantings.

In vitro germination of embryos

Embryo germination results represent the pooled data from three separate experiments (Table 6.2). Percentages obtained for the three clones varied considerably, whereas the percentages obtained for the same clone in different experiments was more consistent (data not shown). Furthermore, observed rates differ from those obtained under *in vivo* conditions. A considerable number of seeds appeared to be empty, highly correlated with the clone under investigation. Empty seeds refer to seeds with either no endosperm or no embryo. As a first criterion for the identification of empty seeds, in the case of Choro and Nobo seeds were soaked and floating seeds were taken as empty. This criterion was not applied in the case of Ketano since for this clone most of the seeds were floating. However, even after floaters were removed, some seeds were still found to be empty. This accounted for the low *in vitro* germination response based on the total number of seeds investigated. Some seeds were damaged as a result of the excision method. A representative enset embryo appeared to exhibit a mushroom-shaped structure including a haustorium (a large cup-like structure), a stalk which terminated into the hypocotyl-epicotyl axis and a cotyledonary sheath. During differentiation, the embryos first became swollen followed by extension of the hypocotyl-epicotyl axis. Further differentiation was apparent in the subsequent two weeks on the initial germination medium. After two weeks the basal corm started to increase in size and bulbous-like structures appeared surrounding the basal corm, which later differentiated into shoot clumps. These were separated into individual shoots at subsequent subculturings.

Table 6.2 Germination rates from *in vitro* cultured, excised embryos of *Ensete ventricosum*

Clone	Total no. of seeds	Empty seeds No. (%)	Total no. of embryos excised	Embryos damaged	Embryos responding to *in vitro* culture No.	*	**
Choro	90	29 (32)	61	9	37	(42)	(71)
Nobo	90	37 (41)	53	13	23	(26)	(58)
Ketano	90	65 (72)	25	11	2	(2)	(14)

* refers to percentages calculated from the total number of seeds
** refers to percentages taken from the actual number of excised, intact embryos

Shoot induction and propagation

Successful shoot induction was achieved on all explant types tested (Figures 6.1, 1-3). To achieve maximum multiplication rates, optimization of multiple shoot induction was achieved using embryo explants and shoot induction media with two different cytokinin concentrations (10 and 20μM BAP). The two BAP concentrations were chosen after preliminary tests in which different concentrations of BAP (between 1μM and 30μM) and kinetin (from 1μM to 18μM) were compared, separately or in combination (data not shown). The number of induced shoot buds in explants varied with cytokinin concentration.

Statistical analysis of the data (Table 6.3) on shoot formation indicated that significant differences existed between the transfers, the clones and the two cytokinin concentrations. The difference between transfers means that there is in fact a true multiplication in the numbers of shoots obtained in time. Nobo was found to be the most responsive clone, followed by Choro and Ketano. This difference between clones was significant, but the most determining factor proved top be the BAP concentration. It was clear that the higher concentration of BAP (20 μM), yielded a higher total number of shoots after 16 weeks. Therefore, this concentration may be regarded as more suitable for propagation purposes. However, tissue browning was more pronounced in this medium, ultimately leading to loss of plantlets. By using medium with the lower BAP concentration and ascorbic acid (0.57mM) in combination with an increased frequency of subculturing (two-week intervals) blackening of cultures was reduced to acceptable levels.

On an average, two to three new shoots were produced from each single shoot at two-week intervals, whereas for the lower cytokinin concentration, the numbers varied from one to two shoots. The propagation rates presented in (Table 6.3) represent the mean number of shoots generated in two subsequent subculturing intervals of two weeks each. The results in brackets show the multiplication factor, i.e. the rates at which each shoot is multiplied within the given period. Only elongating shoots were counted and considered for further propagation, whereas shoot tips which could not easily be separated from the growing tissue clumps were ignored, resulting in an underestimation of the potential multiplication rate. Root formation on some of the shoots already occurred on the multiplication medium.

Table 6.3 Effect of two concentrations of BAP on multiple shoot induction of three enset genotypes, Choro, Nobo and Ketano

Clone	Week 0*	Week 4		Week 8		Week 12		Week 16	
		$EN_{2.25}$	$EN_{5.0}$	$EN_{2.25}$	$EN_{5.0}$	$EN_{2.25}$	$EN_{5.0}$	$EN_{2.25}$	$EN_{5.0}$
Choro	8	14(1.8)**	20 (2.5)	26(1.9)	45(2.3)	53 (2.0)	104 (2.3)	108(2.0)	231(2.2)
Nobo	8	19(2.4)	21(2.6)	41(2.2)	54(2.6)	90(2.2)	126 (2.3)	149(1.9)	254(2.2)
Ketano	8	11(1.4)	18(2.3)	23(2.1)	43(2.4)	51(2.2)	90 (2.1)	100(2.0)	186(2.1)

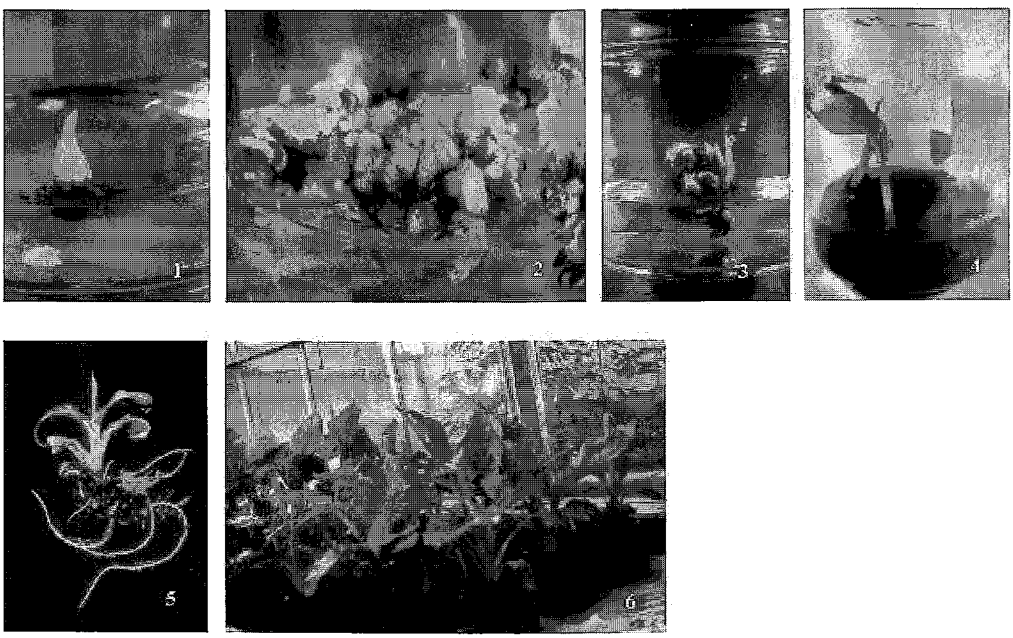
* Week 0 is the week when eight explants for all three clones were first cultured.

** The numbers in brackets indicate the average shoots produced by each explant while the numbers outside the brackets indicate the total number of shoots produced at each subculturing intervals.

Rooting and transfer to soil

Formation of roots (Figures 6.1, 4-6) took place within fourteen days of transfer to root induction medium. The primary root developed in approximately ten days time followed by the occurrence of secondary roots within the next fourteen days. Rooted plants were transferred to soil in the glasshouse. More than 90% of the rooted plants survived after transfer to soil. Further observation of individual plants in the greenhouse regarding leaf color, and leaf shape as well as other conspicuous morphological characters revealed no aberrant phenotypes in comparison with the original material maintained in parallel in the greenhouse.

Fig. 6.1 Stages of *in vitro* shoot multiplication from excised embryos of enset



Figures 1-6 represent different stages of shoot multiplication through in vitro excised embryos and corm and leaf tissues of enset. 1. Excised embryo swollen after 12 days in culture. 2. Bulbous tissues derived from corm and leaf explants ready to produce multiple shoots. 3. Regeneration of shoots. 4. Rooting of single shoots. 5. Rooted plantlet ready for transfer to soil. 6. Established plants in soil in the green house.

6.5 Discussion

In this study, we have been able to demonstrate for the first time rapid propagation *in vitro* and reestablishment of plants *in vivo* using both *in vitro* and *in vivo* derived materials. Qualitatively similar results in multiple shoot induction and regeneration were obtained for the three clones studied, indicating that the technique may not be highly genotype-specific and hence may be applied to many different genotypes.

The inherent difficulties in germinating seeds have hampered progress in breeding. *In vivo* germination of enset seeds has been reported to take as long as 71 days (Association of Official Seed Analysts, AOSA, 1978). Enset has a hard seed coat, which is impermeable, and in addition, chemical inhibitors on the seed coat affect the germination efficiency. Further scarification is an absolute necessity to allow imbibition.

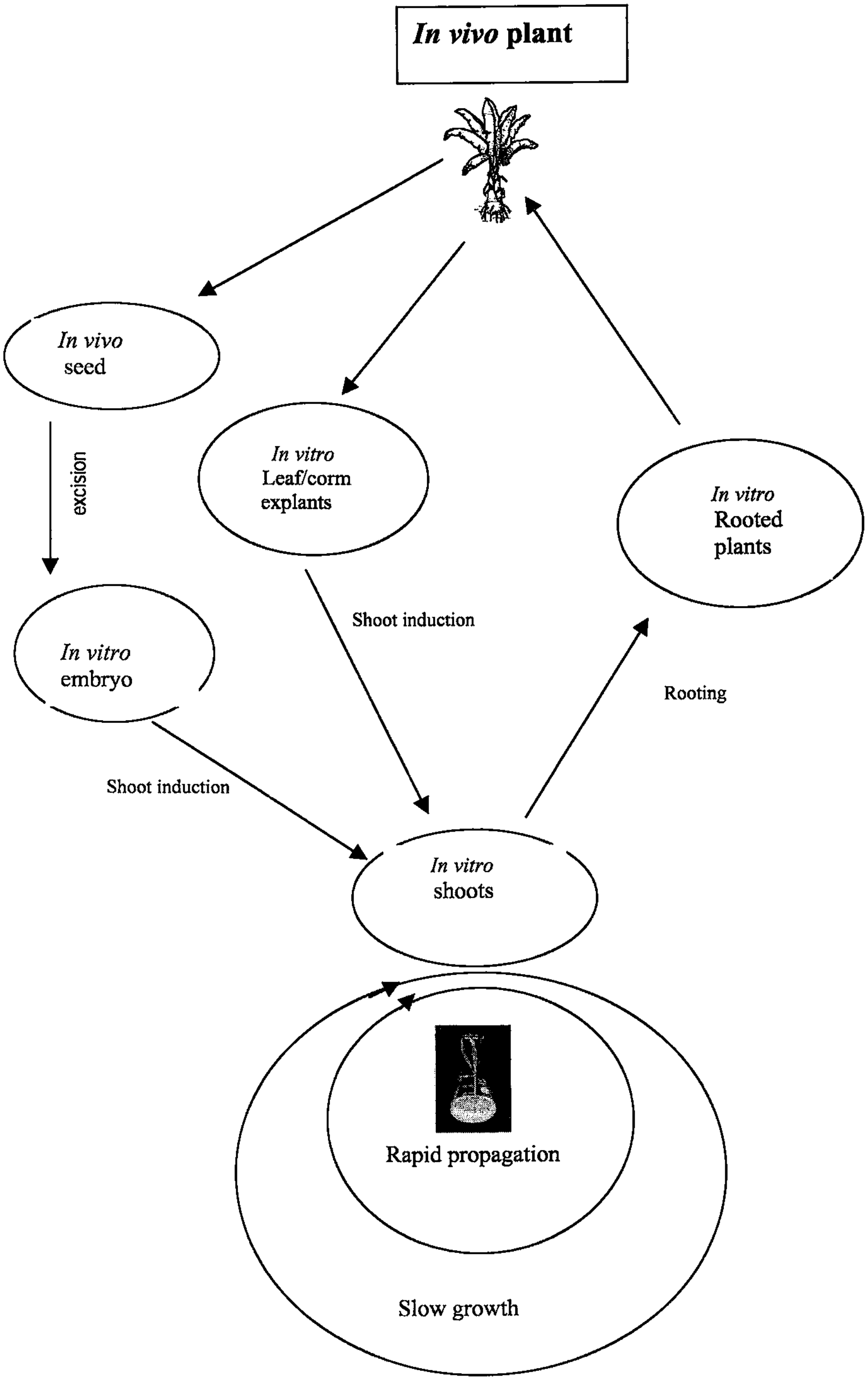
Difficulties in germinating enset seeds both *in vitro* and *in vivo* also occurred in our initial experiments. In our hands the procedures of Bezuneh (1971) and Messele (1992) were not successful. We also observed that some seeds, which were intact and looked normal, contained either no embryo or no endosperm when opened mechanically. These so-called empty seeds are probably one of the main reasons for the observed low germination frequencies. Germination of excised embryos was achieved after 10-12 days of incubation on germination medium. This result is similar to that of Bezuneh (1980) who observed germination occurring two weeks after pre-treatment of seeds with gibberellic acid. Embryo *in vitro* culture has also been successfully applied for banana, a close relative of enset (Cox *et al.,* 1960). Root induction in enset was easily induced in two weeks time using a low concentration of IBA (5 μM). This agrees with the observation of Bezuneh (1971) who reported root formation within three weeks.

Availability and long-term storage of botanical seeds facilitate crop improvement and conservation of genetic resources. Low seed viability, dormancy, and a high percentage of empty seeds can be compensated for through the use of mature embryo culture and generation of *in vitro* plant material, which allows effective conservation of crop diversity and access to aseptic seedling material, which can rapidly be propagated *in vitro*. In our hands, the use of *in vitro* embryo culture has also considerably reduced the length of time needed to germinate seeds and produce plantlets.

Partial success in propagation of the species has been reported by Afza *et al.* (1996) who encountered extensive tissue mortality due to excessive blackening. Similar blackening occurred at the higher BAP concentration in our hands, but the effect was less pronounced at the lower concentration (10 μM). From our studies, it appeared that all explants derived from embryo, shoot or corm can be successfully used for propagation. Mathew and Philip (1996) for *Enset superbum* obtained results comparable to ours for the induction of multiple, adventitious shoots using slightly lower concentrations of BAP either alone or in combination with other cytokinins. The use of a higher concentration of cytokinin (20 μM BAP) in our hands had a significant stimulatory effect on the generation of multiple shoots. Obviously, in determining the optimal BAP concentration there is a trade-off between high initial multiplication rates and blackening resulting in the loss of materials at a later propagation stage.

Bearing in mind the significance of enset as a subsistence crop to a large Ethiopian population, and the difficulties in traditional propagation of the crop, as outlined above, an efficient micro-propagation protocol has been developed using *in vivo* corm and leaf material as a source. This protocol allows for conservation of enset clones, rapid propagation of selected disease-free germplasm and more efficient breeding procedures.

Fig. 6.2 Schematic representation of the protocol for *in vitro* propagation of enset (*Ensete ventricosum* Welw. Cheesman)



Chapter 7 *In vitro* conservation of enset *(Ensete ventricosum* Welw. Cheesman) under slow growth conditions*

7.1 Abstract

Studies on *in vitro* storage of enset under slow-growth conditions were carried out to develop an efficient protocol for the conservation of the genetic diversity of the crop. The response to different treatments aiming at growth retardation was examined using three enset clones collected from Southwestern Ethiopia. *In vitro* cultures could be effectively maintained for six to nine months at 15 °C and 18 °C on MS medium supplemented with 10μM BAP, in the presence of mannitol at concentrations of 0, 1 or 2% as a growth retardant. Shoots were subsequently recovered and multiplied on MS medium supplemented with 10 μM and 20 μM BAP in a growth room at 25 °C and rooted shoots were successfully transferred to the greenhouse. Incubation at lower temperature (15 °C) and the presence of mannitol in the culture medium had a significant positive effect on maintenance, measured by recovery of shoots after storage.

7.2 Introduction

Conservation of plant genetic resources is of crucial importance for the production and improvement of crops. Whereas biotechnological methods based on *in vitro* culture have made an impact on crop improvement in general, tissue culture has also yielded benefits for germplasm conservation, in particular for vegetatively propagated crops. When conventional techniques are difficult to employ (seed conservation may not be feasible, and field genebanks may be considered too costly or risky), *in vitro* techniques present a new and improved approach to conserving and utilizing the available genetic diversity.

In vitro conservation offers the advantage that the material can be maintained under aseptic conditions in a controlled environment (free of fungal and bacterial diseases, climatic fluctuations, etc.) for a long time period. In addition, plantlets can be rapidly propagated and disseminated from an active *in vitro* genebank collection whenever the need arises. Slow-

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growth storage for the short or medium term is now routinely used for the conservation of a number of species, including banana, potato, yam and cassava (Ashmore, 1997).

Enset is one of the oldest cultivated plants of Ethiopia (Zeven and De Wet, 1982). It is a large tree-like perennial, which resembles the banana plant and is the most important staple or co-staple crop for more than ≥20% of the population of Ethiopia. It is a multipurpose crop, of which almost every part is utilized either for food or non-food purposes and forms a major contribution to food security of the local population.

Enset growing areas are shared by various ethnic groups and a large number of clones is recognized by enset growing communities of different ethnic groups. Available data on the properties of the crop and on its propagation and conservation are very limited. This might be partly attributed to the long life cycle of the plant, taking between 4 to 12 years to reach maturity. Enset can be propagated by seed as well as vegetatively. However, seed production is not common, as most farmers harvest the plants before they have matured and produced seeds. Conservation of various enset clones representing its genetic diversity is traditionally carried out *in situ* in farmers' backyards. However, farmers have lost, and are still loosing, valuable clones as a result of diseases (e.g. bacterial wilt disease), selection pressure and unfavorable environmental conditions. A small number of accessions collected by the Ethiopian Biodiversity Institute is currently conserved in field genebanks. No alternative storage strategy has so far been developed for enset.

Efficient *in vitro* conservation protocol will contribute to the conservation of existing diversity in enset genetic resources as a backup to on-farm maintenance. This chapter describes such a protocol.

7.3 Materials and Methods

Explant source

Three clones of enset, 'Choro', 'Nobo' and 'Ketano', obtained from farmers' backyards in the Kaffa Shaka zone in southwestern Ethiopia, were used for the described *in vitro* storage studies.

Shoot initiation

Shoot explants were obtained by germinating seeds *in vivo* or by *in vitro* excision of embryos. Corm tissues were isolated from five-month-old greenhouse-grown plants or from *in vitro* grown embryos. Corm tissues were cut into 2-cm pieces, surface-sterilized in 2% (w/v) NaOCl for ten minutes and rinsed three times with sterile water. For shoot induction from *in vitro* grown plants, explants were cultured on MS medium (Murashige and Skoog, 1962), supplemented with cysteine HCl (50 mg/l), sucrose (30 g/l), gelrite (1 g/l), agar (5 g/l), IAA (1 μM), and BAP (10 μM), incubated at 25 ^{0}C, 16 h photoperiod and 80 μmol. m^{-2} s^{-1}, and subcultured and transferred to fresh medium every two weeks until shoots were produced. Likewise, embryos were isolated from mildly scarified seeds after soaking at 40 ^{o}C in sterile water overnight. Isolated embryos were germinated on MS medium supplemented with 30 g/l sucrose, 2 g/l gelrite, 2 μM BAP and 1 μM IAA and kept at 25 ^{o}C in the dark. Embryo-derived corms were subcultured every two weeks using a higher concentration of BAP (10 μM) until shoots were induced. Prior to the slow growth experiments, subculturing and separation of shoots on to the same media was carried out for at least eight weeks.

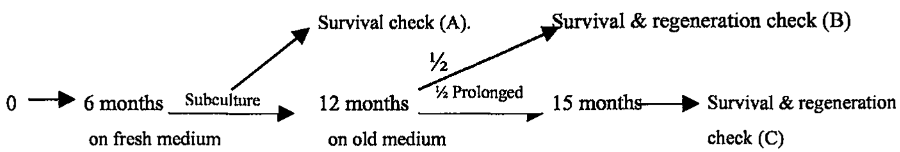
Treatments for slow growth

The effects of temperature and osmotic retardant on the *in vitro* viability of three genotypes of enset were investigated using MS medium supplemented with sucrose 30 g/l, gelrite 2 g/l, ascorbic acid 100 mg/l, BAP 10 μM, IAA 1 μM and 250 mg/l cefotaxime.

Six different treatments were applied, i.e. two storage temperatures (15 ^{0}C and 18 ^{0}C), and three different concentrations of mannitol (0, 1 and 2% w/v). Each treatment was represented by 12 shoots of each clone. After the appropriate mannitol concentration was added to the media mentioned above, the pH was adjusted to 5.7. Fifty ml of the medium was dispensed in screw-capped tubes and autoclaved at 121 ^{0}C for 15 minutes. A single shoot tip explant was inoculated per tube and tubes were sealed with parafilm and kept at 15 ^{0}C or 18 ^{0}C (16hr light/8hr dark) and examined visually at monthly intervals. Survival, defined by the presence of intact, green shoot tips or meristems, was monitored, and subsequently regeneration was undertaken

As a standard procedure, subculturing was carried out after six months. However, in a second cycle, part of the cultures were left on the same medium for an additional three months (for a total of 9 months without subculturing) (Fig. 7.1). Data for survival of shoots after slow-growth storage under different temperature and mannitol treatments were analyzed using Genstat 5, release 4.1. and are presented as mean±standard error (S.E).

Fig 7.1 Schematic presentation of applied slow growth storage regime



Shoot multiplication after storage, rooting and transfer to soil

After two cycles of *in vitro* storage under slow growth conditions, including one subculturing step, surviving cultures were incubated at 25 ^{0}C. Necrotic shoots were discarded and remaining shoots were subcultured on MS medium with 30 g/l sucrose, 2 g/l gelrite, 125 mg/l ascorbic acid, 1 μM IAA and 250 mg/l cefotaxime. For subsequent monitoring of multiplication efficiency two different concentrations of BAP (10 and 20 μM) were added to this medium. Separation of individual shoots and transfer to fresh medium was carried out at two-week intervals. Shoot count was done simultaneously with subculturing.

Shoots were kept in culture for 18 weeks and then transferred to root induction medium, i.e. a semi-solid MS medium with half the concentration of the macro and micro salts including vitamins, supplemented with 1 g/l activated charcoal, 2g/l gelrite, 30g/l sucrose, 5 μM IBA, 1 μM IAA and 1 μM BAP. Rooted shoots were potted in soil and transferred to the greenhouse for further growth.

7.4 Results

Characterstics and viability of shoots maintained under slow-growth conditions

With the aim to maintain viability, medium-term storage was studied using three enset clones. Reduced temperatures and addition of mannitol were employed to induce a reduction in growth rate of *in vitro* shoots, thereby extending the interval of subculturing to a much longer period than the normally practiced two week interval.

Shoot tip cultures derived from the three different enset clones showed a varying degree of viability after two cycles of *in vitro* storage under different slow growth conditions. During storage, only the basal part of bulbous tissues slowly expanded. Subsequent shoot multiplication occurred from these parts. The increase in size of the bulbous tissues was more apparent in cultures maintained at 15 °C while these cultures also remained green. Shoot length did not increase significantly during storage and the main shoot axis appeared dormant or non-viable in most cases, while small shoot-like structures emerged at the bulbous shoot base, which later developed into viable plants upon transfer to fresh maintenance or multiplication medium at 25 °C.

High regeneration rates could be observed. Results of regeneration experiments indicated a significant difference in viability between the two storage temperatures, 15 °C being superior to 18 °C (Table 7.1). The addition of mannitol also significantly improved survival of *in vitro* shoots, although no difference was observed between the two concentrations (1% and 2%) (Table 7.2). The slightly higher values for observed viability after twelve months of storage as compared to six months of storage could indicate a certain level of adaptation to low-temperature maintenance. The three genotypes which genetically are different from one another (data not shown) did not show any statistically significant difference in their response over one or two subsequent periods of six months storage, suggesting a considerable level of genotype independence of viability under the selected slow-growth conditions.

Extending subculture interval to nine months led to very low survival and this storage regime was thus not fully included in the analysis.

Table 7.1 Effect of temperature on viability under slow-growth conditions per genotype

	Survival at 15 °C (mean ± S.E.)			Survival at 18 °C (mean ± S.E.)		
Incubation period	A	B	C	A	B	C
Choro	69.4 ±8.7	86.1±6.6	38.9±9.2	69.4±8.7	69.4±8.7	19.4±7.5
Nobo	72.2 ±8.5	88.9±6.0	33.3±8.9	58.3±9.3	75.0±8.2	19.4±7.5
Ketano	94.4 ±4.3	94.4±4.3	44.4±9.4	69.4±8.7	77.8±7.9	25.0±8.2

Figures are given in percentages and represent green shoots. Data of different mannitol treatments were pooled.

A = survival after 6 months, B = survival after 12 months (one passage) and C = survival after 15 months of storage (one passage).

Table 7.2 Effect of mannitol on viability under slow-growth conditions per genotype

Geno type	Mannitol concentration (%) (mean ± S.E.)			Mannitol concentration (%) (mean ± S.E.)			Mannitol concentration (%) (mean ± S.E.)		
	0	1	2	0	1	2	0	1	2
	A			B			C		
Choro	63.9±3.9	75.0±3.5	69.4±3.7	75.0±3.5	87.5±2.7	69.4±3.7	13.9±2.8	34.7±3.8	41.7±4.0
Nobo	45.8±4.0	75.0±3.5	75.0±3.5	77.8±3.4	83.3±3.0	83.3±3.0	8.3±2.2	41.7±4.0	34.7±3.8
Ketano	70.8±3.7	84.7±2.9	91.7±2.2	79.2±3.3	87.5±2.7	91.7±2.2	16.7±3.0	45.8±4.0	55.6±4.0

A = survival after six months, B = survival after twelve months (one passage) and C = survival after fifteen months of storage (one passage).
The data of materials kept under different temperatures were pooled.

Shoot multiplication after storage

Shoots that had been incubated for twelve months (2x six-month subculture intervals) multiplied rapidly on multiplication medium under normal growth conditions (Table 7.3). Those which were visually scored viable after incubation under slowth-growth conditions showed a full regeneration capacity except for the samples treated at 18°C and 0% mannitol. Shoot tips regularly produced two to four new shoots during each subculture at both BAP concentrations.

However, shoots, which had been kept under slow-growth conditions for two subsequent cycles of six and nine months (15 months total) multiplied very slowly. This phenomenon was most conspicuous during the initial multiplication stage, no shoot multiplication occurring during the first two subcultures. In particular, shoot cultures, which survived after 15 months at 18°C (either 1% or 2% mannitol), did not generate new shoots at all.

Table 7.3 Shoot proliferation rates of the three enset clones after long term storage *in vitro*, multiplied at two different BAP concentrations

Clone	Subcultures	Interval time=6months BAP		Interval time=9months BAP	
		10 μM Mean no. of shoots ± S.E	20 μM Mean no. of shoots ± S.E	10 μM Mean no. of shoots ± S.E	20 μM Mean no. of shoots ± S.E
Choro	1	2.6± 0.60	3.6± 0.70	1.6± 0.45	1.8± 0.47
	2	2.8± 0.62	3.4± 0.68	1.6± 0.45	2.2± 0.52
	3	2.8± 0.62	3.0± 0.64	1.8± 0.47	2.2± 0.52
	4	2.6± 0.60	3.4± 0.68		
	5	2.8± 0.62	3.2± 0.66		
Nobo	1	3.2± 0.66	4.2± 0.76	1.4± 0.42	2.0± 0.50
	2	2.8± 0.62	4.2± 0.76	1.4± 0.42	2.0±0.50
	3	3.2± 0.66	3.8± 0.72	1.6± 0.45	2.2± 0.52
	4	2.8± 0.62	4.0± 0.74		
	5	3.4± 0.68	4.0± 0.74		
Ketano	1	2.6± 0.60	3.0± 0.64	2.2±0.52	2.6± 0.57
	2	2.6± 0.60	3.0± 0.64	2.4±0.55	2.8± 0.59
	3	3.0± 0.64	2.8± 0.62	2.4± 0.55	2.8±0.59
	4	2.8± 0.62	3.0± 0.64		
	5	3.0± 0.64	3.4± 0.68		

The data presented are for both storage intervals. Only results of three subculturings are presented for samples subcultured at nine months interval as shoot multiplication after storage was slow within the given timeframe.

The mean and standard deviation were calculated for the number of shoots that proliferated from ten individual shoots per each subculture.

Shoot browning

Browning as described elsewhere (Negash *et al.*, 2000) was perceived as a problem, but frequent subculturing (two-week interval) was effective in overcoming the difficulties. Similarly in this study, browning occurred early during shoot initiation preceding slow growth. Under slow growth storage conditions, this phenomenon disappeared and cultures did not exibit browning throughout the slow-growth period. However, the phenomenon reappeared on multiplication medium at 25 °C. The effect varied depending on the BAP concentration used and was more pronounced at the higher concentration (20 μM).

Rooting and transfer to soil

Root formation in all three clones took place in less than two weeks after transfer to root induction medium, as in cultivars, which were not subjected to slow-growth treatment. Some shoots produced roots even before they were inoculated on the root induction medium. More than one hundred plantlets were transferred to the greenhouse and ca. 100 % of the plantlets became established. No differences were observed in comparison to the starting material.

7.5 Discussion

Approaches to achieve slow growth and efficient storage have included modification of the culture medium, incubation at reduced temperatures and application of low light intensity (Banerjee and De Langhe, 1985). In bananas, slow growth could be achieved by changing osmotic conditions of the culture medium. However, the most successful and widely applied approach to slow *in vitro* growth in plants has been reduction of temperature (Withers, 1992).

The present study has made clear that the use of low incubation temperatures combined with low concentrations of mannitol in the growth medium offers an efficient way to reduce the growth rate allowing a period of approximately six months without the necessity of subculturing while maintaining high survival frequency.

Of the two storage temperatures tested, 15°C, gave better results allowing medium-term storage of enset shoot cultures. This finding is in line with those reported by Banerjee and De Langhe, (1985), Bhat and Chandel, (1993) and Van den Houwe *et al.*, (1995) for *Musa* species. The presence of mannitol as an osmotic growth retardant in addition to the reduction of the growth temperature also proved beneficial in our hands. Similar results have been reported by Westcott (1981), Staritsky *et al.* (1986),Vysotskaya (1994), Love *et al,* (1987) and Mix (1985) for potato, *Colocasia,* strawberry, *sweet potato* and Solanum respectively.

Shoot browning has been reported to be a major problem in *Musa* species, a close relative of enset, by Afza *et al.* (1996), Banerjee and De Langhe (1985) and Novak *et al.* (1989). The effect in enset was minimal and only appeared during the multiplication phase following the slow growth at high concentration of BAP.

The three clones studied did not show statistically significant differences in their response to the applied slow-growth conditions, although varietal differences at storage under low temperature have been recorded for *Musa* (Banerjee and De Langhe, 1985; Van den Houwe *et al.*, 1995). The similarity in response to the storage potential of the three clones studied suggests that the technique may be applicable to a wide range of enset germplasm.

Shoots recovered from cultures subjected to low temperature storage showed rapid multiplication with proliferation rates better than those shoots maintained at normal growth room conditions. Rooting and establishment in soil was also easily attained. Difficulties in rooting after repeated subculture on media containing cytokinin and poor establishment of cultures after slow growth as reported by Drew (1992) and Withers (1992), were not apparent in our experiments.

Prolonged periods of slow growth storage beyond six months without subculturing appeared detrimental. In general, our findings show that incubation of shoot tips at 15 °C with 1% mannitol and six-month subculturing interval is suitable to allow storage of enset shoot cultures, guaranteeing high survival and rapid regeneration and multiplication rates.

Presently, bacterial wilt disease is the overriding constraint to on-farm conservation and production of enset. So far, research and stock management efforts to overcome this problem have not lead to any improvement of the situation. The production of disease-free planting stocks obtained through *in vitro* culture might constitute a feasible control method and *in vitro* cultures might be stored for extended periods under conditions as described above, thus contributing to an improved conservation and utilization of the enset genetic diversity.

Chapter 8 Genetic analysis of enset (*Ensete ventricosum* Welw. Cheesman) diversity in Ethiopia to improve efforts in conservation*

8.1 Abstract

Enset (*Ensete ventricosum* Welw. Cheesman)) is a major multi-purpose (food, fibre, medicine, etc.) crop in Ethiopia. The country has been identified as the centre of origin and diversity of enset. An array of (vegetatively propagated) clones are maintained by local farmers. Reflecting a global tendency, over the last decades the local farming systems in which enset is maintained, have become endangered. Therefore, an effective conservation strategy is needed to secure the future avialability of enset as a major food source in Ethiopia. Conservation of clonally propagated crops like enset is complex and relatively expensive, and therefore an assessment of clonal diversity was regarded essential in order to optimally conserve the genetic resources identified.

In the present study 146 clones were collected from five different regions in Southwestern and Southern Ethiopia. These clones were characterised using AFLPs generated with four primer pairs. A total number of 181 bands were scored of which 105 (58%) appeared polymorphic. Twenty one duplication groups consisting of 58 clones were identified. Many duplicates had similar vernacular names. In some cases, duplication could be ascribed to the variation in utilisation of the same clone by local farmers. Other duplicates apparently occurred since different names had been given to a single clone by different ethnic groups in Ethiopia. Despite the distinct agro-ecological differences, cluster analyses did not reveal substantial genetic differentiation between the five distant regions (exceeding 450 kilometres) studied. An analysis of molecular variance showed that only 4.8% of the total genetic variation was found between regions, whereas 95.2% was found within regions. This result may indicate that, enset clones have traditionally been exchanged over large distances. Implications of the results for conservation strategies are discussed.

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8.2 Introduction

Enset (*Ensete ventricosum* Welw. (Cheesman)) is a perennial monocarpic crop belonging to the family of the *Musaceae*. For thousands of years it has been used as a food crop only in Ethiopia (Smeds, 1955), where it was once domesticated. Enset is an important (co-)staple crop for over 20% of the Ethiopian population living in the Southern and Southwestern parts of the country, which includes many different ethnic groups (Brandt *et al.*, 1997). It is a diploid (2n=18) species that phenotypically resembles the banana plant, but the edible parts of the plant are formed by the pseudostem and the underground corm rather than by the fruit. Enset is predominantly vegetatively propagated by the majority of enset farmers, although regeneration by seed is sometimes practised. Unlike banana, the production of voluntary suckers is rare unless the plant is intentionally induced to do so.

Characterization of clones using morphological markers has been given little attention and a well-established taxonomic classification system and descriptor list of visible characteristics are lacking. In addition, only few attempts have been made to document and analyse clonal identity using farmer's taxonomy. In these cases, clonal names reported in literature are associated with only limited phenotypic data provided by enset farmers (e.g. Shigeta, 1991). Local knowledge of farmers is the main source of the passport and agronomic data of the genetic resources collections of enset maintained by the Institute of Biodiversity Conservation and Research in Addis Ababa, the Institute of Agricultural Research at Areka and the Awassa College of Agriculture in Awassa. Detailed information about the genetic diversity in this crop is virtually absent.

Most of the genetic diversity of enset is traditionally maintained *in situ* by farmers. Unfortunately, many valuable clones have been lost due to various human and environmental factors (Gebremariam, 1996), which may have reduced the total available genetic diversity of the crop. Lack of knowledge about the genetic diversity that is still available complicates the conservation, improvement and utilisation of enset, either by farmers or by conservationists and breeders.

Farmers' classification systems have been applied in the past to characterise the germplasm morphologically. However, morphological variation often appeared to be limited and genotypic expression was probably severely influenced by environmental conditions.

Moreover, as the area where enset is grown is inhabited by various ethnic groups, different names for identical or similar clones may be used by different ethnic communities. Therefore, in this study, molecular methods have been applied to characterise the germplasm diversity.

Molecular genetic marker techniques such as RFLPs (Botstein *et al.*, 1980), RAPDs (Williams *et al.*, 1990), and microsatellites (Hutokshi *et al.*, 1998), offer the necessary methods to characterise germplasm at the DNA level (Westman and Kresovich, 1997). Molecular genetic markers are usually unaffected by the environment and can often be generated in large numbers (Vosman *et al.*, 1999). The AFLP™ technique applied in this study is a more recently developed DNA marker system based on a combination of PCR and RFLP techniques (Vos *et al.*, 1995). AFLP fingerprinting profiles can be generated without prior knowledge of genome sequences and can therefore be developed for DNAs of any origin. Compared to other molecular marker systems, AFLPs are generally considered more powerful due to the high number of genomic fragments that can be analysed in a single assay (Lin *et al.*, 1996; Powell *et al.*, 1996). AFLPs have been applied successfully to characterise germplasm of various crops, including *Musa spp.*, which form close relatives of enset (Engelborghs *et al.*, 1998; Barrett and Kidwell, 1998).

In the present study, AFLPs have been employed to characterise 146 enset clones from Southwestern and Southern Ethiopia. The objectives of the study were to assess genetic relationships among the clones, to identify duplications and to investigate regional variation. Implications of the results in relation to the conservation of enset genetic diversity in Ethiopia are discussed.

8.3 Material and Methods

Plant material

Leaf samples from 146 enset clones were collected on farm from Southwestern and Southern Ethiopia in 1999 (Table 8.1). Clones were randomly selected from the available diversity maintained on farmer's fields. Vernacular names were also obtained from the enset farmers who provided the germplasm. Samples were collected from the districts Chena (n = 36) and Decha (n = 29) of the Kaffa-Shaka zone in Southwestern Ethiopia which are located 70 kilometres apart, and from Sidama (n = 30), Hadiya (n = 45) and Wolaita (n = 6) in Southern

Ethiopia. The Kaffa-Shaka zone is located at about 450 km from the closest other regions where samples were collected.

Pieces of leaf tissue were harvested for each clone and stored in 50 ml tubes containing a saturated NaCl-CTAB preservation buffer following the procedures of Rogstad (1992). Upon return in the laboratory, two weeks later, the CTAB was washed off thoroughly with distilled water. About 50-100 mg of leaf tissue was then transferred to 1.5 ml Eppendorf tubes and stored at -80 °C awaiting further analysis.

Table 8.1 Vernacular names and collection sites of all enset clones investigated in the present study

Sample code	Vernacular name	Collection site	Sample code	Vernacular name	Collection site	Sample code	Vernacular name	Collection site
D2	Chele bocho	Decha	C23	Chele nobo	Chena	H4	Shate	Hadiya
D3	Shoto	Decha	C24	Shelako	Chena	H5	Astara	Hadiya
D4	Achecho	Decha	C25	Ofichi	Chena	H6	Merza	Hadiya
D5	Kekero	Decha	C26	Bakamo	Chena	H7	Gimbo	Hadiya
D6	Bajo	Decha	C27	Macha deme	Chena	H8	Tebute	Hadiya
D7	Kochi tato	Decha	C28	Goshno	Chena	H9	Woshamaja	Hadiya
D8	Korimo	Decha	C29	Shimo	Chena	H10	Zobra	Hadiya
D9	Utro	Decha	C30	Kebo	Chena	H11	Agade	Hadiya
D10	Agene	Decha	C31	Bumbo	Chena	H12	Hayiwona	Hadiya
D11	Tarelo	Decha	C32	Omo	Chena	H13	Wordes	Hadiya
D12	Woiro	Decha	C33	Hichewi	Chena	H14	Tegaded	Hadiya
D13	Chamero	Decha	C34	Gebeti	Chena	H15	Necho	Hadiya
D14	Tayo	Decha	C35	Akibero	Chena	H16	Beneja	Hadiya
D15	Shatako	Decha	C36	Kachichi	Chena	H17	Hiniba	Hadiya
D16	Wango	Decha	C37	Adeli bocho	Chena	H18	Landwesa	Hadiya
D17	Kalo	Decha	C38	Ganji bocho	Chena	H19	Mesmesicho	Hadiya
D18	Chongo	Decha	S1	Kule	Sidama	H20	Eshamwesa	Hadiya
D19	Ginkayo	Decha	S2	Made	Sidama	H21	Dirbo	Hadiya
D20	Utino	Decha	S3	Birbo	Sidama	H22	Sokido	Hadiya
D21	Bongo	Decha	S4	Wubisho	Sidama	H23	Shewrad	Hadiya
D22	Geno	Decha	S5	Gena	Sidama	H24	Bedadeda	Hadiya
D23	Gayo	Decha	S6	Astara	Sidama	H25	Gishera	Hadiya
D24	Epecho	Decha	S7	Micho	Sidama	H26	Gariya	Hadiya
D25	Yahi bajo	Decha	S8	Garbo	Sidama	H27	Manduluka	Hadiya
D26	Madi	Decha	S9	Siltite	Sidama	H28	Disho	Hadiya
D27	Shuri	Decha	S10	Shewite	Sidama	H29	Moche	Hadiya
D28	Yeshankila e.	Decha	S11	Addo	Sidama	H30	Orada	Hadiya
D29	Choro	Decha	S12	Arisho	Sidama	H31	Teigo	Hadiya
D30	Katino	Decha	S13	Aydara	Sidama	H32	Oniya	Hadiya
C1	Neche nobo	Chena	S14	Derassa addo	Sidama	H33	Kombotra	Hadiya
C2	Gesh ariko	Chena	S15	Alaticho	Sidama	H34	Bokucho	Hadiya
C3	Anami nobo	Chena	S16	Gulumo	Sidama	H35	Mekelesa	Hadiya
C4	Kopri	Chena	S17	Gamachela	Sidama	H36	Woshamaja	Hadiya
C5	Machi nobo	Chena	S18	Wanikore	Sidama	H37	Torora	Hadiya
C6	Waji beli	Chena	S19	Chacho	Sidama	H38	Hanzena	Hadiya
C7	Chele ariko	Chena	S20	Bufare	Sidama	H39	Unjama	Hadiya
C8	Kapicho	Chena	S21	Agena	Sidama	H40	Kaseta	Hadiya
C9	Neche ariko	Chena	S22	Haho	Sidama	H41	Mariye	Hadiya
C10	Mocho	Chena	S23	Kincho	Sidama	H42	Gozoda	Hadiya
C13	Ketano	Chena	S24	Kire	Sidama	H43	Uskruz	Hadiya
C14	Aei nobo	Chena	S25	Awulecho	Sidama	H44	Kiniwar	Hadiya
C15	Bedado	Chena	S26	Gedmo	Sidama	H45	Bekecho	Hadiya
C16	Chekero	Chena	S27	Kiticho	Sidama	W1	Shalakumia	Wollaita
C17	Garamanji	Chena	S28	Genticha	Sidama	W2	Kucha	Wollaita
C18	Tuti ariko	Chena	S29	Gossalo	Sidama	W3	Alagena	Wollaita
C19	Besano	Chena	S30	Nefo	Sidama	W4	Ankogena	Wollaita
C20	Omichi	Chena	H1	Sapara	Sidama	W5	Halla	Wollaita
C21	Gebi nobo	Chena	H2	Awuneda	Hadiya	W6	Chichia	Wollaita
C22	Deki	Chena	H3	Siskela	Hadiya			

DNA isolation

Tissue samples were vacuum dried overnight and mechanically ground using a retch-shaking mill and about 5 glowed glass pearls per Eppendorf tube. Since DNA analyses in enset had not been described before, three different DNA extraction procedures, as described by Fulton *et al.* (1995), Rogstad (1992), and the Qiagen spin column extraction method (Dneasy™ Plant Mini Kit) respectively, were tested in order to determine the optimal protocol. No subsequent amplification using PCR could be accomplished with DNA obtained by the microprep protocol of Fulton *et al.* (1995). The other two protocols both resulted in DNA that enabled proper amplification, but slightly better results were obtained from DNA isolated with the Qiagen spin column method. This method was therefore adopted to isolate genomic DNA from all samples. Extracted DNA samples were stored at 4°C. DNA concentrations were estimated by comparing 2 μl of each sample with 20, 40, 60, 80 and 100 ng of phage lambda DNA on a 0.8% agarose gel.

AFLP protocol

The AFLP protocol basically followed the procedures described by Vos *et al.* (1995). Briefly, about 300 ng of total genomic DNA was digested to completion using 5 units of *Eco*RI and 5 units of *Mse*I. AFLP adapters for both restriction enzymes were then ligated to the fragments, without selection between the *Eco*RI-*Eco*RI and *Eco*RI-*Mse*I fragments by the use of biotinylated *Eco*RI adapter and magnetic beads. Subsequently, template DNA was preamplified using primer pairs based on the sequence of the adapters, and 3' extended with one selective nucleotide ("A" for the *Eco*RI primer and "C" for the *Mse*I primer). Successful amplification was verified by electrophoresis of part of the PCR product on a 2% agarose gel. Diluted preamplification product was then used as template in a second amplification reaction, using primer pairs variably extended with a number of selective nucleotides at the 3' end. The *Eco*RI primer was radiolabelled with ^{33}P prior to PCR. Labelled PCR products were separated on 6% denaturing polyacrylamide gels (Biozym, Sequagel-6) and exposed to X-ray film (Kodak, XOMAT AR) for several days. Goldstar *Taq* DNA polymerase was used for PCR and all amplification reactions were performed on a single block of a Perkin Elmer 9600 thermo cycler, programmed with the following thermal profile: 1 cycle of 30 s at 94 °C, 30 s at 65 °C and 60 s at 72 °C; 12 cycles in which the initial annealing temperature of 65 °C was lowered by 0.7 °C each cycle; 23 cycles in which the annealing temperature was held constant at 56 °C. More details about the experimental procedures followed are given by Arens *et al.* (1998).

Following preamplification of the samples, 12 different primer combinations (E+AA, E+AC and E+AG in combination with respectively M+CCA, M+CCT, M+CGG and M+CTC) were tested on six clones in order to identify suitable primer pairs. Four primer combinations were selected for further analysis based on resulting AFLP profiles which were scored for sufficient polymorphic fragments that could be scored unambiguously. As a control for the reproducibility of the patterns, four replicate tissue samples from a single individual were included in all experimental steps in order to estimate the frequency of artefact bands on the autoradiograms.

Data analysis

Autoradiograms (approximate size range of the fragments: 50-500 bp) were manually scored and variation in the presence of bands was recorded as polymorphic AFLP fragments. The number of polymorphic and monomorphic fragments was determined for each primer pair. Clones were only considered identical when all AFLP fragments generated with the four primer pairs fully matched. Band sharing data were used to calculate genetic similarities between samples based on the simple matching coefficient (Sokal and Michener, 1958). The similarity values were used to graphically represent genetic relationships between the clones by the UPGMA clustering algorithm (e.g. Nei, 1987) and principal co-ordinate plots (PCO). These analyses were carried out using the Genstat 5 software package (release 4.1). Matrices of Nei's standard genetic distances based on different primer pairs were tested for significant correlation (10,000 permuted data sets) by a Mantel test (Mantel, 1967), using the software package TFPGA (Miller, 1997). To investigate regional variation, an analysis of molecular variance (AMOVA) of genetic distances based on the simple matching coefficient between all pairs of clones was used to compute molecular variance components within and between geographical regions. These analyses were carried out using version 1.55 of the software package WINAMOVA (Excoffier *et al.*, 1992). Monomorphic loci were included in all data analyses.

8.4 Results and Discussion

AFLP variation in enset

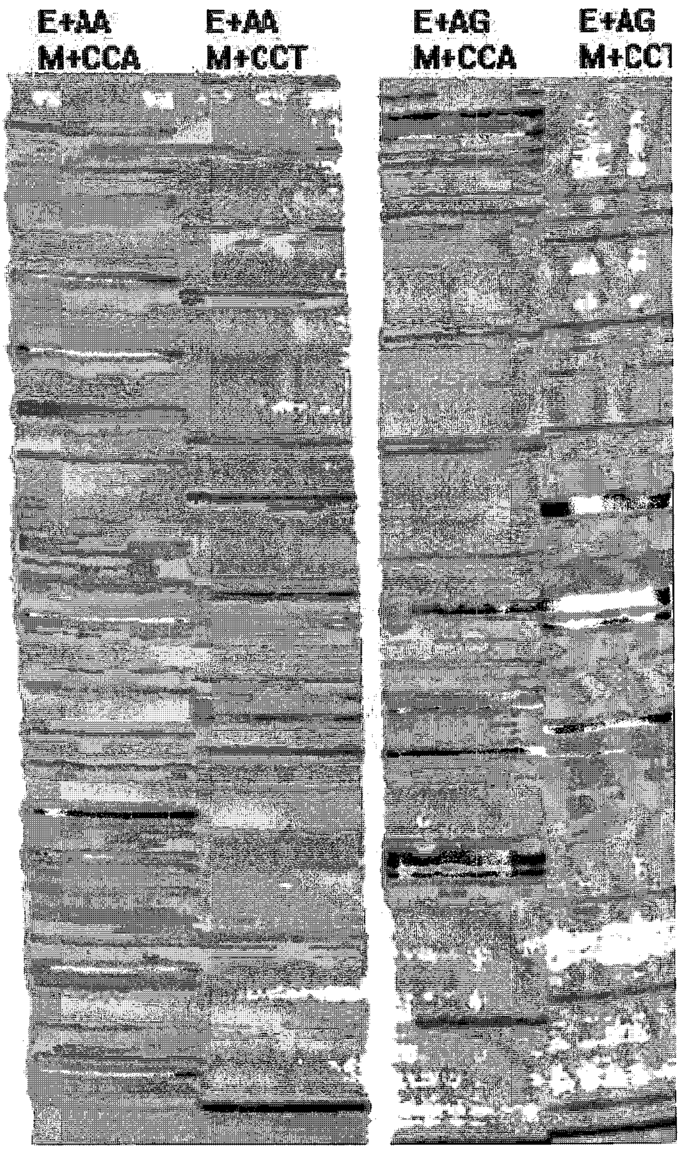
The four primer pairs selected out of the 12 primer combinations generated multiple polymorphic AFLP fragments that could be scored unambiguously (Fig. 8.1). Within the total group of 146 clones a total number of 181 AFLP fragments was scored, of which 105 (58%) were found to be polymorphic.

Similar values of the degree of polymorphism were observed between the selected primer pairs, ranging from 0.52 to 0.63 (Table 8.2). With respect to genetic distances among clones, Mantel tests revealed significant correlations between all pairs of primer combinations tested (range of correlation coefficients: $r = 0.3580$ to 0.4534, $P < 0.001$ in all cases). Thus, with respect to the observed level of variation and the genetic distances among clones consistent results were obtained with the four primer pairs investigated. Identical AFLP profiles were observed for four replicate tissue samples for each of the four primer pairs, indicating a low probability that the results obtained were substantially affected by the generation of artefact bands.

Table 8.2 AFLP banding patterns scored for the four different primer pairs applied on the total number of 146 enset clones

Primer pair	E+AA/M +CCA	E+AA/M +CCT	E+AG/M +CCA	E+AG/M +CCT	Total
Total number of bands scored	49	35	49	48	181
Number of polymorphic bands	30	20	30	25	105
Degree of polymorphism	0.61	0.57	0.61	0.52	0.58

Fig. 8.1 AFLP autoradiograms of the four primer combinations used in the present study for six different clones



Identification of duplicate clones

Within the total number of 146 clones, 19 duplication groups consisting of a total number of 54 clones were identified based on the AFLP data (Table 8.3). In other words, this selection showed a redundancy of 35 clones, i.e. 24% of the total collection sample.

Table 8.3 Duplication groups (1-19) of enset clones based on identical fingerprinting profiles obtained from four AFLP primer pairs. Clones are denoted by their sample code and vernacular name

Group	Sample code & vernacular name	Group	Sample code & vernacular name	Group	Sample code & vernacular name
1.	D29 (Choro) D30 (Katino) C13 (Ketano) C35 (Akibero) C36 (Kachichi)	8.	D18 (Chongo) C1 (Neche nobo) C3 (Anami nobo) C5 (Machi nobo) C14 (Aei nobo) C21 (Gebi nobo) C23 (Chele nobo) C28 (Goshno) C32 (Omo)	13.	H13 (Wordes) H32 (Oniya) H37 (Torora)
2.	D13 (Chamero) C29 (Shimo)	9.	C8 (Kapicho) C33 (Hichewi) W6 (Chichia)	14.	H11 (Agade) H41 (Mariye)
3.	D16 (Wango) D23 (Gayo)	10.	D14 (Tayo) S2 (Made) S3 (Birbo)	15.	H12 (Hayiwona) H21 (Dirbo) H24 (Bedadeda) S10 (Shewite)
4.	D2 (Chele bocho) C38 (Ganji bocho)	11.	S17 (Gamechela) S18 (Warukore)	16.	H34 (Bokucho) H45 (Bekecho)
5.	D5 (Kekero) D9 (Utro)	12.	H20 (Eshamwessa) W1 (Shalakumia)	17.	H27 (Manduluka) H30 (Orada)
6.	D6 (Bajo) D25 (Yahi bajo) D12 (Woiro)			18.	H10 (Zobra) H36 (Woshamaja)
7.	C7 (Chele ariko) C18 (Tuti ariko)			19.	H16 (Beneja) H33 (Kombotra)

In the first case, a number of clones that were found to be identical (mainly the Kaffa Shaka collections) appeared to have very similar vernacular names, i.e. Katino and Ketano in group 1, Chele bocho and Ganji bocho in group 4, Bajo and Yahi Bajo in group 6, Chele ariko and Tuti ariko in group 7, Neche nobo, Anami nobo, Machi nobo, Aei nobo, Gebi nobo and Chele nobo in group 8, and Bokucho and Bekecho in group 16. In most of the cases, these redundancies or duplications have to be ascribed to different utilisation aspects of the same clone. According to our own observations, farmers are using different names for identical clones based on the pseudostem size, time until maturity or other attributable characteristics. For instance, in Kaffa Shaka and some other areas of the North Omo zone, they characterised several clones as male or female, which appeared to be unrelated to the genotype of the plant. We concluded that this habit formed an indication for the qualities desired for by male and female farmers. For example, the male Nobo is a large, vigorous, and strong plant, and has a high yield, whereas its taste is less preferred. The female Nobo is thin, less vigorous and better preferred for its taste (Alemu and Sandford, 1996; Habtewold *et al.*, 1996; Negash *et al.*, 2000). It was concluded that the male or female character of a plant was based on environmental parameters.

In the second instance duplication appeared with in regions (11 duplication groups) but between different ethnic groups. According to the information supplied by farmers, exchange of planting materials is high and vernacular names may be altered after long-term adaptation of the exchanged clone, corresponding to the farmer's own preferences and languages. This might have contributed to duplication of clones, which did not exhibit vernacular similarities.

Although the majority of duplicate clones were collected within districts and zones, rather than between zones, a third group indicates that identical genotypes could be observed across largely varying agro-ecological systems and geographical distances. Examples are duplicates between the Kaffa-Shaka zone and the Wolaita zone (duplication group 9) and between the Kaffa-Shaka zone and the Sidama zone (duplication group 10). This result was unanticipated based on the differences in vernacular names. However, it does indicate that exchange of clones among farmers has not been restricted to single zones or similar environmental conditions. It might also indicate a preference of different ethnic groups in different regions for similar characteristics.

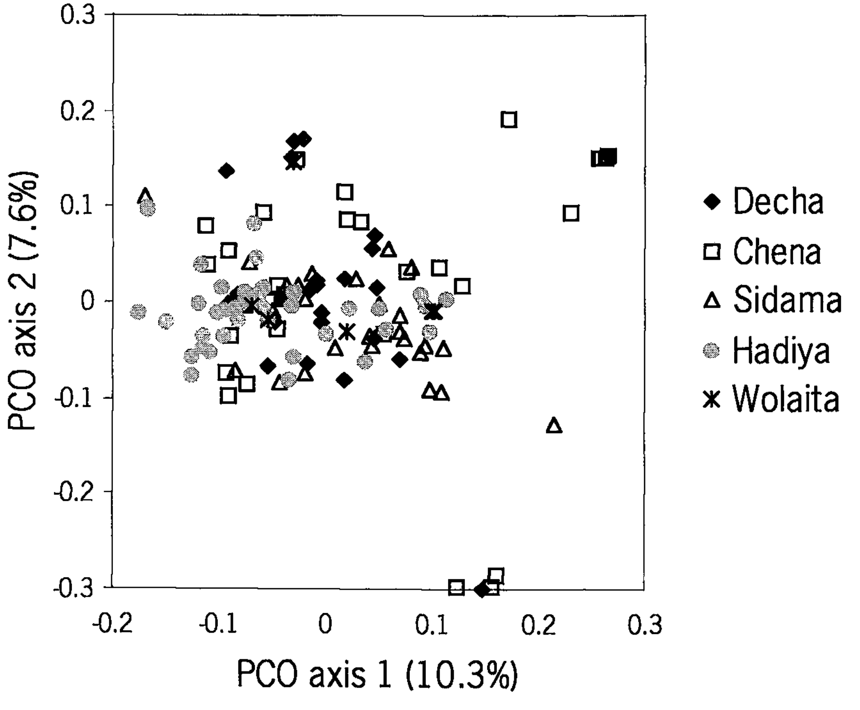
Full identity between clones can only be ascertained when the entire genomes of individuals are compared. Therefore, it cannot be ruled out that some clones that were found identical in the present study are actually genetically slightly different, in particular since farmers distinguished some of the clones regarded as identical according to the molecular analysis. For example, despite the phenotypic differences reported by farmers, identical AFLP profiles were observed for the clones Choro and Ketano using the four selected primer pairs (Table 8.3: duplication group 1). Coincidentally, both clones were involved in the testing of the 12 different primer pairs in the initial phase of the study. Re-examination of the fingerprinting profiles revealed one or two polymorphic fragments between these clones for three out of the eight additional primer pairs tested (E+AC/M+CCT, E+AC/M+CGG and E+AG/M+CGG). Although a limited number of primer pairs is sometimes found to be sufficient for cultivar distinction (e.g. Schut *et al.*, 1997; Cervera *et al.*, 1998), the results obtained for the clones Choro and Ketano indicated that an increase in resolution may be needed to discriminate between closely related clones of enset, and that the actual number of duplicates might be lower than 54. Farmers very easily differentiated between these two clones, providing further evidence that molecular markers are not always able to differentiate morphologically different individuals.

Regional variation of enset in Ethiopia

Genetic relationships among the clones investigated were studied using an UPGMA cluster analysis based on similarity values. Regional differentiation appeared to be limited as no clear clustering of genotypes from a single district or zone could be detected for the material investigated (results not shown). This finding was supported by a principal co-ordinate plot of all the enset clones studied (Fig. 8.2). The two principal axes, together, explained only 17.9% of the total variation, indicating the limited genetic differentiation within the sample of clones investigated. An analysis of molecular variance revealed that only 4.8% of the total genetic variance is distributed between the five regions studied, whereas 95.2% can be found within regions. This result was rather unexpected based on the large variation in agro-ecology and the comparatively large geographic distances between the different regions within Ethiopia.

Phenotypic plasticity of enset may be assumed based on its adaptation to agro-ecological variations with elevations ranging from 1400 to 3100 meters above sea level (Endale *et al.*, 1996). This might explain how single genotypes may occur across different locations. The traditional migration or exchange of clones among regions irrespective of geographical distances has been reported to occur frequently among enset farmers in order to increase the diversity of individuals for utilisation (Tsegaye, 1991; Tsegaye and Struik, 2000). The fact that identical clones were found even between different zones supports this view.

Fig. 8.2 Principal co-ordinate (PCO) plot of all clones investigated in the present study. The percentage of total variation explained by the axis are given between brackets in the axis legends



Implications for the conservation of enset in Ethiopia

Lack of empirical knowledge about the genetic diversity of a crop hampers the efficient conservation, improvement and utilisation of its genetic resources. No data on the clonal variation in enset have so far been available. The results described in the present study indicate that AFLP analysis can successfully be applied to study clonal diversity in enset. In addition to genetic analysis, studies on agro-morphological diversity, specific characteristics (disease resistance, medicinal value, fiber quality, etc.) and utilisation of enset clones by farmers are underway. A comparison of the results of these investigations and the molecular genetic data has been planned. Together with a detailed study of the indigenous knowledge of farmers, molecular and agro-morphological data will provide the necessary information for an efficient strategy for the management of genetic resources of enset.

Conservation of enset genetic resources *ex situ* as seed in cold storage is difficult or even impossible. Seeds cannot be obtained easily and if so are difficult to store because of their bulky size, and hard to germinate. Moreover, conservation of seeds has limited value for utilization in view of the usual clonal propagation of the crop. Therefore, genetic resources of the crop can only be conserved either *in situ* on-farm, *in vitro* or in field genebanks. Since these approaches are capital-intensive and enset has been a neglected crop due to its geographically limited use, optimal effectiveness of conservation programmes is of major importance. Knowledge about clonal diversity will allow to decide which clones are of priority for conservation, by minimising redundancies and optimising genetic diversity and hence optimizing the cost-benefit ratio in maintaining the crop's germplasm.

The results from the present work indicate that there is a considerable diversity in the species and our findings are comparable to the one reported for *Musa* (Engelborghs *et al.*, 1998). A more extensive investigation including major production areas not yet covered would provide an even broader overview of the diversity that exists in enset genetic resources in Ethiopia and allow its effective conservation.

PART III

Chapter 9 Profile of the households in the survey

In this chapter, the more general profile of the households in the survey will be presented. Results of the survey regarding age and sex, ethnicity, religion, household size and composition, marriage, migration, and household practices, will be discussed.

9.1 The socio-demographic context

Household structure of the study population

According to the census we carried out, 1610 household members comprising 240 farming households were covered in the area surveyed in both *woredas*. For comparisons however, total population size and distribution of households for the entire *woredas* and zone has been presented in Chapter 4. On average, in our survey the household had 6.7 members whereas a slightly higher mean of 7 members is recorded for the Chena *woreda*.

The study population comprised 49.48 percent male, and 50.52 percent females for the Decha *woreda* and 50.83 percent male and 49.17 percent female for the Chena *woreda* respectively. Table 9.1 presents the distribution of households by sex categories and total household size of the study population.

Table 9.1 Distribution of households in the study *woredas*

	Number of individuals covered			Average HH size
woreda	Male	Female	Total	
Decha	380	388	768	6.4
Chena	428	414	842	7.0
Total	808	802	1610	6.7

Source: survey data

As discussed in chapter 3, the household, in this study is defined as a family-based co-residential unit, which takes care of resource management and the primary needs of its members. The members have common cooking arrangements and reside in one homestead, which can comprise one or more houses. The study focussed on a household as a whole where by the (male) head of the household, his wives and the other adult members of the household are considered important actors.

Kinship composition of households

In the Ethiopian context, the domestic organization of households in rural as well as urban settings is mostly based on an extended family. Many of the households surveyed had more than one adult or young dependant in addition to their own children. In Table 9.2, the family composition of the households studied has been presented according to the adapted categorization in Niehof (1985).

This categorization classifies:

- Natural children, adopted children, and stepchildren and their parents are considered as children and parents, and
- A divorced son or daughter who resides with his/her parents as a son or daughter.

In addition, other relatives can be: mothers or fathers, brothers or sisters, and nieces or nephews of either the household head or his wife. Given the patrilineal kinship system, it is very rare that relatives of the wife of the household head will come to her place to reside, either temporarily or permanently. Therefore, it is commonly the man (household head) who brings his close relatives to the homestead. Adopted children and hired farmhands may form additional members.

Table 9.2 Category of household members in the survey

Category	Number	Percentages
1. Husband (HH head)+wife only	2	0.83
2. Husband (HH head)+wife+children	129	53.75
3. Husband (HH head)+wife+children+other relatives	39	16.25
4. Husband (HH head)+wife+others	6	2.50
5. Husband (HH head)+children only	1	0.42
6. Husband (HH head)+children+others	6	2.50
7. Husband (HH head)+others	5	2.08
8. Widow (HH head)+children	31	12.92
9. Widow (HH head)+ children+others	12	5.00
10. Widow (HH head)+others	9	3.75
Total households	240	100

Source: survey data

Among the households studied, 15.8 percent were found to be polygamous in both *woredas* combined.

The age and sex structure of surveyed households

The age structure of the sample population for the two *woredas* (Table 9.3) follows the normal age structure for the southern part of Ethiopia in which large numbers of children are observed while the proportion of the elderly persons is relatively very small. As shown in the table below, the population under 15 years of age accounted for 51.3 percent, those between 15 and 64 years 45.6 percent and the remaining with ages of 65 and above accounted for only 3.1 percent. The large proportion of persons under 15 years indicates a high level of fertility, about which we have no direct data. The large average household size, while only 9.0 percent of the households are households without children (see Table 9.3), points in the same direction.

Table 9.3 Distribution of population by age and sex class of the sample households

Age	*Male*	*%*	*Female*	*%*	*Total*	*%*
0-4	156	19.3	107	13.3	263	16.3
5-9	158	19.6	146	18.2	304	18.9
10-14	158	19.6	102	12.7	260	16.1
15-19	90	11.1	87	10.8	177	11.0
20-24	42	5.2	55	6.9	97	6.0
25-29	35	4.3	58	7.2	93	5.8
30-34	24	3.0	46	5.7	70	4.3
35-39	31	3.8	45	5.6	76	4.7
40-44	19	2.4	35	4.4	54	3.4
45-49	27	3.3	30	3.7	57	3.5
50-54	17	2.1	27	3.4	44	2.7
55-59	14	1.7	11	1.4	25	1.6
60-64	17	2.1	24	3.0	41	2.6
65-69	7	0.9	5	0.7	12	0.8
70-74	5	0.6	13	1.6	18	1.1
75+	8	1.0	11	1.4	19	1.2
Total	808	100	802	100	1610	100

Source: survey data

9.2 Ethnic and religious composition of households

As mentioned elsewhere in this thesis, diverse ethnic groups inhabit the SNNPR. It is reported that more than 16 ethnic groups are living in the Kaffa Shaka zone alone. The study population comprised four major ethnic groups, namely: Kaffa (N=215), Sheko (N=21), Bench (N=3), and Oromo (N=1) households. As the Kaffa ethnic group dominates the study area, the kaffa language (*keffigna*) is also the most spoken by almost all the inhabitants in the area especially in common gathering places such as in markets, churches, and during special meetings or religious ceremonies.

Regarding religion, predominantly orthodox Christians inhabit the two study areas, although a considerable number of people are of another religious denomination such as Protestants, Catholics and Moslems (Table 9.4). Minority tribes exist which do not adhere to a religion and therefore are considered pagans. The *Menja* tribes are an example. They are said to have been dominant in the area in the past. Now, they are isolated from the other ethnic groups, as they do not belong to any of the religious denominations. Because of that, they are not allowed to mix with other ethnic groups during any of the social occasions, though they speak the same type of language. The following was the comment forwarded by participants in our focus group discussions regarding the M*enja* tribes:

> *We live in harmony with all other ethnic groups around us and we respect each other. However, we do not consider the menja's as equal human beings because of their way of life. Religion to us is very important and most respected in our culture regardless to which religious denominations people belong. However, the menja tribes do not have any religion, do not choose the type of food they eat such as the meat of animal, not properly slaughtered (in the Christian or Moslem way), which is forbidden in any type of religion. They are not buried in any of the church cemeteries whenever a member of their family member is deceased. Therefore, they are not allowed to participate in any of our social or cultural events. Nobody buys their agricultural produce if he or she knows that the products belong to that tribe. Wealthier farmers, whenever they face shortage of labor, hire them because they are a cheap source of labor. This is the only chance they have in order to integrate themselves with us.*

Table 9.4 Religious composition of the study population by *woreda*

Religion	Orthodox Christian	Catholic	Protestant	Moslem	No religion	Total
Woreda						
Decha	116	4	-	-	-	120
Chena	69	3	45	1	2	120
Total	185	7	45	1	2	240

Source: survey data

9.3 Migration

Labor migration both temporarily and permanently occurs as a common phenomenon in the country in general. In the SNNPR, it is reported that migration to other areas accounts for 10% of the total population in the region. According to the reports of the regional planning bureau, two zones of the SNNPR, the Kaffa Shaka and Bench Maji zones, show the highest (16%) migration rates.

However, from the results of our survey, the figure on migration is lower than reported at the regional and zonal levels. Only 6.3% of the household members in the survey are reported to have migrated. Migrants, according to Ezra (1997), are people who have moved at least once in their lifetime from a given *woreda* or town in which they were born to any other town or *woreda* within the country, for a substantial period of time. Jones (1990) distinguished several types of migration depending on the distance and time spent away. He also stated that movement of people seasonally or temporarily in search of work, and of students moving regularly between their home and schools is often referred to as circulation, as these movements are short-term, recurrent and periodic in feature. In our case, the temporary migration in the area of study fits into this pattern.

The migration in the enset growing areas is both rural-rural and rural-urban in character, and concerns seasonal migrations for wage labor or other reasons. According to Shack (1966), there is a considerable positive correlation between enset cultivation and labor migration. This might be attributed to the nature of the cultivation of the enset crop. As enset is a multi-year crop, there is a time gap with low labor requirements between the different growth stages, which favors labor migration. Men in these areas usually participate only at the early stages of the crop's cultivation, especially during land preparation and planting or transplanting. Thereafter, it is the woman who usually takes care of manuring, weeding, harvesting and processing of the plant. This gives men the opportunity to migrate for seasonal wage labor to the state or private owned coffee plantations or to food-for-work programs. Migration of women is very rare and only one case was reported in our survey.

Male migration results in a higher workload for the women (wives) who will be *de facto* household heads, as they are the ones who shoulder all responsibilities both in the house and on the farm activities. The burden on the women is even more pronounced when school children who used to help their families both with house and farm activities also migrate to nearby or distant towns to get education.

Migrants who have left their families behind send remuneration in cash or in kind. However, most of the respondents with migrant husbands or relatives responded that the remittance is very little or nothing at all and if there is any, it is not sent on a regular basis.

9.4 Marriage and polygamy

Marriage is an important social institution in Ethiopia, as families are not only reproductive units but also play a vital role in the organization of production, and in various traditional and religious activities. Marriage and family formation processes across the country have similar characteristics, be it in urban or rural areas, except for the fact that urban marriages nowadays are not as stable as the rural ones. In most rural areas once the marriage has taken place the couple tends to stay together and have as many children as possible, even though there may be ups and downs within their relations.

As is evident from this survey, in Kaffa Shaka marriage is usually restricted to within ethnic groups and tribes for reasons such as religion, discrimination of one ethnic group over the other, and so forth. For instance there is no intermarriage with the *menja, mesengo* or *minit* tribes as they are regarded as inferior. Early marriage, starting from the age of fifteen for women, is a common phenomenon. All marriages are arranged based on the full cognizance and permission of the parents of both sides. The man or his parents pay a bride price (*tilosh*) in cash or in kind unless she is a divorced woman. After marriage, the new couple can stay in the man's parents' homestead, as it is customary that the woman follows her husband, at least until they are able to settle on their own (virilocality). The bride also brings some consumables with her, as she is not supposed to prepare food during the first few weeks of marriage.

In some cases, such as among the Bench ethnic groups, the woman is moved to the family of her husband once the *tilosh* is paid. Initially, when the marriage is arranged, the man pays seven head of cattle. However, if she doesn't give birth to a child within a certain period of time, then she will be transferred to his brother. This process continues until a child is born or she gives back the *tilosh* that was given for her and after which time she is returned to her family. This practice may easily lead to spread of diseases such as AIDS.

According to the report from the Zonal Planning Bureau, 1997, a woman between the ages of 15-49 will at an average give birth to 8.0 children, which is higher than the national average (7.7 children). The high rate of childbirth in the region is also attributed to the lack of awareness and knowledge about family planning. Only 7 percent of the women are reported to benefit from birth control treatments. During our survey, when we inquired in each household about the number of children they have and why they would not take birth control pills, the most common response of women was:

> *Children are a gift of God. I don't want to take any medicine, which will make me infertile. God is able to feed them and that is why he allowed me to have many children. I am always happy with my kids, they also help me at home or with the farm activities. If we can afford it, I feed them good food and buy them clothing. But, if we don't have the money they won't trouble us and they accept whatever is available in the house.*

Having many children also has an impact on the children themselves, especially the daughters. In most households in the study area, daughters are often not sent to school or they drop out after they have started. The main reason is that they have to assist in raising and caring for their younger brothers and sisters or help in cooking and in other household activities. A second reason is that parents complain that when they send their daughters to school, they start dating and in most of the cases they get married without their knowledge and never come back again. Therefore, parents prefer to keep their daughters at home and have them marry a person of the parents' preference.

As in some other rural areas, in Kaffa Shaka polygamous marriage is a culturally accepted phenomenon. It was observed that 15.8 percent of the surveyed households (N=14 from Decha and N=24 from Chena *woredas*) were polygamous. The number of wives of the household head ranged from 2 to 6. This idea of having more than one wife even remains attractive to some of the young farmers; we met a farmer aged 25 who was ready to sell his ox in order to marry a second wife.

Parents sometimes agree to give their young daughter to an old man to be his x^{th} wife as long as he is wealthy. Polygamy in the case of the Kaffa people is a system in which the woman is considered to be property. After marriage, when her husband dies, his brother who is often already married inherits her whether she likes it or not. This is done in order to avoid an outsider getting access to the family property. She has no right over the property as she used to have with her deceased husband. She can only use the land or other resources thanks to the goodwill of the parents of her deceased husband and her sons, and as long as she stays in that homestead. If she has an older son, he will take all the responsibilities on behalf of his father, including the right over the land and other resources and assets. He can even chase his mother out if she cannot get along with him and does not obey his orders. If there are no elder sons, she remains a widow, which is a vulnerable situation, as there is no one to help her in farming activities. Due to these reasons, for women in Kaffa Shaka, the death of a husband is considered disastrous.

When the husband wants to marry a second or third wife, the wife or wives at home will be consulted. However, they cannot object to the decision made by their husband. Some even allow their husband to marry their own sister (a case we observed) and live in harmony. Most women accept this situation and value its benefits. They consider that staying married provides them with security and that both household and farm activities will be shared with the other wife. Enset processing, a tedious and time-consuming job, can be done together, the same counts for other activities. When there is a work party (*debo* or *jige*) organized by the household head, whereby friends and neighbors are invited to assist him in farming or construction activities, all his wives will be involved in preparing the meal and coffee for the group.

Each of the wives will have a house of her own, mostly within the same homestead. They don't eat together except on special occasions but will invite each other for coffee every day. However, the husband shares food with each of his wives based on his own set schedule. The wives have their own enset plots in their backyard from which they can harvest and process as much as they want depending on the needs of the household. It is also from the sale of this harvest that a woman buys consumables such as salt, pepper, kerosene, etc. for her household.

There are several reasons for a man to have more wives. These are explained by many of the respondents such as: to have more family labor, to be able to cultivate more land and raise more livestock, and to have many children and a large family.

Ato Alemu Tessema, a farmer with six wives and 18 children was proud and comfortable when he explained the need for having many wives:

> *My father had only two wives and eleven children. Later, nine of his children died and he was left with my brother and me. My brother served in the war at the front and never came back. Therefore, had my father been married to more wives, he could have had many children so that I wouldn't have been left alone. This is why I wanted to have more wives and many children. Children by themselves are wealth to the family. There will also be enough land for farming and more household labor for all the farm activities.*

9.5 Food Situation of the households

As a primary institution, the household is not only responsible for resource mobilization and the provision of farm labor, but also organizes household consumption and has to ensure food security. The members, especially the women, decide on what part of the produce to consume and what part to sell in order to fulfill household requirements.

Not all households are capable of producing enough food to sustain their members, especially when they don't own their land or have limited land. In some cases sharecropping is practiced, especially in cases of (*de jure*) female-headed households with little land and without a man to do the ploughing for them. In at least some of the households studied, this resulted in food self-insufficiency. Some widows in the study area sell locally brewed beer, mats, and malt in order to earn additional income to be able to buy additional food for their households.

Food is shared among all members in the household regardless of the quality and quantity of food. As Netting (1993) put it: "The emic view of household members may well be that their exchanges reflect the ideals of a perfect community in which the doctrine 'from each according to his abilities and to each according to his needs'". However, I would like to argue -also from my own observations- that in some rural settings, it doesn't always work out like that. Though all members of the household contribute labor according to their abilities, they are not always given enough food to satisfy their needs. In most of the cases, it is usually the head of the household who is given priority in getting more and better food in the household. According to the survey results 5% of the women interviewed responded that the household head is given more food than other members as he performs more duties in the farm. In reality, in the enset-based farming system women do the majority of the activities both in the farm and in the house. However, they don't look at it this way, and come at the last place in terms of sharing of food. Moreover, because it is the woman who is responsible for the provision of the daily food needs of members, she always gives priority to her husband, and next in line are the children, especially when there is a special dish or when there is insufficient food to be prepared.

Enset is the major food of most households. Ninety-six percent of the respondents said that enset is their main staple, even though they produce other food crops such as barley, teff, maize, sorghum, beans, vegetables and root and tuber crops. Based on our survey result, on average, 10.44 enset trees are consumed by each individual per year. This finding agrees with most of the estimates reported: 10-12 plants by Bezuneh and Feleke (1966), 10 plants by Shack (1966) and 12 plants by Smeds (1955). Pijls *et al.* (1995), however, reported that only 5.9 enset plants would be consumed per person per year. Other food crops are consumed as supplementary food or used for brewing the local beer. The rest is usually taken to the market for covering other expenses. As regards maize crops, household members tend to eat or sell the green cob and thus the final harvest is very low. Other consumables are bought from the market. These include salt, pepper, coffee, cooking oil, soap and kerosene.

During the household survey, a seven-day monitoring (food frequency assessment) was also conducted on selected households, representing different wealth statuses (lower, middle and upper class). By using this method we did not intend to measure the quantities of food or the nutrient intake of household members. The monitoring was carried out to get some insight into the type and frequency of consumption of food items by different households during consecutive days. A literate member of the household was requested to list all food items consumed each day for a total of seven days. Although this method is limited in its level of precision, it is a simple and cost-effective tool for establishing consumption patterns between households.

According to the results, every household irrespective of the wealth status is consuming enset at least twice a day. However, the way enset food is combined with other crops, livestock or dairy products, such as cabbage, beans, taro, meat, milk, cheese, and eggs differs distinctly according to wealth. During breakfast, coffee and *kocho* bread with roasted bean or maize is common in almost all involved households, except in two poorer households that skipped breakfast once or twice a week. For lunch and dinner in the better off households *kocho* bread was combined with cabbage or bean sauce for five days and they also had beef stew, or cottage cheese (beef stew was reported in two households and cheese in the other two) for two days. *Enjera* (a flat bread which is a staple food in the north and central part of the country) is also consumed with either bean or cabbage sauce once a week by these households. From our observations, households that are well off, (both middle and upper class households) ate sufficient and diversified food during the week. According to them this consumption pattern is more or less consistent throughout, but gets more affluent during harvest season. The women in this type of household are not short of cash to buy consumables. Since they have more plots for enset cultivation, they are able to generate more cash by selling kocho in the local market and can afford to shop once per week. It is stated in Maxwell and Frankenberger (1992) that there is a positive correlation between dietary diversity and socio-economic status of households. In poor households, food shows little variation throughout and kocho with bean sauce or cabbage and taro dominate the meal for the whole week. Sometimes the same type of food is eaten throughout the day. We encountered one household in the lower economic-status group that had beef stew with *enjera* once during the week of observation. They justified this by saying:

> *We had meat last week because it was Christmas time and we get meat only during those special holidays like the New year, Easter and Christmas either with our money or by borrowing from neighbors.*

Such households are food insecure as they are not able to get sufficient food, especially in terms of quality, as they consume enset products routinely with little added protein and vitamin sources. They also don't produce much and hence have little cash to buy other consumables.

As was observed during the survey, children are disadvantaged in getting an adequate diet, though there is no high child mortality reported in the area. When parents go to the market to sell their produces, usually once a week or once every two weeks, they go to small restaurants where they can buy and eat meat, cheese and other varieties of food with reasonable prices.

The children are left at home usually with only kocho bread to eat. This might be the reason that many children in the locality look stunted in growth as a result of consuming more carbohydrate food and little or no protein and vitamin supplements. Moreover children who go to school usually have only two meals per day. This is due to the fact that they have to travel a long way, sometimes up to four hours, to get to the nearest school after having eaten breakfast. They cannot go home for lunch and return home in the evenings. In the study by Kusin (1973) on the nutritional status of school children in Kaffa areas, it was reported that most school children that came from agrarian households dependent on enset were found to be nutritionally inferior compared to other children not dependent on an enset diet. Marked differences were found in disease prevalence, bodily maturation and stunted growth.

9.6 Provision of public services and infrastructure

Access to basic public services such as health clinics, schools, roads, electricity, pure drinking water supply and so forth is not adequate or in some cases absent through out the Kaffa Shaka zone. Lack of access to these facilities will have a negative impact on the productivity and food security of rural households.

In both *woredas* investigated during the survey, there is no supply of electricity, neither in the *woreda* town nor in the villages. We saw one small generator in the Decha *woreda* that was privately owned, working on and off. The owner usually did not distribute electricity to the inhabitants in the town, but rather used it only on market days so that people would watch television and pay a certain amount of money or buy drinks at higher prices from his shop. Even in the zonal town Bonga, a town more than one hundred years old, there is no continuos supply of electricity and the distribution to the inhabitants and institutional organizations is not more than six hours per day. Otherwise, people in towns use kerosene lamps or candles, while farm households use only fuel wood.

There is no access to clean water supplies. Households in the study area use water from streams or small rivers and springs, fetched by women and children. Access to health facilities in the study area is limited. There are no well-equipped health clinics nearby and there is only one hospital in the zonal town Bonga. To reach the nearest health clinic, farmers sometimes have to travel the whole day carrying the patient. There is one private pharmacy in each *woreda* town with a limited supply of medicine, which is expensive. Sometimes farmers cannot afford to buy medicine and tend to use traditional medicine from plants such as enset and wild plants from the forest.

The infrastructure in both *woredas* of study is poor. The gravel (non-paved) roads, which are available in the area, connect *woreda* towns to the zonal town only. During the rainy season, these roads are sometimes not accessible as they turn muddy and become difficult to drive. Similar types of roads connect Kaffa Shaka to other towns such as Jimma and Mizan Teferi (Bench Maji zone). Lack of access to suitable roads has a negative impact on income generation of farm households. Some better-off farmers use donkeys and mules to bring their products to the market. Others who do not have such animals have to carry their produces on their back (especially the women) to the nearest market. During the survey, although it was a dry season, none of the villages could be accessed by a vehicle, and the team had to travel more than four hours each day for interviewing after parking the vehicle on the main road.

Availability of schools in the study area is very limited and if there are schools, they are often too far away to reach on foot. There is only one secondary school in the zonal town Bonga. When students complete their primary school, they have to migrate to other towns for a high school education. There is a high dropout rate. This is attributed to the distance and economic reasons. Although there is no fee for public schools, many farm households cannot afford to send their children to school, as they have to buy clothing and stationary. Moreover, if students are transferred to another town for a high school education, parents also have to pay rent for a room if there are no relatives nearby and have to cover other expenses such as food.

According to the survey data, the level of education of household heads was as follows: 65.8 percent were illiterate, 5.8 percent had some basic education, 20.8 percent had primary school education, 5 percent with junior secondary school education and only 2.5 percent have attended secondary school. In accordance, when parents were asked whether they sent their children to school, 58 percent of the parents said that children who were of school age did not go to school. In most of the cases, it is the girls who are not sent to school. As we explained, rural households generally do not believe in educating their daughters, especially if the school is far away. Children are interested in getting an education and when we asked both boys and girls why they didn't go to school, they responded that their parents wouldn't let them go. However, if enough schools were available around the villages, the situation would change greatly and more children from the rural villages would have a chance to attend school.

Chapter 10 Household Resources and Strategies

This chapter will be devoted to the analysis of household resources in the study area, as they are the key factors in understanding the status of household food security and sustainable livelihood. As visualized in the conceptual model (Chapter 3), households use resources and perform various production activities to generate food and income. Therefore, account will be given on access to and availability of assets and resources such as land, livestock, crop genetic diversity, and indigenous knowledge. Major attention will be paid to the analysis of data on gender roles such as division of labor and decision-making. Household strategies and mechanisms of coping during stress situations will also be discussed.

10.1 Land Resources: access and availability

In Ethiopia land is under the ownership of the government. Land is not a sellable property but every farmer is granted to free use of it since the 1975 land reform proclamation of the military (Derg) regime. Land redistribution has since then been carried out for more than three times because of the increase in land claimants as a result of population increase and resettlement programs. The current government has maintained state ownership of land both in rural and urban areas.

The average land holding size of the farming population at the national level is 1.0 ha CSA (1998), although the figure varies from region to region as some are endowed with more cultivable land resources while others have little or no land. With such limited farmland resources, a rapidly increasing population and a poor rural infrastructure, the country has failed to meet its food requirements by domestic food production since the early 1960's. According to Adal (1999), of 27 million people who were categorized as food-insecure during the year 1991, resource poor farmers accounted for the largest portion of those affected.

Access to land and other resources is crucial for production and sustainability. Land is one of the key production factors and the sole means of livelihood for farming communities.

As in many other regions of the country, land distribution guidelines and procedures apply to the study area as well regardless of the sexual discrimination. It is one of the basic economic resources of the SNNPR. The economic strength of any agricultural household is related to the size of the agricultural land holding it possesses. However due to the rural population pressure especially in the North Eastern zones of the region, land holding per household is very small and is reported to be below 0.5 ha.

The Kaffa Shaka zone on the other hand, is less densely populated and individual land holdings are relatively better compared to other zones of the SNNPR. Moreover, since in some *woredas* of the zone the nearby forest is still intact, some households have a chance to expand their holding at the expense of clearing these forests. The forest area, which once was densely covered with natural forest, is now declining as a result of claiming more land for agriculture. This situation has even inspired farmers to have more wives to work on the land, and this caused an increase in polygamous households. In the Chena *woreda* for instance, farmers themselves witnessed that the area around the villages used to be densely covered by indigenous forests. However, by the time this survey was conducted, we saw few trees, scattered around the villages and in other cases once forested land was replaced by exotic eucalyptus trees that farmers grow for fuel wood and as an additional source of income.

Land holdings of the study *woredas* (data obtained from each respondent) are given in the table below (Table 10.1). Each respondent informed us about the size of the farm plots that he or she holds. For the sake of verifying the information from them we tried to measure the fields ourselves in some cases. However, it was difficult to measure every household's land holding as some of them own large plots and some farms are far from the homesteads. In such cases, we cross-checked the data with what has been recorded at the *woreda* agricultural bureaus.

Table 10.1 Land holdings in the two study *woredas*

District	Land holdings (in hectares)			
	0-0.5	0.5-2	2.1-10	Total
Decha	25	65	30	120
Chena	22	56	42	120
Total	47	121	72	240

Mean=1.73 and Standard error=4.50

Over 50 percent of the households have holdings between 0.5 to 2 hectares of land with slight differences in holdings seen among the two *woredas* especially seen in the middle and upper land groups (higher figures for Chena). The higher per household land holding in this *woreda* might be attributed to more families or increased polygamous households observed.

Households have an average land holding of 1.73 hectare, which is much higher than both the national and regional averages (0.1 and 0.5 ha respectively). The average landholdings for the study area are computed from the figures reported by the respondents. Regardless of the size, (minimum holding being 0.01 hectare), each household has enough land at least for a house and a small backyard with a few enset plants. Those groups with very small land holdings are either new settlers or female-headed households (widows who lost the land they had with their husbands). The survival of these types of households is largely dependent on their small enset plots or off-farm activities. Some of the male farmers participate in share cropping with those who have land and oxen. These types of households in general are sometimes unable to meet their annual food requirements even during the harvest season.

Land holding per household was also related to household size. In most of the communities in the country, land distribution or redistribution is said to be based on household sizes. As regards the study area, land holding and household size have a positive correlation, though other factors such as polygamy may contribute as well. In Chena, where there are more polygamous households, land holding increased with increased household size.

In Table 10.2 below, household size is related to size of the land holding for the households in the sample.

Table 10.2 Distribution of respondents by household size and land holdings

Land holding (ha)	Household size 1-3	4-6	7-9	10+	Total	Percent	χ^2
0-0.5	20	20	5	2	47	19.58	
0.51-2	20	55	33	13	121	50.42	
2-10	3	16	18	35	72	30.00	
Total	43	91	56	50	240	100.00	73.32

χ^2 is significant at 0.05 level

In general, in the foreseeable future, land will definitely be a scarce resource in the Kaffa Shaka zone, because farmers have no way to expand their land holdings further, as the nearby forests have almost been completely degraded and the government is taking action as well. Those farmers with more land and large families might face a serious problem of food insecurity when more land becomes more fragmented because of redistribution as has now occurred in other regions of the country such as the Amhara region.

Women and land in Kaffa Shaka

At the beginning of this chapter, it was discussed that the law regarding land in Ethiopia allows equal access to land for each citizen. Moreover, for any sustainable project to be instituted, equal access to land, credit and other resources for women has now been considered as the minimum precondition. However, rural women in Ethiopia are still disadvantaged, as many factors such as deep-rooted traditions, culture, and religion have remained bottlenecks.

In the study area, whatever rules or guidelines are set by government officials, male farmers have never accepted the equality of women when talking of access to and control over resources, especially land. By tradition land inheritance is patrilineal. In the family, only boys are entitled to inherit land from their parents, while daughters may get other assets such as household utensils. When the head of the household dies, the oldest son immediately becomes the household head in the presence of the wife or his mother and will take the responsibility for all the resources of the household.

When respondents were interviewed on whether women are entitled to get land through inheritance or other means, the response given by almost all the respondents, including the female household heads was negative. The following reasons were forwarded:

> *In our culture, women are not allowed to have land as they usually bring an outsider to the family by means of marriage. We therefore don't want somebody from outside to own the family's land. The woman should use the land of her husband and not of her parents. Even in her husband's place, she uses the land as long as her marriage lasts or as long as he is alive. When the husband dies, if she is not willing to stay widow or get married to one of his brothers, then she is not allowed to own the farm. The widow has to leave the land, if she wants to remarry someone, as inheritance is through descent, not by marriage. Only her sons are allowed to inherit their father's land.*

It is sad that such discrimination exists nowadays. Women accept this situation as given, as they have no choice or are not aware of alternatives. Article 4 of proclamation No. 31, 1975 states: "without differentiation of the sexes, any person who is willing to personally cultivate land shall be allotted rural land sufficient for his maintenance and that of his family". However, this article has not been put into operation and most rural women did not benefit from this act.

It is clear that women constitute half of the farming communities both in the study area and in the country in general. Without their participation, the goal to achieving sustainable land use and food security is inconceivable. There should be clear government policy or enforcement of Article 4, which would improve the existing situation and facilitate women's access to land and other resources.

10.2 Livestock Resources

Crop production and animal husbandry (mixed type of farming) is the mainstay of the household's economy in the rural Ethiopia. Similar to other enset growing areas, also in the surveyed *woredas*, the cultivation of enset is highly integrated with livestock production. Thus this integration contributes to the sustainability of the farming system. Livestock plays a significant role in the enset based farming system in various ways.

Enset is a manure loving plant and livestock are primarily used to fertilize enset and other crop fields and hence maintain soil fertility. Likewise enset leaves are also used as feed for livestock. In areas dominated by the cultivation of enset, none of the farmers use artificial fertilizer to maintain the productivity of the enset plant for several reasons. Most subsistence farmers cannot afford to buy synthetic fertilizer even for annual crops, while manure is available from the owned herds. Enset is a perennial crop and stays on the land for several seasons and hence the frequent application of inorganic fertilizer is inappropriate and expensive. The application of manure according to McCabe (1996) is also said to hasten the growth and maturity of enset plants as compared to those with no manure applied. The application of organic manure provides a favorable growing environment for enset by improving the structure and water holding capacity of the soil, which ultimately contributes to sustainable yield throughout the year.

Nearly all small-scale subsistence farmers in Ethiopia use traditional farm tools and implements. Farm households in the study area use the ox with small farm implements such as the wooden plough with the iron ploughshare and the wooden hoe to till the land both for enset and other crops grown in their localities. Despite the significance of an ox for ploughing, a large number of households do not own oxen (Table 10.3). However, those with only one ox, pair with their neighbors and others who don't have oxen engage in share cropping with those who have. The equines are also used as a means of transport both for humans and agricultural produces to the local markets. As it is shown in the following table, 21.67 percent of the farm households do not own oxen while the majority of the surveyed households own between one and two oxen.

Table 10.3 Distribution of households by oxen holdings

Quantity	Frequency (N=240)	Percentages
no oxen	52	21.67
1-2 oxen	173	72.08
>2 oxen	15	6.25
Total	240	100

Mean =1.84, and Standard error =3.269

Livestock products are consumed together with enset and make a significant contribution to the diet. However not all the surveyed households own livestock (Table 10. 4). Farm households cannot afford to eat meat frequently, even those who are better off. However, depending on their economic status, they consume milk, cottage cheese and butter, which are important nutritional supplements, as enset is claimed have less protein and vitamins (Kusin, 1973).

Table 10.4 Distribution of households by number of livestock holdings

Group	Frequency (N=240)	Percentages
0-4 cattle	136	56.7
5-10 cattle	78	32.5
>10 cattle	26	10.8
Total	240	100

Mean=1.54, and Standard error = 4.41

Livestock are considered major assets for the household and an important source of readily available cash. As land is not a sellable property, farming households depend on their cattle or small domestic animals as cash reserves. When they are requested to pay annual land taxes or other debts, for hospitalization of household members, and so forth, the animals are the only assets that can be converted into cash. Households with many livestock resources are proud and in general these resources are considered to be an indicator of wealth in the area. Smaller animals or their products such as eggs, butter and cheese, when not meant for own consumption, are also brought to the nearby market to be sold, together with enset or other crops.

10.3 Other assets, farm and off-farm income

Farm households in the surveyed villages have few durable assets at their disposal. They do not own assets such as jewelry. Some farmers own small plots of eucalyptus and bamboo trees, which they said are used for sale when they run out of cash and when there is no other source of income. Usually these trees are kept for emergency purposes, as they don't want to sell their trees and enset plants unless they are forced to do so.

The type and quantity of the dwelling units and the ownership of household utensils are also indicators of the household's wealth. According to our data, 19.6 percent of the households have more than one house with a separate kitchen and stable. It was in the better-off and polygamous households for which we were able to record more than one house and also the presence of a tin-roofed house (a house built with corrugated iron sheet), which is usually meant for the senior wife.

Few households (less than 10 percent) were observed to possess a radio, a wooden box where they can put their clothes and a wooden bed. About 15.8 percent of the households do not have any appliances; even a bed to sleep on and simply use enset leaves as sheets on the ground. All farmers own small farm implements such as the plough, hoe, shovel, spade etc..

Households with insufficient land and other resources, try to find supplementary sources of non-farm cash income to meet their food demands. These types of households, which include the female-headed households with no adult members to help, are usually vulnerable and have to find sources of income in order to survive. This is effected by either being hired by the wealthier farmers or by being engaged in petty trade. Women will be hired to process enset in the better-off households, while men do ploughing, construction and other duties. Some male farmers engage in weaving (making clothes from cotton), or making mats. The women on the other hand, brew and sell the local beer (*shoko* or *borde*), which is usually made from teff or barley and are also engaged in preparing malt barley for the local market.

In the surveyed households, cash income is derived from: sale of enset products or the standing enset plant, sale of other annual crops, sale of eucalyptus and bamboo trees, sale of livestock, and from off-farm activities.

Respondents were requested to state the total annual income they earn from each activity and the allocation of their income into the different household expenditures (Tables 10.5 and 10.6).

Table 10.5 Income distribution per annum of households surveyed

Woreda	Income group in birr (N=240)			Total
	≤500	501-1000	>1000	
Decha	42	60	18	120
Chena	29	55	36	120
Total	71	115	54	240

N.B.: One US dollar was equivalent to 8.30 Ethiopian birr at the time of this survey

Table 10.6 Distribution of annual expenditure of households surveyed

Woreda	Grouping by annual expenditure (Birr) (N=240)			Total
	≤260	261-500	>500	
Decha	41	60	19	120
Chena	15	81	24	120
Total	56	141	43	240

The household's levels of income and food expenditure were considered important indicators of household wealth. They indicate the degree of strength and vulnerability among the farming households. The respondents reported the amount of crop and livestock sold in a given period and their weekly expenses. Though it was difficult to assess the accuracy of the figures, we tried to do so by cross-questioning in various ways. For annual crops it was not difficult as they harvest once a year and know what amount is taken to the market and what amount left for consumption. In the case of enset, they were able to tell the average harvest per week and the number of standing enset plants sold without being processed. However, the income from off-farm activities might be underreported. What is important to note here is that households who earn more were also noticed to have more expenses and this fact is also true for those with a larger land holding size and livestock resources.

The average household expenditure amounted to 476.65 Birr. Whatever money is left from consumables is used for covering other costs such as annual land taxes, community contributions, and fertilizer debts. During the 1990 land redistribution, the average national annual income estimated by the National Committee for Land Redistribution and parceling, for a household size of 4.5 members was 451.65 birr (Diriba, 1995). This figure now is almost equivalent to our survey figure but for an average household size of 6.71 members in our case. This shows that household income and expenditures have not kept pace with the population increase (3 percent annually) since that time. This is a clear indication of increased vulnerability and overall food insecurity in many farm households.

10.4 Farmer's indigenous knowledge and the genetic resource of enset

Farmer's knowledge of enset genetic diversity

'Indigenous technical knowledge is the tool by which local people interact with the environment in order to meet needs and goals ranging from survival goals to that of achievement and esteem' (Atte, 1993:28). It is knowledge, which is unique to a local area, culture, or society, passed down from one generation to the next, usually through oral tradition. McCorkle (1989) states that indigenous knowledge has to do with theories, beliefs, practices, and technologies that local people have elaborated without any assistance from the modern, formal and scientific communities and/or institutions. According to Farrington and Martin (1987) indigenous knowledge is not abstract like scientific knowledge; it is concrete and strongly relies on intuitions, historical experiences and directly perceived evidences.

It is very recently that the role of local knowledge in agricultural systems has been given attention. Very few agricultural scientists recognized the complementarity of the two types of knowledge systems. Van Dusseldorp and Box (1993), pointed out that the way of communication between farmers and scientists in the exchange of agricultural knowledge is a crucial issue, as people have different perceptions, symbols, socio-economic positions, meanings and associations. Close relationship and regular exchange of ideas and knowledge between the two sets of knowledge systems is therefore indispensable.

Indigenous people have a long tradition in maintaining biodiversity as a sustainable resource. Farmers have played and still continue to play a tremendous role in developing and nurturing crop genetic diversity. Many studies have shown that farmers in developing countries have intimate knowledge of environmental processes and make rational resource management decisions based on that knowledge (Atte, 1993). They have also developed effective ways of ensuring that their knowledge and the physical resources of the environment are used sustainably. Local communities still employ the knowledge and technology they have been able to accumulate over many generations in the use of native plants, herbs and other natural resources as part of their culture. Farmers play a key role in selection and management and make decisions on which populations to maintain and which ones to discard (Bellon, 1996).

As Prain (1993: 346) put it "farmers are inveterate botanists". Unlike modern breeders who are interested in uniformity for certain specific characters such as high yield or disease resistance, farmers are more focussed on maintaining diversity in order to spread risk while maintaining sustainable crop yield. Farmers' characterization and selection of crops is part of their management of diversity. According to Slikkerveer (1993), many technological solutions from the west implemented so far to overcome the shortages of staple food have not been successful as they fail to take into account the value of indigenous agricultural knowledge systems. He further noted that strategic research on current problems in agriculture in a number of developing nations has documented very well that indigenous knowledge and technology provide alternative methods of solving problems where other solutions to complex agricultural configurations fail to fit into the local context (Slikkerveer, 1993: 464).

The enset farming system is a witness to farmers amazing knowledge of diversity and the role they played in maintaining the crop for present and future use without any support from the modern scientific community. As first cultivators and being experts, their knowledge together with the significance of enset as a food security crop have attracted a few researchers and paved a way for research on enset. According to Bezuneh (1996), the cultivation of enset has evolved as one of the most stable and sustainable agricultural development systems during the last several decades. Among other facts, the system has been efficient in building and sustaining soil fertility. It is therefore valuable to learn from the century's of farmers' practical experience and benefit from their understandings and perceptions. This will help to improve the livelihood of enset-dependent farmers and meet their immediate needs. Moreover, it will also have implications for better utilization and future conservation of such an indispensable crop.

As in many other enset growing areas, farm households in the area of study maintain large amount of enset plants depending on their status (Table 10.7). According to the information we obtained during the focus group discussion, a farmer with a large number of enset plants and with many types of clones, which also consist of diverse maturity groups, is considered to be rich, food secure and well respected in the community. This comment by farmers agrees with the studies of Shack (1966) and Brandt *et al.* (1997), in other enset areas. These studies also indicate that a household's status and wealth is often assessed in terms of the number of enset plants it owns and in terms of the height and girth of the plants.

Table 10.7 Distribution of households by number of enset plants owned

Range (number of plants)	Frequency	percent
≤600	81	33.8
601-1200	79	32.9
>1201	80	33.3
total	240	100

N	minimum	maximum	Mean	Standard error
240	50	10,000	1714.75	3.64

As it has been observed in the field, farmers with more land not only grow more in quantity (Table 10.8), but also grow more diversified clones. Some households even extend their enset plantation beyond the backyard to steep areas around small riverbanks for security reasons or as a protection against disease. For others, with only a small plot of land, few types of clones are maintained. As enset disease is becoming a serious problem in the area, farmers with smallholdings are victims to such an adverse situation and grow clones, which can tolerate the bacterial wilt even if they are willing to have more diversified clones.

Table 10.8 Distribution of households by number of clones maintained in the backyard

Number of clones	Frequency (N=240)	Percentages
≤5 clones	8	3.3
6-10 clones	101	42.1
>10 clones	131	54.6
total	240	100

Sixty-five different types of enset clones (See Chapter 8 for list of clones) have been recorded during the survey, which are maintained by different farm households. These landraces are named and recognized based on certain specific characters. Each farmer is determined to maintain as much diversity as possible as long as he/she has enough land. We were able to verify the existence of up to 36 different types of clones maintained by one household. Each respondent was able to name a significant number of vernacular names though not all clones are planted and maintained in his or her backyard.

Some elderly farmers said that there were more than one hundred types of clones grown in their localities a few years' back. However, they claim that most of the clones were lost due to disease (bacterial wilt) locally named as *nusho* and wild animals such as mole rat, porcupine and warthog. According to farmers, bacterial wilt disease is one of the most threatening problems they have ever faced. We saw a farmer who had completely abandoned his enset plantation and replaced it with sorghum and other cereals. Many farmers complain that there is no support from the formal sector for combating enset disease. During our conversation, an 80-year old farmer stated the following:

> *We have been familiar with nusho disease since my child hood. During the early times, it was not as serious as it is now. Many people from The Ministry of Agriculture, other sectors including you are coming to us and asking about our problems. We are fed up with being questioned for several years. There is no time that we haven't complained about the disease. No solution has been sought from any group until now. None of you seem much concerned with our problems. We tried all our best to overcome the disease with our traditional means to control it. Now the disease is becoming stronger and each time reducing our diversity, as the susceptible ones are gone for good.*

Whatever the farmers' complaints, enset research especially with regard to finding a solution to bacterial wilt, has a long way to go. The growth cycle of the crop, which usually takes between four to seven or more years to reach maturity, is one major difficulty, making it unfavorable to national researchers especially with regard to conventional breeding. Secondly as enset is a crop domesticated and used as a food crop only in Ethiopia, it is not attractive to external research or funding institutions. However, looking at its potential for future food security and considering Ethiopia's recurrent drought and failure of annual food crops, it is high time to rescue the available diversity and back enset farm households.

Farmers use of enset for medicinal and ritual purposes

In rural Ethiopia, 80 percent of the population is believed to rely on traditional medicine, as modern clinics or health facilities are inaccessible. In the areas we surveyed, farmers have to travel a long way (sometimes up to six or more hours) carrying a patient to reach the nearest health center. Apart from being used as food, animal feed, and so forth, some enset clones are used as a traditional medicine or ritual purposes by farm households of the Kaffa Shaka area. Over 90 percent of the surveyed households in both *woredas* responded that they use different enset clones against several illnesses. The following are some of the enset clones that are claimed (by farmers in the study area) to have medicinal and ritual value:

- Choro: this clone has a deep red color of the leaf, midrib and the pseudostem. The boiled corm (*amicho*) is mixed with butter, milk and cottage cheese and is fed to a woman during or right after delivery of the baby in order to stimulate the discharge of the placenta. Likewise, the leaf after beating the back of the dairy cows three or four times with it, is chopped, mixed with salt and is given to serve similar purposes. Choro has a ritual significance among the Kaffa's and farmers say that all the devil or evil spirits will go away if they plant this clone in their backyard.
- Tayo: the starchy powder (*bulla)* or the boiled corm (*amicho*) is the product used from this clone. These products together with milk or butter are consumed to cure illnesses, such as backache, displacement of joints, swelling, and bone fractures.
- Shasi wagi (Wagi beli): the boiled corm (*amicho*) of this clone is given to a woman to relieve stomachache or to prevent uterus contractions after delivering a baby.
- Ariko: when a person catches flu, the corm will be boiled and fed so that the pain is relieved. Moreover, the true stem of this clone is fed to children, uncooked, to keep the children healthy and to help them gain weight.

10.5 Gender roles in enset cultivation

'While an individual's biological sex is simply a product of being male or female, what one is socially expected to do as a man or a woman is learned behavior' Price (1999). The biological differences between the two sexes, therefore, do not fundamentally result into significant social differences. The concept of gender serves to distinguish socially defined roles and accountabilities of men and women under a given set of circumstances (Carney, 1992; Niehof, 1999a). Men and women play different roles and their roles are highly influenced by differences in societies and culture, class and age, ethnicity, religion, the type of productive activity that persists in their respective localities and the economic status of the household or the community. According to FAO (1999a), gender-specific roles and responsibilities are often conditioned by household structure, access to resources, and ecological conditions.

As briefly explained in Chapter 3, Moser (1993) has identified three sets of roles that women play in a given society. The first is the reproductive role, which includes responsibilities such as child bearing and domestic tasks in order to guarantee the maintenance and reproduction of the labor force. Both the biological reproduction and the care and maintenance of the workforce of the household members are taken care of by the women. The second is the productive role, which involves activities done by both men and women for payments in cash or in kind. It includes both market production with an exchange value, and subsistence/home production with an actual-use value, but also a potential exchange value. As regards women in the sphere of agricultural production, it is comprised of women, who are independent farmers, wageworkers and farmers' wives. Although women especially in low-income societies play a significant productive role, it is not valued as such and tends to be invisible. The third role is in community managing and community politics. These are activities undertaken by women at the community level. These activities are usually considered as an extension of the reproductive role. The participation of women in such activities ensures the provision and maintenance of scarce resources such as water, health care and education. The community-managing role, which includes serving the community by involving in various committees, which require women's role is usually unpaid labor and is done in their free time. Community politics, on the other hand, includes activities primarily carried out by men at the community level and is paid work either directly or indirectly through wages or increases in status and power with in the community.

Rural women in Ethiopia comprise nearly half of the farming community. They have multiple (productive, reproductive and community) responsibilities on which they spend a considerable amount of time and energy each day. They have higher fertility and more living children when compared to urban women. All household related chores such as cooking, fetching water from the source, fuel wood collection and cleaning and grinding are assigned to women. Other duties like child care and care for the elderly are their responsibilities as well. All these activities are carried out in the absence of adequate social and economic facilities, such as health clinics, childcare centers, schools, credit facilities, and extension services, which embrace women farmers.

Women participate equally in the various production activities as men. They actively participate in field operations such as planting, weeding, manuring, harvesting processing and marketing. They have good knowledge of the varieties they are handling and are efficient in selection and characterization for various purposes. They are very much concerned with the household's day-to-day food availability and security. Similarly, women participate in various community activities. During community celebrations such as wedding, funerals and religious gatherings, women are responsible for the preparation of food and for most of the arrangements for the ceremony.

However, as stated in Price (1999), women's work in the agricultural field and their roles have been more invisible. Their participation until recently was not credited and their contribution was often neglected and considered marginal. It is usually the men who are considered producers because of the biased tradition towards women. Even in the cereal farm, in Ethiopia, when men plough, women remove the remains of the old harvest besides preparing food and carry it to the field. However, when the men were asked 'who does the planting', they respond by saying that it is only the men who plough the land and the women are only consumers. The man is considered the breadwinner in the family, although the contribution made by the woman and other members of the family is quite significant.

The women in most of the rural areas in Ethiopia, do not try to defend themselves as, either they are shy to talk or it is shameful to challenge a husband who usually is very respected as head of the household. While interviewing households in the study area, we were able to note that the views forwarded by the woman differ when she speaks in the presence or absence of her husband. When both are present to be interviewed, the woman hardly speaks before her husband unless invited to do so. However, she feels happy and proud to explain things in detail especially when her husband gives her the chance or invites her to discuss matters that he is not fully aware of.

Gender and preferences in enset diversity

Women have tremendous knowledge of the diversity in enset and their preference for the different clones also varies slightly from that of the men. They have the traditional wisdom in describing many of the qualitative aspects of the crop. During our survey, when both men and women were questioned about which clone is used for which purposes or which clone is of more quality and tastier, women dominated the discussion and tended to give a more elaborate response. Habtewold *et al.* (1996) also argue that women farmers in the enset cultivation know more about the different varieties and are more concerned with the balance of the clones to be harvested at different stages than men. The men's interest is more in harvesting at maturity at the later stage.

During the focus group discussion, selected case households from the surveyed *woredas*, both male and female farmers (ten each) were requested separately to freely list the enset landraces they know. Free listing gives information on the most culturally important varieties besides giving a complete set of native categories (Martin, 1995). When people are requested to freely recall things, they will definitely call the most important and frequently used ones first. Free listing, according to Gatewood, which he refers to as 'the loose talk phenomenon', is said to vary by gender (Bernard, 1995).

Farmers were given time to think and give names of the various clones they could recall. Amazingly over one hundred names were listed by both sexes. The women were able to list 95 clones with the longest list being 64. The men on the other hand listed 97 clones with the longest list 59. There were few clones listed by the women, which were not recalled by the men and vice versa which made the total list over a hundred. Prioritization of clones also varied slightly, which indicates the different interests between men and women according to use quality, yield and other criteria. Ranking was done using an index of relative saliency in order to rank the most to least important categories (Martin, 1995).

The top ten clones listed by the female according to the highest frequency of mention include; *ariko, bocho, nobo, gayo, choro, utro, bajo, tayo, shimo and shelako*. According to the male farmers, the lists were; *nobo, bocho, ariko, bajo, shelako, shimo, choro, tayo, gayo and kekero*. Women combined variables such as taste, quality, less fibrousness, resistance and early maturity, in their listing of clones. Men on the other hand focussed on higher yield, late maturity, and resistance, as their major criterion. In both cases however, there are common interests in prioritizing and listing most important clones first according to the preferences. In the list above the most important ones selected for yield, quality, resistance, medicinal values are also the ones frequently mentioned by most of the respondents during the formal survey of households when ever they were requested 'which clones do you prefer most and want to preserve'?

Gender and division of labor

The sexual division of labor in Ethiopia in general varies with the different farming systems and in various cultures and agro-ecological locations. In a study by Sandford and Kassa (1996) in the Southern part of the country, a clear distinction in division of labor has been observed when three food crops mainly enset, teff and maize were compared. More involvement of women both in production and marketing in enset and less in the other two crops were reported.

Similarly in the area we studied, women have much embedded knowledge of the practices in which they are primarily engaged both in the house and in the farm. As regards enset cultivation, they are more involved in carrying the suckers for transplanting, manuring, harvesting, processing, storage and marketing (Table 10.9). Men are usually involved at early stages, which is planting and transplanting of the crop. All members of the household usually do weeding of enset plantations. For other annual crops, where the ox plough is engaged, men dominate both in cultivation and marketing of the crops although there is a significant participation of women. Sandford and Kassa (1996) have also stated that the contribution of labor and domination of the sale is often influenced by the location of the crop. The fact that enset is a backyard crop, contributes to making it a women's crop, because most of the production activity is accomplished around the house and by women. The money from the sale of enset except the standing plant is fully controlled by the women and is used to buy household consumables.

In the study area, other crops such as teff, maize, sorghum, and so forth are usually cultivated far from the house and the men do most of the production activities. Men also control the income from the sale of these crops. Men are traditionally responsible for paying taxes, the purchase of clothing for household members and payment of other fees. The money obtained from the sales of other crops will be used for such expenses. Whatever money is left after covering those expenses, is used by the men for recreation in the nearby market place. The women have no say in such matters. However, women also take part in selling small amounts of the cereals but the income from this is still used for household consumables.

Table 10.9 below shows the variability in the sexual division of labor in farm operations and in processing and marketing carried out by men and women. Land preparation and planting are the activities where men have the greatest involvement. Weeding of enset fields is shared between men and women while the women with an insignificant involvement of the men perform the rest of the activities.

Table 10. 9 Chi-square test on division of labor in pre and post harvest activities of enset cultivation (N=240)

activity	Division of labor				
	Husband	wife	shared	χ^2	significance
Land preparation	232	1	7	433.425	+
Planting	133	2	105	118.975	+
Weeding/cultivation	10	6	224	388.900	ns
Manuring	2	217	21	354.175	+
Harvesting	-	239	1	236.017	+
Processing	-	240	-	constant	
Marketing	1	226	13	400.575	+

+ =significant at 0.05 and ns = not significant

Likewise, variation in division of labor in the various household activities has been recorded (Table 10.10).

Table 10.10 Chi-square test for division of labor in household activities

Activity	Division of labor			Test statistics	
	Husband	wife	Older children	χ^2	significance
Fuel wood collection	22	122	96	67.300	+
Fetching water	3	220	17	368.725	+
Cooking	2	224	14	389.700	+
Child care	3	222	15	378.975	+

+=significant at 0.05

Gender and traditional post harvest handling of enset

Apart from assisting in digging of the fermentation pit prior to harvesting, men are not seen around the backyard where enset is being processed, unless situations dictate otherwise. They said that enset processing is women's work and besides, it is shameful for a man to see his wife decorticating as her body will be exposed when her leg is on to the processing plank.

The storage (fermentation) pit is prepared prior to harvesting and is lined with fresh enset leaves. The wife, either alone, with her work parties (usually neighbors or relatives whose service is for free) or hired women (if the household is wealthy) starts harvesting usually in the morning. The wife selects matured enset plants and also the type of clone depending on her needs. According to the women, two or more persons can process one to two enset plants per day. If the processing is to be done by one woman, it takes up to eight hours to process one enset plant. Although enset can be harvested any time of the year, the women prefer the dry periods, as the *kocho* quality is higher due to low absorption of water through the pseudostem.

For processing, a wooden plank is put at an angle of approximately 25^0against an enset plant. Using a sharp knife, the leaves above the petiole and the outer bark, which is dry, will be removed. The petiole base is then peeled one after another from the pseudostem until the peduncle (true stem) is reached. A woman sits in front of the wooden plank (*mato*). A sharp bamboo split (*maro*) is prepared and the woman scrapes the petiole until the fiber remains on the plank. At last the peduncle is pounded with a toothed wooden pestle (*tepe meeto*) and mixed with the product. The corm when not meant for boiling is also grated using *tepe meeto* and mixed with the processed starch. When they want to process *bulla* (*etino*), the liquid, which oozes out while scraping the bark and leaf sheaths is collected on enset leaves prepared separately. After the water is precipitated, they obtain a white starch called *bulla* and they wrap it with enset leaves and let it ferment. The rest of the mixture of the decorticated pseudostem and pulverized corm is collected into the fermentation pit. A starter (*kisho)*, which is prepared and stored in the hollowed out corm ten to fifteen days before processing, will be added to the product to hasten fermentation of the starch. The starter is prepared from a mixture of grated corm, different grasses and herbs, chopped and stripped leaf sheath, and a herb known as *kell*o. The pit will be carefully covered with layers of enset leaves. The product will be ready after a minimum of four weeks of fermentation for making the *kocho* bread. It can be kept in the pit for over a year and according to the farmers, the longer the storage, the higher the *kocho* quality will be.

In the Kaffa tradition, women prepare a skirt from enset leaves, which they put on during harvesting and processing of enset. The reasons are to keep the product clean while processing and it is also a belief. According to them, unless they put on a skirt made from enset leaves during processing, they would not get a blessing from Saint Mary and the *kocho* will not last long.

This entire activity, which is tedious and time consuming, is performed without any assistance from husbands or any male member of the household. However, when processing technique improves, there is a chance that men will be attracted and share the task with their partners (Boserup, 1970). This idea was supported by the fact that we observed a shift of perception by male farmers who once said; '*it is shameful in our culture for a man to process or to see his wife processing enset*'. They expressed an interest in processing when an enset-processing tool was introduced to them. The equipment was brought for three selected enset conservator farmers in Kaffa Shaka by the Biodiversity Institute in 1997 to see the reaction of farmers towards the adoption of the technology.

Despite the positive attitude of the farmers about the availability of such equipment, and their willingness to purchase such tools, the Rural Technolgy section of the MOA (inventers of the tool) did not encourage the purchase of the tools by farmers. It seems that the tool was meant for demonstration purposes only.

As processing of *kocho* and *bulla* is labor-intensive, the introduction of such technology to the enset farming households in the future will reduce the workload from the women, although loss of control over the income from enset sales might be an issue of concern. Furthermore, it will improve the marketability of the product both in quality and quantity as more *kocho* and *bulla* will be processed and brought to the market, which in turn improves household's income and sustainability.

Role of gender in decision-making

Understanding the roles of men and women in decision-making has been given due emphasis in agricultural economic development (Feldstein *et al.*, 1990). The knowledge on men and women's participation in decision-making in agricultural activities is vital, as it is an important aspect of family power relations. Women along with men are important actors in agricultural decision-making. In the household, husband and wife usually make the decision regarding the various matters. However, factors such as women's access to land, women and men's education, labor contribution, women's income, farm size, and gender role perception determine the wife and husband's decision-making in most of the cases (Chen, 1997).

In the study by Chen (1997), in China, decision-making varies depending on the farming practices, whether it is male managed, female managed, or both. The study has revealed that there is gender specific decision-making in agricultural production. According to Ghezai (1999), in the Kunama farming communities in Eritrea, women make decisions on selection of good quality seeds of sorghum although in most of the cases, the power of decision-making is based on gender ideology. In the rice farming community of Bohol, in the Philippines, all decisions regarding crop production, seed management, and family matters are shared equally between husband and wife (Bertuso, 1999).

From the table below (Table 10.11), there are gender specific decisions in most of the agricultural activities in the studied households. Women make decisions on harvesting time for enset and on income from the sale of enset products. Decision-making is shared between husband and wife regarding which type of clone to plant and time of planting, on the purchase of clothing for the household members, and on the purchase of additional food items. However, in particular areas of major agricultural production and sale, such as the purchase of agricultural equipment, adoption of new cultivation techniques, income from sale of other crops and on income from sale of livestock, it is only the husband who makes the decision.

Table 10.11 Results of chi-square test on gender and decision-making

Decisions	Frequency (N=240)					
	Husband	Wife	Son	Shared	χ^2	Significance
The type of clone to plant and time of planting	80	24	1	135	180.033	Ns
Purchase of agricultural equipment	216	14	4	6	541.733	+
Adoption of new cultivation technique	177	13	5	45	319.133	+
Harvesting time for enset	4	232	-	4	433.200	+
Income from sale of enset	3	220	-	17	368.725	+
Income from sale of other crops	163	32	1	44	252.167	+
Income from sale of livestock	167	22	5	46	268.567	+
Purchase of clothing for HH members	75	32	5	128	144.300	ns
On additional food items to be purchased	21	42	-	174	174.152	ns

+= significant at 0.05 and ns= not significant

From the chi-square test results above, there is gender specific decision-making in enset farming in the study area and husbands dominate most of the decisions. The involvement of women in decision-making in selection and sale of enset might be related to the division of labor in the cultivation of the crop and underlines the fact that enset is a women's domain. Similarly, men are more involved in the production of other crops and hence make their decisions on the income from the sale. Traditionally, men are responsible for matters outside of the house such as payment of taxes, and other community contributions, which come from sale of livestock and other crops. This result therefore shows that men have more decision-making power and also control over the greater portion of the household's income.

10.6 How farm households' cope with stress situations

Ethiopia has experienced several periods of drought and famine, which have resulted in ecological degradation and food insecurity in many parts of the country especially in the northern and central parts (Ezra, 1997). For rural producers, the decline in rainfall and the yearly fluctuations poses a serious threat to food security and leave most rural households vulnerable. Other factors such as villagization and resettlement, which were some of the components of the former policies of the military Derg regime, had also a negative effect on food production. The degree to which people are affected in different periods of drought and famine varies from region to region or within different farming systems. Although government projections indicate that there is some hope of improvement, the food security situation in the country has been in the state of serious deficit.

Throughout these events, farmers have responded to cope with the situation of food shortages and income depletion in various ways. The strategies employed vary from diversification of their farming practices to outmigration to other rural or urban areas for wage labor. This section will discuss the knowledge and perceptions on the crisis, their responses and measures taken during the last few stress periods by farm households in the study area.

As discussed in Chapter 3, coping according to Davies (1993) is a short-term response to an immediate and inhabitual decline in access to food. These kinds of strategies are responses by the poor to declining food availability and entitlements in irregular seasons of the year. Anderson *et al.* (1994) also defined strategy as "the overall way in which individuals, and possible collectivities, concisely seek to structure, in a coherent way, actions within a relatively long-term perspective". While interviewing households about periods of food shortages, and how they were able to cope with such situations, the recent famine of 1984/85 is the one most remembered by the surveyed households. Members of the household mentions a combination of several steps, which they have taken as mechanism for coping and as production strategies.

During the 1984/85 drought, households in most of the north and central part of the country were severely affected as a result of a complete failure of rainfall for prolonged periods. As a response, a massive movement of people took place in the form of resettlement from drought prone and ecologically degraded areas of the North and central part to the fertile lands of the south-western part of the country (Ezra, 1997). The inhabitation has occurred even in the vicinity of the study area. By most of the agricultural specialists and the World Bank, this was considered to be a solution to the famine crises and a sound way to the country's economic and social development. According to Ezra (1997), over 343,000 households were moved between 1980 and 1990 to the uninhabited areas of Western and Southwestern regions. However, for several reasons this was not successful. The land was not as productive as it was expected to be. More forest degradation was encountered. The inhabitants did not welcome the new settlers. Many of the settlers suffered from diseases and death, and some returned home because of dissatisfaction. The resettlement resulted in more problems of forest degradation and ethnic clashes.

Similarly, the surveyed households expressed their opinion of the drought as one of the most difficult times they encountered in their lifetime although it was not as bad as it was in the other parts of the country. According to them, they lost almost all their livestock and the annual crops. What was left on all of the farmers' plots were enset and taro (a tuber crop). They were able to survive because of these crops. According to most of the respondents, before that event, some farmers did not care to have more diversified enset and taro crops in their fields. During the time the other crops failed, those farmers with little or no enset were forced to buy or borrow enset from their neighbors or from distant places. Likewise, the taro plant was usually grown wild around the fences and riverbanks and most farmers were not used to eating this crop. The following captures the response of most of the household heads interviewed:

> *Enset and taro saved our life. Otherwise, we all would have suffered like the people in the north and we would have been taken away from our land to distant villages where there is no more enset plantation. We were not hurt much except loosing our livestock, cereals, pulses and oil crops, which mostly were sources of income for the household. Those who did not have many enset plants bought or borrowed from others and some went to find a job in order to sustain their family.*

Besides relying on these crops, other coping strategies employed by households to overcome the crises were sending a family member to other rural or urban areas for wage labor. The migration was mostly to state coffee farms and other food for work programs. However, some said that the remittances sent or brought to the family were not enough as the migrant had to sustain him/herself in the work area stayed and send or bring in whatever was left for the rest of the family members.

Afterwards farm households in the study area began to employ medium and long-term production strategies in order to overcome difficult circumstances. According to them, they understood the benefits of having diversified their farm activities to save them both from hunger and from lack of income. Many farmers informed us that they started planting many clones of enset and taro by either buying from or exchanging with neighbors and kin. They have also allotted more plots for enset. Some of them have even extended their plantation beyond their backyard for security reasons.

According to them, diversification of the farming system by growing a mixture of many crops such as taro, cabbage, coffee, legumes and other root crops among the enset plants is useful to have many harvests at different times. Inter-cropping of crops with varying maturity (early maturing with late maturing ones) is also the best way to safeguard the household's food situation. In this case, it is possible to off set the risk of crop failure and enhance food security as the failure of one crop can be compensated by the success of the other. Sixty eight percent of the respondents (163 households) said that they practiced mixed cropping in order to have more and stable output from their land. They can also have harvest throughout the year from crops maturing at different times.

Farm households have also developed the culture of planting tree species such as bamboo and eucalyptus depending on the amount of land they have available. They said that having this tree species is like an asset and brings income to the household, as there is always a demand for construction and fuel wood in the *woreda* towns. According to them, though enset is a crop to rely on in time of food crises, the income from it is not sufficient for covering all expenses. The existing transportation facilities are in poor condition and the backward traditional processing techniques have contributed to the low marketing of enset products. They use enset for food and the little income from it for buying household consumables. The income from the annual crops, tree species and livestock help them pay all other expenses. However, they concluded that all other crops and livestock are not reliable, as they cannot withstand severe stress situations when the stress comes back. There is also shortage of land to expand and to cultivate many crops. Therefore, they profess to be highly dependent on enset and thus will keep on planting as many and diverse enset plants as possible as they can keep it long on the backyard.

Few respondents (8 percent) also encouraged polygamous marriage as a means to secure more land so that they will be able to grow and produce more crops. They also believe that by increasing the household size there will be more labor force for production, which results in higher income for the household. However, this kind of strategy might not seem feasible, as land is becoming more and more scarce. Especially, since the increase in the number of new households being formed each year and also the fact that most of the forests in the area have been cleared and there is no way to expand the individual land holding in the future.

Past experiences of the drought and the resulting food shortage has taught farm households to develop more conscious and diverse strategies, so that they can be food secure and insure their household income. Labor migration to food-for-work programs and to coffee plantations in the surrounding areas are also practiced in the enset farming system as a type of livelihood strategy. As explained in Chapter 9, labor migration in the study area accounted for 6.3% of the households surveyed. In the respondents' opinion, this figure will definitely rise in the future. This is due to the formation of more and more households each year with more labor force in the family and less land to cultivate. However, migration has a negative impact, especially on the women. Among the reported migrants in the study area, women accounted for only 0.42%. This indicates the fact that men participate at the early stages of cultivation (land preparation, planting and transplanting) of enset and then go for wage labor, leaving the entire farm and the family to the women. In the absence of the household heads, the women are responsible for all the activities in the house and on farm.

PART IV

Chapter 11 Linking conservation of enset genetic diversity to utilization

This chapter focuses on the identification of linkages between conservation and use of enset genetic diversity. Socio-economic and cultural analysis of the farming system emphasizing the conservation and utilization of agrobiodiversity, in particular regarding genetic resources of enset will be presented. Various indicators that were selected to determine the food security and livelihood status of the households studied will also be analyzed from this perspective. The hypothesis, which constitutes the central aim of the study (see Chapter 3) reads:

> *By maintaining enset diversity a subsistence farmer can secure food self-sufficiency and therefore, a positive relationship exists between conserving the diversity of genetic resources of enset and household food security.*

In this chapter, this central hypothesis will be revisited. The farmers' selections and characterization of enset clones were shown to be functional. It is based on use value. The farmers' characterization system and the values farmers attach to the characteristics determine the decisions and choices they make in the management of the crop. Therefore, it is relevant to examine the relation between the farmers' characterization system and the data resulting from the molecular genetic analysis, and to compare the two classification approaches. This will be done in the second part of the chapter.

11.1 Introduction

In Ethiopia, resource-poor farmers practice agriculture in marginal lands and under low-input conditions. Genetic diversity of crops cultivated under these adverse growing conditions is claimed to sustain productivity and rural livelihoods. Worede *et al.* (1999) assert that for many African countries that have adopted western agricultural models (including the use of few major cash crops and increased external inputs in order to increase food production) the maintenance of a sustainable balance between conservation and production for use has been a major challenge. Experiences elsewhere in the world indicate that tendencies of agricultural development based on narrow options are affecting the livelihoods of many farming communities in a negative way (Feyissa, 1999). When there is a shift from subsistence to cash crop farming, the traditional subsistence crops are often replaced and this shift may result in decreased diversity in food crops leading to increased dependence on outside food sources. As a result, food consumption and nutritional status may be adversely affected resulting in decreased food security of households.

The management of agro-biodiversity should ideally link conservation with utilization through a network of on-farm and *ex situ* practices to facilitate farmers' access to the materials they need (Feyissa, 1999). Materials, which perform better under low-input and diverse agro-ecological conditions, should be recommended to these subsistence farm households in order to sustain their livelihoods. The support for community-based conservation of genetic resources as a means to maintain a dynamic crop evolution, to increase options in using crop diversity and to decrease vulnerability as a consequence of crop failure or famine is indispensable. This policy facilitates the decision making and cooperation by farming households in identifying problems, in selecting crops for conservation and in the efficient utilization of these crops.

Farm households in small-scale rainfed farming systems tend to maintain more complex production systems in comparison to industrial or Green Revolution systems, and are often more dynamic in exploiting unpredictable conditions (Frankenberger, 1990). Poor people in such areas seek to diversify production and appropriate their selection criteria of crops in order to raise their income and reduce risk. According to Ellis (2000), diversification both on-farm and off-farm has to do with avoidance of risk through the adoption of a variety of activities. Thus diversity seems to be the key component in the sustainability of the household food security and livelihood.

In the theoretical part of this thesis (Chapter 3), the definition of food security by the World Bank 'access by all people at all times to enough food for an active and healthy life' was given as it was deemed appropriate. It was also stated that operationalizing the concept at the national level is quite different from that at the household level. At the national level, it implies access to adequate food supplies either through production or food imports. The availability of adequate food at the national level does not necessarily mean that there is equal distribution of food throughout the country or equal access between households.

Access to food of households is determined by entitlements that may include viable means to procuring food, human and physical capital, assets and stores, and access to common property resources which does not lead to environmental degradation (future vulnerability) (Maxwell and Frankenberger, 1992). The risk of entitlement failure and lack of access to such resources determines the level of vulnerability of a household to food insecurity. As food availability and stable access are both critical to household food security, data on the genetic diversity resource base, production and access/entitlements must be incorporated as indicators while assessing household food security.

In the farm household system, crop biodiversity is considered as a resource for multiple activities of the food and livelihood system. It is used for consumption, conservation, income source, for housing, medicine, and as feed for livestock (Hardon- Baars, 2000). Decisions on use and management of this diversity as part of their food and livelihood strategy are also made at the household level. Moreover, as farm households maintain and use genetic diversity, they are the key players in the conservation and utilization strategy for plant genetic resources in the case of on-farm management (Begemann *et al.*, 2000). The existence of crop genetic diversity in the various farming systems suggests that farm households value them and they benefit directly from the production and consumption of their landraces (Brush and Meng, 1998). It is therefore, vital to identify linkages between factors of the household production system i.e. crop biodiversity among other household resources and assets to the farm household food security and livelihood systems.

11.2 Testing indicators for household food and livelihood security

In this study, several indicators were used to measure household food and livelihood security. Most of these concern household resources and assets. In the survey one question was asked about experiencing food shortage. Food shortage is a simple indicator of food insecurity of households. The logical assumption would be that households with many plants and a diverse collection of clones would experience less food shortages than those with less plants and fewer clones. In the Tables 11.1 and 11.2 this assumption is tested.

Table 11.1 Relations between food shortage and total number of enset plants owned

Have you ever been faced with seasonal food shortages?		Grouping by total number of enset plants				χ^2
		<600 plants	601-1200 plants	>1200 plants	Total	
	Yes	56 (69.1%)	48 (63.2%)	55 (66.3%)	159 (66.2%)	
	No	25 (30.9%)	28 (36.8%)	28 (33.7%)	81 (33.8%)	$.646^{ns}$
	Total	81 (100%)	76 (100%)	83 (100%)	240 ((100%)	

ns: not significant

Table 11.2 Relations between food shortage and enset clonal diversity

Have you ever been faced with seasonal food shortages?		Grouping by the number of clones maintained		Total	χ^2
		≤ 10 clones	> 10 clones		
	Yes	75 (31.2%)	85 (35.4%)	160 (66.6%)	
	No	34 (14.2%)	46 (19.2%)	80 (33.4%)	1.749^{ns}
	Total	109 (45.4%)	131 (54.6%)	240 (100%)	

ns: not significant

As the non-significant values of the computed chi-square show, contrary to our expectation, there is no relationship between these variables. An explanation for the lack of significance may be the following. The numbers of plants and clones were measured at the time of the study. The experience of food shortage dates from another period, notably the period of serious drought during the eighties. As described in Chapter 10, many people realized the value of enset at that time and households increased their number of plants and clonal diversity afterwards. This is one possible explanation why the test did not yield significant results.

Household size can be seen as an indicator for the labor potential in the household. In Chapter 10 we discussed the importance of household labor as a resource. Large families are favored because of the labor they can provide. Hence, in the tables 11.3 and 11.4 the variable of household size is related to the total number of enset plants and the observed clonal diversity respectively.

Table 11.3 Relations between household size and total number of enset plants

HH size	Grouping in total number of plants			Total	χ^2
	<600	601-1200	>1200		
1-3	24	14	5	43	
4-6	35	34	22	91	
7-9	16	18	22	56	40.94
10+	6	11	33	50	
Total	81	77	82	240	

*: χ^2 significant at 0.01 level

Table 11.4 Relations between household size and diversity of clones maintained

	Diversity of enset clones maintained				
HH size	<5	6-10	>10	Total	χ^2
1-3	4	25	14	43	
4-6	4	47	40	91	
7-9	-	22	34	56	37.66
10+	-	7	43	50	
Total	8	101	131	240	

*:χ^2 significant at 0.01 level

As can be seen in the tables, increased household size resulted in the increase of both total number of enset plants and the diversity of enset clones maintained by the household. Larger households have more people and as a result there is more labor involved in the various production activities to secure food and livelihood.

Apart from household size, a number of socio-economic factors have an influence on a household's food and livelihood security. In our research, several indicators were selected that are considered to be relevant for measuring the socio-economic status of households and for the stratification of households according to wealth. These include: total number of enset plants, variability (diversity) of clones maintained, land holding size, livestock holding, annual household income, annual expenditure, and number of houses owned. The selection of these indicators was based on the theoretical framework (see Chapter 3). It was derived from the literature regarding household surveys (informal) in other enset growing areas in the country (e.g. Brandt *et al.*, 1997) and thorough discussions with community leaders and focus groups. During the focus group discussions in both *woredas*, participants were requested to list criteria they use in distinguishing farmers in their communities according to wealth status. The most important criteria suggested were the ones listed in table 11.5 below. According to the focus groups, landholding size, enset genetic diversity (number of enset plants and the diversity within) and livestock holding were their priorities. Most of the indicators are related to (access to) resources and entitlements. Accordingly, lack of or unavailability of those resources would lead to food shortages and income insecurity.

In Table 11.5 below, the correlation coefficients are computed for the relationships among the selected indicators of socio-economic status. The results show that all are positively correlated amongst each other.

Table 11.5 Pearson's correlation coefficient for indicators of food and livelihood security

	Total enset plants	Diversity of clones	Land holding	Livestock holding	Annual income	Annual expenditure	Number of houses owned
Total enset plants	1.000	-	-	-	-	-	-
Diversity of clones	.526**	1.000	-	-	-	-	-
Land holding	.442**	.470**	1.000	-	-	-	-
Livestock holding	.471**	.384**	.609**	1.000	-	-	-
Annual income	.381**	.379**	.548**	.555**	1.000	-	-
Annual expenditure	.348**	.355**	.396**	.441**	.409**	1.000	-
Number of houses	.354**	.251**	.389**	.428**	.371**	.471**	1.000

**: Correlation is significant at p = 0.01 level

Although all indicators show a significant positive correlation, some correlations are stronger than others. There are strong correlations between total number of plants and clonal diversity; total number of plants and livestock holding; landholding and livestock; landholding and annual income; livestock and annual income; total number of plants and land holding. On the other hand, the correlation between total number of enset plants and annual income and enset diversity and annual income appears to be less strong. Annual income is the best indicator for livelihood security. The weaker correlation with this indicator could be interpreted as follows. Households can be food secure according to the other socio-economic indicators that correlate very strongly with the total number of enset plants and the diversity of clones i.e. landholding and livestock holding, but that does not necessarily make them secure in terms of livelihood. Households with a high annual income also have more land and livestock (strong correlation) and, hence, will also be food secure. But food secure households in terms of number of enset plants and clonal diversity will not all have a relatively high annual income. This correlation appears to be weaker, and thus households with higher number of plants and diversity will be generally less secure in terms of livelihood. We may conclude that a high number of enset plants owned by the household and clonal diversity are important for food security, while the other indicators such as annual income, landholding and livestock are important in the context of livelihood security, and thus also food security.

By using factor analysis we tried to combine all indicators in the table into one composite indicator for socio-economic status. The procedure searches for high loading for some of the factors and loading close to zero for the others. The results of the factor analysis indicated that there is no effect of loading of one factor over the other. Therefore, all seven items were considered important in indicating the wealth status of the households studied. Furthermore, reliability analysis was also carried out and has proven that all the selected items create a reliable index for socio-economic status (cronbach's α = .8355). Subsequently, the data for the seven indicators were computed with a range of 7 to 21 for all households studied. Three classes of socio-economic status were then identified: lower class (poor), middle class and upper class (rich) households (Table 11.6)

Table 11.6 Number and percentage of households by socio-economic class

Socio-economic class	Number	Percentages
Lower class	85	35.4
Middle class	112	46.7
Upper class	43	17.9
Total	240	100

The lower class households, which represent 35.4 percent of the households studied are those with very few resources at their disposal. They earn less than 500 Ethiopian birr (approximately 61 USD) per year, have no oxen for ploughing and cultivate less than 0.5 ha of land. As regards the ownership of their enset plantation, they have less than 600 plants and a limited level of clonal diversity (the maximum diversity owned in this group was five clones). On the other hand the upper class (rich) households cultivate more than 2 ha of land, posses over 1200 enset plants, have more than ten varieties, own more than 2 oxen and have over 10 livestock. They earn an income of over 1000 Ethiopian Birr per year. These households comprise 17.9 percent of the households studied. The middle class, which constitute 46.7 percent of the studied households, occupy a position in between.

In Table 11.7 below, we related socio-economic status to household size. Most polygamous households (15.8 percent) are found amongst the larger households. Because the computed chi-square is highly significant, it can be concluded that larger households own more land, have more than one house, more number of enset plants, more clonal diversity and other household resources.

Table 11.7 Household size grouped by wealth status

Household size	Wealth status			total	χ^2
	Lower class	Middle class	Upper class		
1-3	27	15	1	43	114.67*
4-6	43	45	3	91	
7-9	11	38	7	56	
10+	4	14	32	50	
Total	85	112	43	240	

*:χ^2 significant at 0.01 level

Land is a key socio-economic factor in both *woredas* studied, as most of the other household resources such as the amount of enset and other crops planted are associated with the availability of land. As can be seen in Table 11.5, landholding correlates strongly with income and possession of livestock. At the same time, land is important for food security, as indicated by number of plants and clonal diversity.

In all the cases, enset is important to the cultural, social and economic life of the households. People consider enset not only as their cultural heritage but also as a security against crop failure and food shortages. This is why we were able to record the existence of considerable clonal diversity in all the socio-economic status groups, regardless of the total number of plants maintained by the household.

Wealthier households diversify their fields by growing different types of clones and also other cash crops, as opposed to the lower class households. Wealthier farmers believe that by doing so many objectives, i.e. resistance to disease; higher yield; good kocho, bulla, corm, and fiber quality; and household income, can be achieved. Households in this category have resources to sustainably maintain the household's food situation and are able to pay their taxes. They also diversify their diets by consuming supplementary food derived from cereals and pulses and have adequate food all year round. However, enset is still the most preferred and most frequently consumed food. As regards the distinction between the two *woredas*, the major difference observed was in the source of income, as households in Decha have the opportunity to collect wild spices (e.g. *Aframomum corarima*) from the forest, which they can sell, so that it increases their income to some extent.

Poor households in both *woredas* are food insecure. They have limited land and no oxen to plough their farm. They are more dependent on off-farm activities and on their labor, which they sell to wealthy households. In these households, especially where there is a prevalence of disease, they plant only tolerant enset clones due to selection pressure and hence only few enset plots with only one type of clone (usually Nobo) can be observed in their backyard. As their income is limited, their daily menu does not vary much and is enset-based with few protein and vitamin supplements (see also Chapter 9 for details of food habits).

The socio-economic status of households has been found to be an important determinant for the management of enset genetic diversity. In the middle and upper socio-economic groups, there is more land and labor (larger household size) and, hence, more diversified clones and more enset plantations with various age groups are maintained. The availability of livestock in these households also allows for a better, balanced farming system and incorporation of animal products to the diet of the households together with enset.

11.3 Characterization of enset landraces: formal versus informal classifications

Farmers' characterization of enset landraces

Enset farmers classify their landraces and give different names based on several attributes that distinguish these landraces from one another. These include phenotypic differences, unique traits and specific uses of clones.

Farmers have their own way of distinguishing one clone from the other based on use value and associated characteristics, and sometimes it is difficult to understand and reproduce, even while watching them characterize. While studying the genetic relationships among individuals and populations of crops is vital from a conservation and utilization point of view, there is no well-established classification system and descriptor list for characterizing enset so far. Alemu and Sandford (1996) have attempted to establish a field guide system in order to characterize enset clones, in North Omo, using morphological characters. Some attempts have also been made to document and analyze clonal identity using farmer's taxonomy of the Ari people (Shigeta, 1991). In all cases, clonal names reported in the literature are associated with only limited phenotypic data provided by farmers. Local knowledge and practices which have co-evolved over time as adaptations to a particular environment, and social and economic circumstances form the main source for the passport and agronomic data for the genetic resource of enset collected and maintained by a few institutions (see Chapter 8).

In some enset growing places such as the Kaffa Shaka and North Omo, farmers tend to distinguish each clone in terms of its sex: 'male' or 'female', as can be seen in Table 11.8. This system of categorization is unrelated to the biological reproduction of the plant. Instead, it reflects the different qualities preferred by men and women. During planting, the men prefer 'male' plants, which are said to be late maturing, have less food quality but are resistant to disease. In contrast, women prefer more 'female' plants, because they mature early and thus can be consumed sooner, and because they yield good quality *kocho* and corm. However, depending on the land holding size and wealth status of households, households try to maintain a combination of 'male' and 'female' clones, with a slight preference for the 'female' (Spring, 1996). According to Habtewold *et al.* (1996), farmers plant a ratio of 56 to 44 'female' to 'male' plants. A similar trend can be observed in the study area and this is a further confirmation of the fact that enset is women's crop, as most of the activities in the cultivation and use of enset are dominated by women (see also Chapter 10). In the current situation, we can see that both categories of plants are maintained with a slight predominance of 'female' plants. The balance of choices by men and women for male and female enset plants is important to keep in mind when considering the future diversity of the crop.

Table 11.8 'male' and 'female' characteristics of enset clones

Characteristics	Category	
	Male	Female
maturity	late maturing	early maturing
fibrosity	more fibrous	less fibrous
plant vigor	vigorous	thin
disease reaction	tolerant	susceptible
kocho quality	less quality	more quality and tasty
corm edibility	mostly non edible	edible, tasty

The field characterization of enset landraces took place in combination with a formal socio-economic survey carried out on 240 households in Kaffa Shaka. During field characterization both male and female farmers who were considered knowledgeable regarding enset landraces in the community took part in the identification and evaluation, sharing their knowledge about each clone. While collecting indigenous knowledge data on the on-farm maintained 65 enset landraces (36 clones from Chena and 29 clones from Decha *woredas* respectively), clones aged three years were used for data collection. This growth stage is considered best for distinction on the basis of color and other phenotypic characters. To avoid redendence, for clones cultivated in both woredas only one was taken as a sample. The following twelve major characters (Table 11.9), based on farmers' evaluation criteria as part of their routine identification of clones, were considered and recorded for each clone.

Table 11.9 List of characters and their corresponding scores during farmers' characterization of enset clones

No	Character	Descriptors and codes used for analysis
1	Pseudostem color	light green=1, light green with pigments=2, green=3, green with pigments=4, dark green=5, dark green with pigments=6, light red=7, light red with pigments=8, deep red=9, deep red with pigments=10, purple=11, purple with pigments=12, red brown=13, red brown with pigments=14, brown=15, light yellow with purple stripe=16
2	Midrib color	light yellow=1, light green=2, green=3, green with red stripe=4, dark green=5, dark green with red stripe=6, light red=7, red=8, dark red=9, red with black pigment=10, brown=11
3	Leaf color	light green=1, green=2, deep green=3, green with purple color at edge=4, green with black color at edge=5, red=6, purple=7
4	Petiole color	light green=1, light green with black pigment=2, light green with red pigment=3, green=4, green with black pigment=5, green with red pigment=6, red=7, red with black pigment=8, dark red=9, dark red with black pigment=10, purple=11, purple with black pigment=12, brown=13, brown with black pigments=14, light yellow with purple pigment=15
5	Plant vigor	poor =1, medium=2, most=3
6	Maturity	early=1, intermediate=2, late=3
7	Kocho yield	low=1, medium=2, high=3
8	Bulla	not good=1, good=2
9	Corm use	not used=1, used=2
10	Fiber quality	low=1, medium=2, high=3
11	Medicinal value	not used 1, used=2
12	Disease response	susceptible=1, intermediate=2, tolerant=3

As can be seen from the above table, four major phenotypic characters (i.e. pseudostem, midrib, leaf and petiole colors); agronomic characters such as vigor; time to maturity and tolerance to bacterial wilt; use value and quality of the products (kocho, bulla, corm, fiber and medicine); were the major characters considered for data collection and analysis. During data collection each character was thoroughly discussed among the principal investigator, the technical assistants and the key informant farmers. Qualitative characters were later coded for data analysis. For colors of the pseudostem, midrib, leaf and petiole, the characterization was also supported by standard color charts used for other crops. It was sometimes difficult to be precise as in the case of pseudostem color, which is not always constant over time. Midrib colors, however, are fairly constant through time from a certain stage of the plant's life cycle onwards (Alemu and Sandford, 1996). All coded characters were used for the principal co-ordinate analysis and the dendrogram.

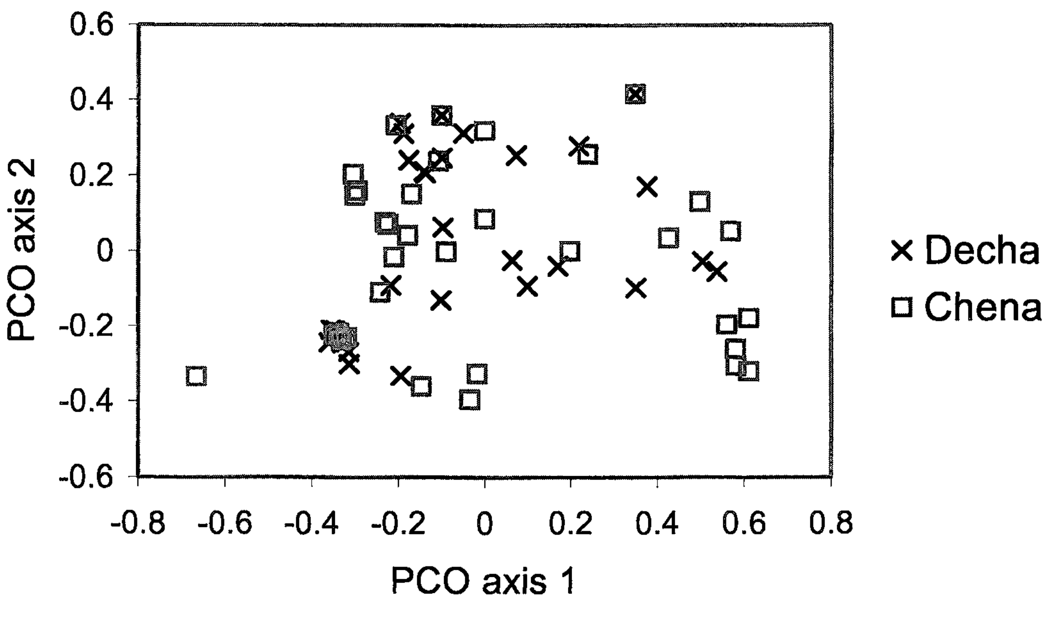
Much variability in phenotypic characters (16 pseudostem, 11 midrib, 7 leaf and 15 petiole colors) has been identified. For color of the pseudostem, the dominant colors were: light green pigmented 26%; red brown 17%; green 12% and light green with pigments accounted for 11% of the clones. For midrib, red color was in 34% of the clones, white yellow in 23%, light red in 12% and brown color in 11% of the clones. As regards leaf color, green leaf color was dominant which was 68%, light green 20%, deep green 8% while red and green color with black stripe each accounted for 3%. For petiole color green with black pigment appeared in 43%, red color with black pigment in 17%, green with red pigment and red color each appeared in 8% of the clones. Similarly variability among individual clones with regard to agronomic characters (plant vigor, maturity periods), use values and specific qualities was recorded (see Table 11.10)

Table 11.10 Characterization data on use value, maturity and specific qualities of enset clones

Descriptor		Percentages	Descriptor		Percentages
Vigor	poor intermediate most	27 51 22	Corm use	not used used	40 60
Maturity	early intermediate late	60 32 8	Fiber quality	low medium high	45 35 20
Kocho yield	poor medium high	34 51 15	Disease reaction	susceptible intermediate tolerant/resistant	74 15 11
Bulla yield	not good good	12 88	Medicinal value	not used used	95 5

Principal Component Analysis was carried out in order to see how these major phenotypic characters, use values and characters for specific qualities separated the clones into respective groups. It was also carried out to evaluate whether there is grouping of clones either within or between the collection *woredas* under the given set of characterization criteria.

Fig. 11.1 Principal co-ordinate (PCO) plot of enset clones based on farmers characterization data



The results of the principal co-ordinate plot analysis (Fig. 11.1) performed to identify the relationships (groupings and differences) among all clones in the two collection *woredas*, explained 37 percent of the total variation by the two principal axes (PCO axis 1 and 2). The results indicate that enset clones investigated from the area studied show a significant variability though there is no clear grouping or clustering of clones observed either within or between the two collection *woredas*.

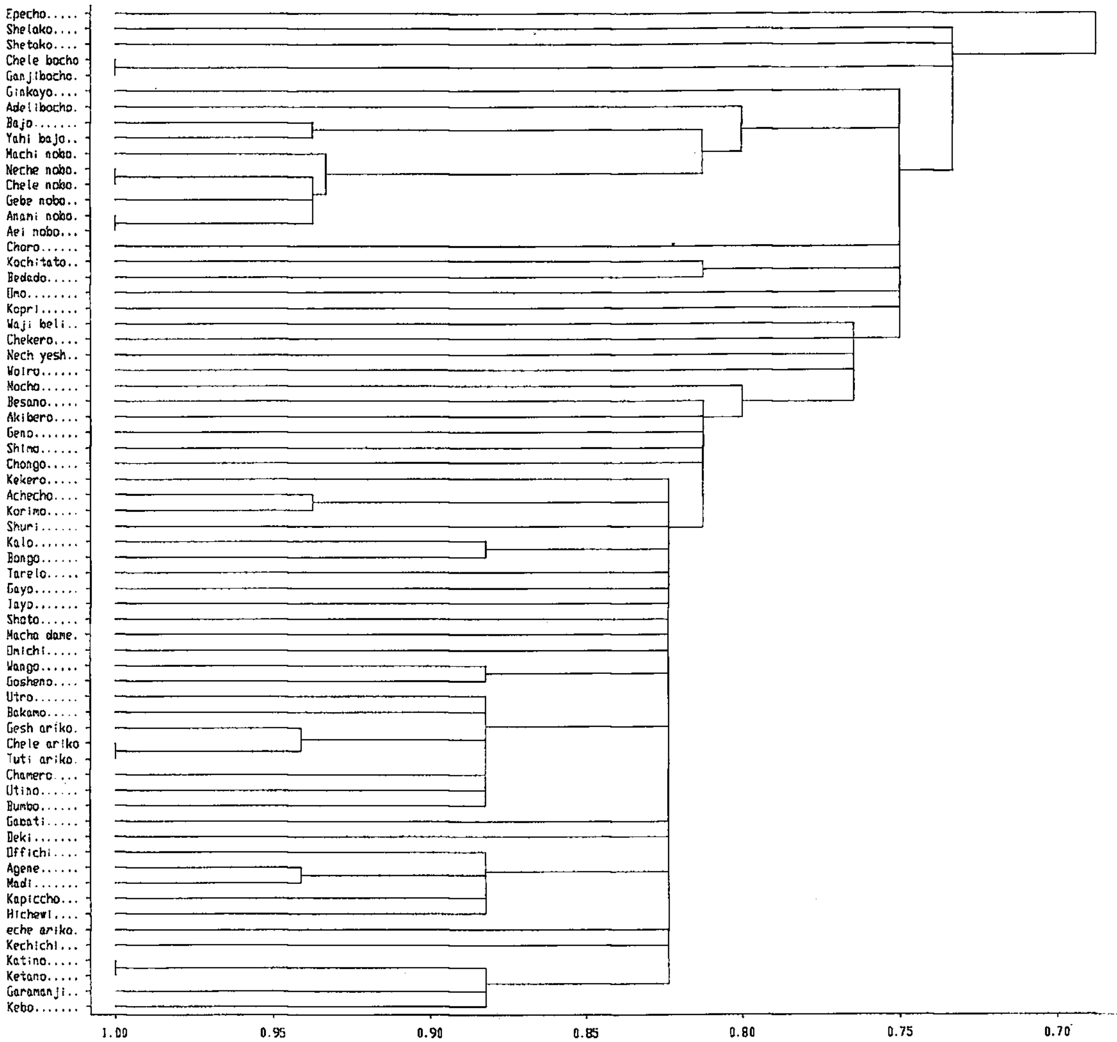
Farmers also categorized some clones into sub-clones based on certain use aspects, which they still believe belong to the same genetic origin (similar vernacular names usually with a pre-fix added). Some examples of those clones are Chele bocho and Ganji bocho, Bajo and Yahi bajo, Chele ariko and Tuti ariko, Neche nobo, Anami nobo, Aei nobo, Gebi nobo and Chele nobo (see also Chapter 8). A dendrogram using farmers' classification data was thus constructed using Jaccards' similarity matrix, in order to identify similarities and distances between all enset clones. The analysis was carried out using Genstat 5 release 4.1 package.

Based on the information from the tree diagram, most of the clones in the different groupings of the sub clones showed very close relationships and some appeared to be identical. Clones Neche nobo and Chele nobo, Anami nobo and Aei nobo, Tuti ariko and Chele ariko, Chele bocho and Ganji bocho were found to be identical with a similarity of 1(see Fig. 11.2). Moreover, Katano and Katino, which were not regarded as sub-clones were also found to be identical. The other varieties with different clonal names differed from one another and showed a varying degree of genetic distances.

In general, the results from the present investigation have revealed the existence of a considerable level of diversity of enset as managed in the traditional farming system. We also concluded that the names given by the enset-growing farmers to the different clones are generally consistent, distinguishing different enset clones linguistically, phenotypically and in terms of their utilization values.

Indigenous knowledge that is accumulated on the crop over many years has played a significant role in characterization and maintenance of the existing genetic diversity. It will support further characterization of the clones using other techniques by avoiding redundancies and optimizing the efficient conservation and sustainable use.

Fig. 11.2 Dendrogram for clones evaluated using farmers' indigenous knowledge data



Molecular characterization of enset landraces

Results from molecular analysis and details of the experimental procedures are explicitly discussed in detail in chapter 8. However, for the sake of comparison of the two methods, some of the issues will be summarized in this chapter.

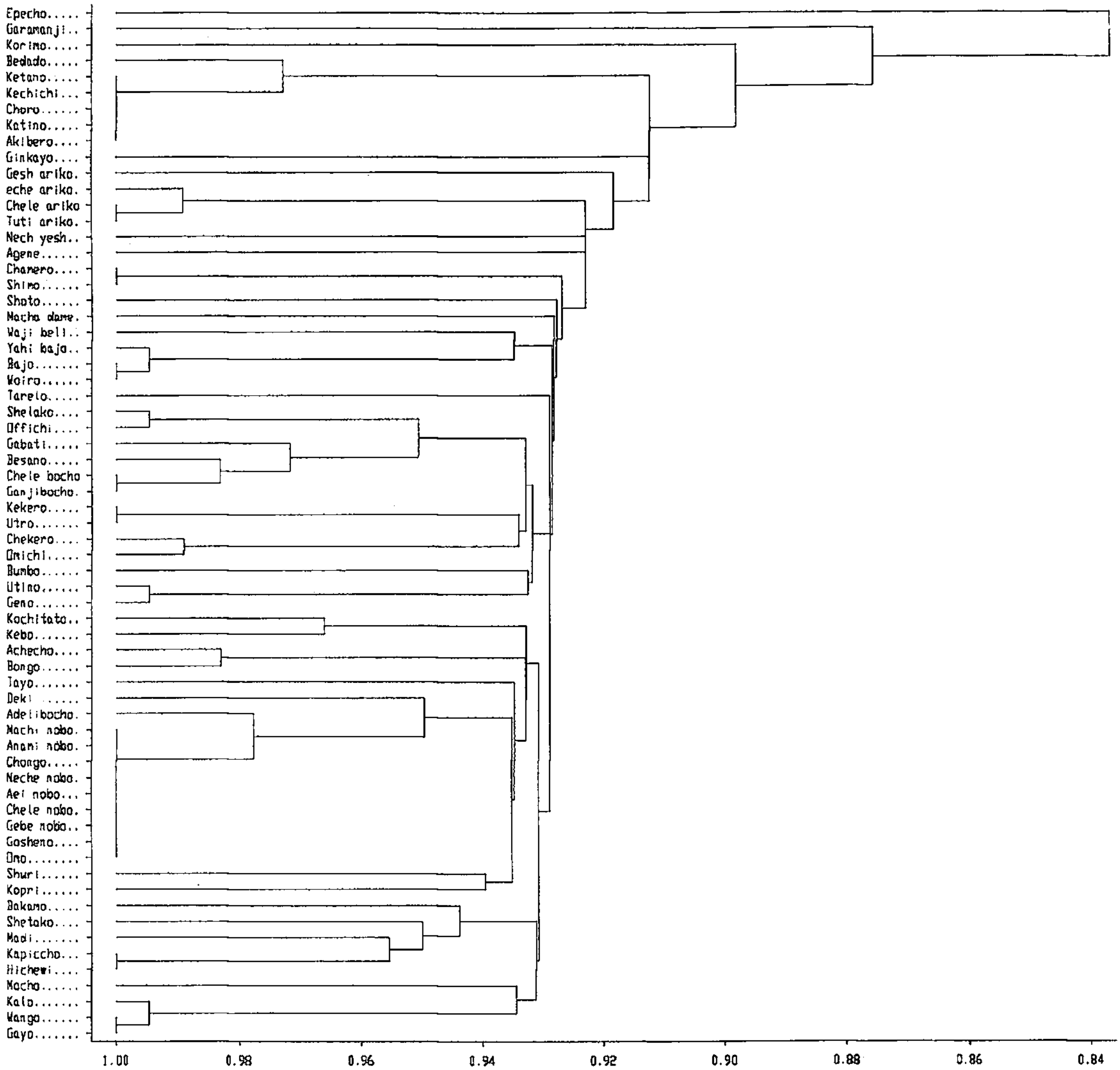
Molecular techniques such as AFLPs are believed to be necessary tools to characterize germplasm at the DNA level. The techniques have successfully been applied to characterize several crop collections including *Musa* spp., a close relative of enset (Engelborghs *et al.*, 1998; Barrett and Kidwell, 1998).

In the case of enset, only farmers' characterization methods have been applied until now in order to characterize the diversity in the crop. However, morphological variation is thought to be limited and expression of the genotype to be highly influenced by environmental conditions. Furthermore, as enset grows in areas where there is large ethnic diversity, different names might be given to the same clones. This increases the redundancy of clones, which in turn affects the design of strategies for future collection and conservation of the crop.

Through molecular marker analysis of 65 clones collected from farmers' fields in the study area using the AFLP technique, a reasonable amount of variability but also a certain level of duplication within the collection was observed (Fig. 11.3). In the total number of clones analyzed, 19 clones were shown to be redundant (29 percent) using this AFLP technique. Similar to the farmers' data, clones did not show clear groupings either between or within collection *woredas*, as was shown in a PCO analysis.

In the PCO for molecular data (figure not shown), 25 percent of the variation was expressed in the first two-dimensional plots. Most of the duplicates appeared to be clones with similar vernacular names in which farmers further subdivided them according to their use aspects. However, in the case of clones Choro and Ketano, an unexpected result was recorded. These clones were found to be identical on the basis of the AFLP analysis, whereas farmers easily distinguish these clones.

Fig. 11.3 Dendrogram based on results from molecular analysis of enset clones



Discussion on the relationships between the two characterization methods

Enset farmers have set certain criteria for classifying their clones based on phenotype, quality, yield, test, tolerance to disease, medicinal value, and so forth. In our case, one of the aims of this study was thus to see whether correlation exists between results from farmers' characterization and that from molecular marker analysis (AFLP).

As far as conservation of genetic resources is concerned, an understanding of whether two plant individuals, which show similarity in a morphological characterization exhibit a similar result when analyzed genetically is of paramount importance. Several studies have been carried out to study the relationships between diversity based on molecular markers and morphological differentiation. According to Burstin and Charcosset (1997) although the existence of a correlation has been reported in a few cases, significant correlation has not been achieved in most of the cases investigated so far. In a study by Bertuso (1999), when three characterization methods, i.e. by farmers, based on formal morphological analysis and molecular marker techniques were compared in a rice crop, significant correlations were observed between the formal morphological and molecular characterization. However, correlation between morphological and farmers' data was found to be negative, and a weak correlation (0.121) was obtained when farmers' and molecular data were compared.

For the enset crop, this study is the first of its kind and our aim was to obtain some guidance in the development of effective conservation strategies both *ex situ* and *in situ* in the near future. Moreover, the investigation may help to validate the indigenous knowledge of enset growing farm households who have greatly contributed to the nurturing of the available diversity in the crop. According to the results, after analyzing both sets of data, a positive but weak correlation (0.1) existed between the two methods when looking at overall variation. This may suggest a divergence between the way farmers characterize the different clones using their selection criteria, and an analysis using molecular markers. Farmers select for specific or functional genetic traits, which represents a measurable and expressed added value whereas AFLP markers score random diversity between clones.

Table 11.11 Grouping of clones, which appeared identical according to both data sets

Grouping from farmers data		Grouping from molecular data			
group	Vernacular name	group	Vernacular name	group	Vernacular name
1	Chele bocho, Ganji bocho	1	Chele bocho, Ganji bocho	6	Wango, Gayo
2a 2b	Neche nobo, Chele nobo Anami nobo, Aei nobo	2	Machi nobo, Anami nobo, Chongo, Neche nobo, Aei nobo, Chele nobo, Gebi nobo, Gosheno, Omo	7	Chamero, Shimo
3	Chele ariko, Tuti ariko	3	Chele ariko, Tuti ariko	8	Bajo, Woiro
4	Ketano, Katino	4	Ketano,Kechichi, Choro, Katino, Akibero	9	Kepicho, Hichewi
		5	Kekero, Utro		

As can be seen from the above table, more duplicate clones are observed on the basis of molecular result (9 groups) than by the farmers' method (4 groups). Moreover, in the molecular method, not only the number of groups is larger but also the numbers of clones per group are found to be higher. Three types of results were identified regarding the similarities and differences in the two methods and these are elaborated below.

In a first type, clones that appeared together (are identical) on the basis of both molecular and farmers' information were identified (Chele bocho, Ganji bocho; Neche nobo, Chele nobo, Anami nobo, Aei nobo; Chele ariko, Tuti ariko; and Ketano, Katino). These are most of the clones with similar vernacular names (sub clones) (see also Table 11.11). Similarly some of the clones with similar vernacular names, were not identical when using data from farmers, but were considered closely related, and are clustered in one group (see Fig. 11.2). This may be attributed to the following reason: informant farmers were able and confident to tell about the history of each clones and according to them, all the subclones originally belonged to the same clone. For example, (1) the clones Chele bocho and Ganji bocho are from the same clone but further subdivided based on certain observable characters or use aspects. Those minor characteristics by which farmers distinguish these two clones were not used to obtain the dendrogram, and therefore, in the dendrogram the two clones appear identical. The same applies to the rest of the sub clones. (2) Clones Katano and Katino, on the other hand, which were not named as subclones also appeared identical in the results of both characterization methods. Farmers justified that both clones are identical but given different names in different communities, villages and *woredas*. When considering the subclones, we might say that farmers consider or distinguish small differences, which do not appear from the results of the molecular analysis.

In a second type, consisting of Choro and Ketano, despite their phenotypic differences based on farmers' data and our own observations, identical AFLP profiles were initially recorded in the molecular analysis. Phenotypically, in use aspects and some specific qualities, these two clones appeared distinct from one another. When farmers' data were analyzed, Choro and Ketano differed in 6 out of 12 major characters, including pseudostem color, leaf color, petiole color, corm use, medicinal value and time to maturity. Further checking of the molecular data resulting from the use of additional primer pairs showed that these clones were indeed not identical. Therefore, it may occur that some clones, which are found to be identical using molecular marker analysis can still be different genetically.

In a third type, six out of the nine groups of the molecular grouping given in Table 11.11, i.e. 13 (20 percent) of the total number of clones (e.g. Kekero and Utro in group 5; Wango and Gayo in group 6; Chamero and Shimo in group 7; Bajo and Woiro in group 8; and Kepicho and Hichewi in group 9) appeared identical based on molecular data but not on farmers data. It is difficult to accept identity in light of the observation for the second type above. Farmers claimed consistently that they are different which is confirmed in the analysis using their characterization data. This may require further investigation.

11.4 Concluding remarks

In this chapter the linkages between the use of enset and the conservation of its diversity were investigated. In the first part of the chapter (11.2) attention was paid to the relationships between the number of plants and the clonal diversity maintained by households on the one hand, and a number of indicators for food and livelihood security of households on the other. In the second part of the chapter (11.3), farmers' functional characterization of enset clones is compared to the genetic characterization based on molecular marker analysis. Below, we will summarize the main findings and reflect briefly on them.

In Kaffa Shaka, farm households having many enset clones both in total number of plants and the variability of clones are said to be wealthier than those having few clones, and, indeed, according to criteria applied in our study they are. We were able to prove that household wealth in terms of number of enset plants and level of clonal diversity correlated significantly with wealth measured by a number of socio-economic indicators. We can therefore conclude that maintaining clonal diversity contributes to household food and livelihood security. However, the positive correlations between the two variables that measure enset wealth, namely number of plants and clonal diversity, and annual income and expenditure are less strong than with the other socio-economic indicators. Our interpretation of this finding is that enset wealth contributes more strongly to household food security than to household livelihood security. Phrased differently, relatively wealthy households will also have many enset plants and much clonal diversity and, hence, are food secure, but the reverse is not necessarily true. Food secure households, as indicated by enset wealth, will not always be secure in terms of livelihood.

Farmers' classification of enset and its household use are closely related. Farm households know the response of each plant to different factors of production, its phenotypic characters (e.g color, height, width) and unique qualities (e.g medicinal value, disease resistance). From this wealth of genetic resources conserved in the backyard, households utilize plants for various purposes, such as for food, medicine, fiber, and so forth. The maturity period of each clone is well recognized by the household. Women who dominate the harvesting, processing and marketing of this crop are keen on selecting the most appropriate clones for daily household consumption or for selling enset to generate income. This corroborates the characterization of enset as a woman's crop. The fact that plants with 'female' characteristics slightly outnumber the plants with 'male' characteristics is a further confirmation of the relationship between women and household food security (Niehof, 1999b). In general, it can be said that enset farmers are maintaining the variability in enset genetic resources for different purposes. Hence, their conservation strategies are related to use.

The results presented in this chapter also indicate that the indigenous knowledge of farmers continues to play a vital role in the conservation and use of enset. The lesson learnt from this study is that farmers maintain diversity and characterize and select for various uses such as yield, quality, and disease resistance. They are interested in clones that perform under adverse environmental and low input conditions. However, this knowledge, which sustains the farming system, has not been well documented nor has the diversity in enset been formally collected and maintained. From our own observations, the elderly household members knew much more about the different clones, their food and other uses, and storability, than the younger generation. Some younger boys and girls in the households studied said that they regret not knowing as much as their parents and grandparents. This clearly indicates that a close collaboration and communication between farmers and scientists is very crucial for exchange of ideas, knowledge and experience.

Chapter 12 Conclusion and Recommendations

The chapters presented earlier explored the issues of enset genetic diversity related to use and sustainability at the household level and in relation to household food and livelihood security. In this concluding chapter, the research questions, which were formulated in Chapter 3 and address various issues related to enset genetic diversity, will be discussed. Furthermore, issues for further study and recommendations will be presented.

12.1 Conclusions

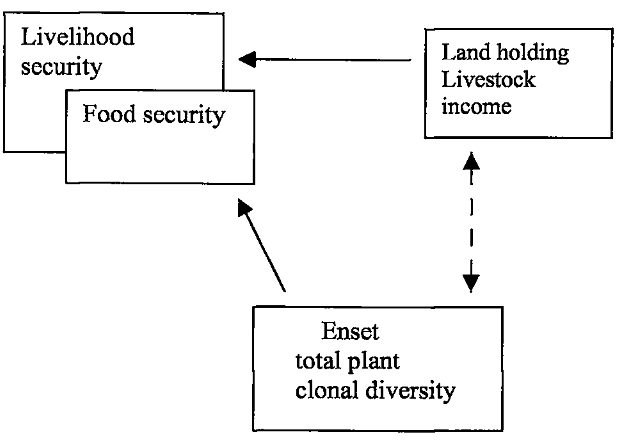
Question 1:
Does enset genetic diversity contribute to household's food security and livelihood security?

The historical background of the cultivation of enset, and its significance in the socio-cultural and economic life of the farming community in the enset growing areas of the SNNPR in general and in the area of study in particular are discussed in Chapter 2. In the study area, enset is a vital crop for over 95 percent of the farm households. This fact has been expressed in different sayings and poems, especially by elderly people. With their long tradition and knowledge accumulated over the years, the Kaffa farmers have been maintaining the crop genetic diversity for many generations. They are focussed on maintaining the variability within the species, while securing sustainability through efficient use.

An assessment of the households food and livelihood security was done by using several indicators, such as the number of enset plants, clonal diversity, land holding size, livestock resources, income, expenditure and the number of houses owned by households (Chapter 11). These indicators are in most cases related to access to resources and entitlements. While some indicators are vital for food security, others were found to be important in terms of livelihood security.

The total number of enset plants and the clonal diversity showed a strong correlation with other socio-economic indicators such as land holding and livestock resources. However, their correlation to indicators such as household income, which is a key indicator for livelihood security, was found to be relatively weak. Therefore, this indicates that enset, as a source of wealth both in terms of the number of plants and the clonal diversity maintained is important for household food security. On the other hand, the weaker correlation to income makes it less important to livelihood security. Households having many enset plants and more clonal diversity are food secure but are not always secure in terms of livelihoods. Other socio-economic indicators such as land holding size, livestock resource and income are found to be important indicators for household livelihood security. Our data revealed that the income from the sale of enset is not much and is used only to cover minor expenses such as household consumables. Households' income for livelihood is therefore secured from the sale of other crops and livestock and their products. The relationships between the different indicators and food and livelihood security of households is summarized in the following figure.

Figure 12.1 Relationships between indicators of food and livelihood security



Farm households maintain large amounts of enset plants depending on their status. A farmer with a large enset plantation, including many types of clones with diverse maturity groups, is considered wealthier, more food secure and well respected among the members of the community (Chapter 10). In one farmer's field for instance, we recorded over 10,000 enset plants and up to 36 different clones. Socio-economic factors also appeared to result in differences in the management of enset genetic diversity. There were differences in the number of clones cultivated by different socio-economic groups (Chapter 10). Poor farm households tended to plant fewer clones and ones that are better yielding and tolerant to the bacterial wilt. Wealthier households on the other hand, are able to maintain a larger clonal diversity with a variety of characters, including the low yielding and susceptible ones, which the poor couldn't afford.

The focus of this study has been to identify to what extent enset growing farmers in the study area cultivate enough of the diversity to secure food self-sufficiency. We further investigated whether households are guaranteed enough income from the sale of enset. In Chapter 11, selected indicators of food and livelihood security were analyzed and revealed that over a third (35.4 percent) of the studied households have a vulnerable livelihood and are less food secure. Household members in this category have few resources at their disposal. They lack the ownership of enough land and consequently have a limited number of enset plants with very few types of clones in their backyard. Thus, they always look for non-farm activities for an income to feed themselves. This thesis stresses that food shortages in this group are serious and underlines the limited value of the country's national food security strategies, which ignore the differences among farming households in terms of monitoring food security. It is thus critical that the government link its national food security system to individual households so that the situation of those vulnerable households is taken into account. The remaining 46.7 percent are categorized as middle class and only 17.9 percent are considered upper class (wealthy). Households in these two groups can afford to diversify their fields by growing different types of clones and other cash crops for food as well as for income generation. Nearly all respondents believed that they are food secure as long as they have enough enset clones both in quantity and variability in their backyard. They also testified that enset has saved them from hunger and food shortages that they experienced during the past years of stress (Chapter 10). According to them, when other crops fail, it was only enset and the other root crop taro, which survived in the backyard. However, the relationship between the indicator of food security and the total number of enset plants and clonal diversity, proved to be insignificant. This seemingly contradictory finding can be attributed to the fact that the realization of the value of maintaining more diversified enset plants in the area came after the period of stress, when farmers having enset plots were able to feed not only themselves but also their neighbors and kin. This has contributed to the existence of many different enset clones in farmers' fields, as they have since then used diversification as a permanent production strategy in securing the households' food supply. Key informants stated that long-term food security is also guaranteed in the case of enset, as the product (kocho) can be stored for up to seven years in the underground pit. As far as food security is concerned, the cultivation of more diversified enset clones becomes indispensable. Even outside of the original area enset is being cultivated now, as 52 percent of the total population of Ethiopia are currently estimated to be food insecure or below the poverty line (Kifle and Yoseph, 1999).

Question 2:

Valuing indigenous knowledge: how do farmers characterize the different enset clones, what are preferences for specific qualities, and who takes part in selection?

Local knowledge of farmers is in part collective and embodied in socially accepted norms and practices for cultivation, selection, exchange, storage and use of local plant germplasm (Friis-Hansen, 2000). Farmers using their knowledge interact with the environment in order to fulfil their needs while managing the natural resources. Their knowledge is unique and is passed on from generation to generation through oral tradition. Based on their historic experience and perceived evidence, they have nurtured the resources for present and future use.

It has been suggested by some scholars that domestication of enset in Ethiopia started some 10,000 years ago (Brandt *et al.*, 1997). Enset farmers since then have maintained and enriched the diversity in the crop through identification and selection using their traditional technical knowledge. They have classified and named the various clones based on several attributable characteristics (Chapter 8). This tradition of sustaining the crop genetic diversity was carried out without any support from the modern scientific community.

For farmers in Kaffa Shaka, the use of enset diversity is intimately related to their culture, as is apparent in the diverse ways that the product is used (for food, feed for livestock, construction, fiber, etc.). Their production strategy is aimed at maintaining a broad diversity both within and between crops in their fields. Farmers, both men and women, select enset clones using their knowledge based on given criteria. From our results, the task of identification and selection of clones was carried out by both men and women and together were able to name over 100 enset clones including clones, which are no longer maintained in their backyard (Chapter 10). The respondents proved to have substantial knowledge of different characteristics and uses of the clones maintained in their backyard. Characterization and selection is based on a range of criteria, which are related to utilization of the product by the household. These include phenotypic characters (color, height, circumference, etc.), use values (yield and quality of Kocho, bulla, corm and fiber) and specific qualities (medicinal value, disease reaction) of individual clones. The women, for instance, select clones that are of good quality for household consumption and for selling. Regardless of the preferred characters by both men and women in the household, they are keen on maintaining as much diversity as possible. They maintain different clones of various age groups to secure harvest any time of the year. By intercropping other annuals and perennials together with enset, supplementary food and cash sources of the household are guaranteed. The knowledge and culture of integrating livestock and poultry with the cultivation of enset is a long tradition of the Kaffa farmers, which helps them fulfil their dietary requirements and to enrich the fertility of the soil.

Exchanging enset clones and the associated knowledge about the crop in order to increase the diversity in their backyard is a tradition for many generations of farm households in Kaffa Shaka. This exchange of indigenous knowledge and planting material is carried out through neighbors, relatives or kin. According to them, whenever they see a new clone or a clone that they have lost from their backyard, they make a concentrated effort to request seedlings, names and characteristics of the respective clones. As a tradition, planting material or knowledge is freely accessed and transferred within communities, villages or even distant places and this is how they were able to increase the diversity of their enset fields.

We observed that the elderly members of households are more knowledgeable and are able to provide more information than the younger ones. However, since this knowledge is transferred through oral tradition, it is obvious that there is a lack of written history about the traditional use, maintenance and characterization of the crop that can be passed over to the new generation. According to key informants, there is fear of not only erosion of enset genetic diversity in the area, but also of erosion of local knowledge.

Despite the social and environmental changes encountered through time, the indigenous knowledge in conservation and use of enset crop has continued to persist. This is due to the fact that enset is a dependable crop in time of food shortages and explains its cultural attachment to the people. The conservation of crop genetic resources entails the actual genetic diversity together with the existing traditional knowledge, and is crucial for attaining food security and sustainable development.

Question 3:

Gender roles: preferences for clones, division of labor and decision making in the production, processing and marketing of enset

In Kaffa Shaka women comprise 50.7 percent of the total population (Chapter 4). They have multiple responsibilities (productive, reproductive and community responsibilities) on which they spend a considerable amount of their time and energy. Despite all the vital roles they play, women are most disadvantaged in terms of getting access to land resource, credit, extension and other services and facilities.

In our study, clear gender differences were observed in the management of enset genetic diversity among the surveyed households. Women play a dominant role in the production, processing and marketing activities of enset. They have slightly differing preferences for the various clones compared to those of men. During our formal survey and focus group discussions, women dominated the discussion when questioned about the different attributes of the clones. When both men and women were requested to free-list enset clones they recall, women recalled more clones than men. We also noticed that there is a slight difference in prioritization of clones according to uses, which indicated the differences in interests between men and women for the different qualities of the crop. In their listing of clones, women were concerned about the balance between the clones to be harvested at different stages and they combined variables such as early maturity, taste, quality, less fibrousness and tolerance. Men on the other hand, included higher yield, late maturity and disease tolerance as their major criteria. In the area, there is also categorization of plants into male and female based on the above-mentioned criteria. The characteristics preferred by women define female enset clones while characteristics preferred by men determine male enset clones. However, both men and women are conscious in keeping the balance between the male and female clones to be maintained in their backyard, with female clones slightly outnumbering the male ones.

Regarding the division of labor in enset cultivation, there is more involvement of women both in production and marketing in enset than in the other crops. Land preparation, planting and transplanting is usually done by the men. Women are more involved in carrying the suckers for transplanting, manuring, harvesting, processing and marketing. Men never engage in enset processing and are not usually seen around the backyard when enset is being processed, unless the situation dictates otherwise. Men believe that enset processing is purely a woman's task. If women did not do the processing, there would not be any food from enset and it wouldn't have been regarded as a food security crop, now feeding over 11 million people in the country. Thus, we can truly say that women are the key to food security in the enset based farming system. Women select matured enset plants and also the type of clones based on the needs of the household. The domination of women in the production activities and the accomplishment of those activities around the house may have greatly contributed to making enset a woman's crop.

Decision-making is important in any family power relations. There are gender-specific decisions in most of the agricultural activities in the studied households. Although women dominate in most of the production activities in the enset based farming system, they are less involved in major decisions made in the household. In general, husbands make more decisions than wives. Women make decisions regarding harvesting time for enset and regarding the income from the sale of enset products. There is shared decision making between husband and wife regarding which type of clone to plant and the right time of planting. Decisions on other matters such as the purchase of clothing for household members and purchase of additional food items are also shared. However, in major areas of agricultural production and sale, such as the purchase of agricultural equipment, adoption of new cultivation techniques, income from the sale of other crops and on income from livestock sale, husbands make decisions. Our results revealed that despite the greater involvement of women in agricultural activities, men have more decision-making power and also control over the greater portion of the household's income.

Question 4:

Impact of population increase on the cultivation of enset

Among the major causes for the decreased production of enset in Ethiopia in general are, population increase, land scarcity, the introduction of improved varieties of crops and diseases such as the bacterial wilt. However, under the current situation in the study area, although there is a significant increase in population (2.5 percent increase annually), they are less affected by land scarcity because of the high forest coverage in the region. Households in both study *woredas* expanded their individual land holdings by clearing the nearby forest.

Our study revealed that there is a positive correlation between household size and land holding in the study area. Household size increased both from having more children through monogamous and polygamous marriages. Large families are favored because they enable farmers to extend their farmland and to acquire more labor force for the various activities both on the farm and in the house. The increase in population in Kaffa Shaka might be attributed in part to the availability of cultivable land in the area. On average, a woman between the ages of 15-49 will give birth to 8 children, a figure, which is higher than the national average. Moreover, based on our observations, farmers in the area are not aware of family planning and the possibility of using contraceptives. They are happy to have more children as long as there is land to cultivate. However, this situation is unlikely to continue. Land will undoubtedly become a scarce resource in Kaffa Shaka as in other regions in the country where farmers have no way to expand their land holdings further as the nearby forest is on the verge of degradation.

As argued by Ezra (1997), there is a different situation in the Northern part of Ethiopia. People in that area, due to stress caused by ecological degradation, drought, food insecurity and land fragmentation, have been forced to change their demographic attitudes and behaviors. According to Ezra's study, farmers are aware of the problem of land shortages, and as a result opt for smaller families and subsequently fertility declines. In a situation where there is more soil degradation and land scarcity, farmers are more aware of the imbalance between population and resources. They are more convinced of having to limit their family size than farmers who are in a slightly better situation, even within the same administrative region.

Our results confirmed that farm households in Chena have more land problems than those in Decha. When questioned whether there is shortage of land, 100 percent of the respondents in Chena responded by saying that there is shortage, while only 52 percent of the respondents in Decha complained of shortage. This is in agreement with the noticeable situation of more forest degradation and lack of cultivable land in Chena. Moreover, there are more polygamous households and household size is larger in Chena as compared to Decha. As a result the area devoted to the cultivation of enset and other crops is declining. Enset is a dependable crop in the area, and as a result its production is increasing despite the decline in the available diversity. This shows that as land becomes more and more scarce, farmers tend to grow only few tolerant and high yielding enset clones and hence there is loss of the total genetic diversity in the crop. Furthermore, when land is scarce, they will be forced to grow only enset, as productivity per unit area is much higher as compared to other annual or perennial crops. This in turn affects the livelihood of many farm households as their income from production and sale of other crops is declining.

In general, an effort to create awareness and change in the perception of farmers is needed with regard to the following factors: i. An increase in family members should coincide with the availability of resources such as land; ii. Both men and women farmers should be aware of family planning and the use of contraceptives in order to have a limited number of children; iii. Polygamous marriage, which is a culturally accepted phenomenon in Kaffa Shaka should gradually be avoided and; iv. Farmers should be educated not to burn forests for the sake of extending their private holdings. It might take a long time until the impact is well recognized by the farm households themselves and until then, they will keep on extending cultivable land, having more wives and children. Similar to the situation in the north, where people started limiting their children and taking birth control measures as a result of degradation and land scarcity, the system in Kaffa Shaka also breaks down if there are no more forests to be burned or cleared for cultivation.

The fact is that the crop genetic diversity, food security and livelihood of many farm households in the study area are at risk and the government should take this fact seriously. It is not worth waiting until farmers learn from their or others experiences. This might lead to the recurrence of the situation that has happened in the North and more land scarcity and soil degradation, which leads to total food insecurity will soon be obvious.

Question 5:

Will tissue culture techniques such as micro-propagation and in vitro conservation solve some of the farmers' production problems?

Farmers in Kaffa Shaka have been cultivating enset for many generations. However, there are many problems surrounding the production of the crop. From results of this research, farmers have lost a fairly large number of clones in cultivation owing to diseases, abiotic selection pressures, or due to changes in land use systems. Farmers named from memory over one hundred enset clones, but the available diversity in their field is less than seventy. We also documented that over 95 percent of the respondents were demanding planting stocks of various enset clones. The farmers need a system, which can serve as backup for the existing traditional methods of propagation and on-farm maintenance of enset landraces. Although the use of botanical seed has been proven to facilitate crop improvement and conservation of genetic resources, enset seed is not used as a planting stock both by farmers and formal institutions to maintain varieties. A field genebank collection in combination with appropriate biotechnological approaches such as the use of improved tissue culture methods for conservation, rapid propagation and distribution of planting material was thus found indispensable in our study. This research has for the first time demonstrated *in vitro* conservation through slow growth (Chapter 6) and rapid propagation of different enset clones (Chapter 7), which will allow the conservation, rapid propagation of disease free germplasm. The similarity in response of the three clones tested to various propagation and storage treatments also suggests that the technique could be applied to a wide range of enset germplasm in the country.

It is essential to analyze farmers' propagation problems and assist them by providing them with sufficient desirable planting materials, which will eventually enable them to produce more, and to increase their selection options for (food, income, etc.). The materials, which are maintained *ex situ* or *in vitro*, which can be kept disease-free, can be introduced or re-introduced into farmers' fields. This increases the possibility for farmers to get insurance against man-made or natural erosion of genetic diversity, which threatens their production. We are certain that such approach contributes to an improved conservation and utilization of enset genetic diversity and also strengthens the link between the formal (institutional) and the informal (farmers') conservation strategies.

Question 6:
How does farmer's classification of clones' correlate to the results of scientific methods making use of molecular markers?

As far as the selection and classification of enset genetic resources in the country are concerned, farmers' methods have been the only way by which clones are maintained either in farmers' or researchers' fields. So far, knowledge on the use of morphological or molecular methods for characterization of clones is virtually lacking. Absence of a well-established classification system is one of the major bottlenecks. Farmers' knowledge has remained to be the main source of information regarding all passport and agronomic data of the existing collections. Most of the genetic diversity is also maintained traditionally by farmers' *in situ* (on-farm). However, as diverse ethnic groups live in the area where enset is cultivated, it was felt by many researchers and by farmers themselves that different names may have been given to the same clones across several enset-growing regions. This hampers straightforward identification and classification of clones.

Farmers characterize and maintain enset landraces for different purposes i.e. some clones are maintained for consumption, some for generation of income, some for their medicinal use and some for their good quality fiber. In this respect characterization and use are closely related. Thus it was worth verifying the correlation of the existing variation at the genetic level and see if conservation strategies are related to type of use.

The results from our study have indicated that molecular marker analysis such as the AFLPs can successfully be applied to study clonal diversity in enset (Chapter 8). The result from the molecular analysis was compared to farmers' indigenous knowledge data. The different clonal names given by farmers are based on several characteristics such as phenotype (leaf, petiole, midrib and pseudostem color), earliness, plant vigor, specific traits (disease resistance/tolerance, medicinal value, fiber quality) and utilization of the crop (kocho, bulla, corm and fiber). The main interest in this study was to assess the relationship between the farmers' and molecular characterization systems used in characterizing and selecting the genetic diversity in enset. A positive although limited correlation was observed between the two methods, which provides additional information for an efficient strategy for the conservation of enset genetic diversity. Our results indicated that the clones investigated showed a significant duplication (29 percent of the clones). Furthermore, in most of the cases the names given by farmers based on different characters are consistent and largely matched the molecular analysis (Chapter 11). Lack of complete matching of the two techniques, which resulted in more duplicate clones in the molecular analysis, might be attributed to the refined way farmers characterize and the criteria used in selection of the various clones and the limitations of the molecular study. Farmers' characterization system is functional, and they select for specific genetic traits. However, AFLP technology scores for diversity randomly, and this may explain why specific variation was not picked up. This result and those of other related studies show that farmers' indigenous knowledge is essential for a detailed and correct classification of crop diversity.

In conclusion of the discussions above, maintenance of genetic diversity by farm households is a function of multiple uses and a mechanism of security against risk. If food security and the need for sustainable livelihood of communities are to be met, local farmers should be supported in areas where they need assistance from the formal sector. The management and efficient use of genetic diversity should be considered essential as potential indigenous crops such as enset will increase food supplies and may also broaden the food base at both the household and the national levels. Molecular studies provide additional support to farmers' classification efforts.

Nowadays many valuable enset clones are lost as a result of diseases, pests, and farmers' preferences such as early harvesting of immature or late maturing enset plants as a result of food shortages. There is, therefore, an indication of loss of the diversity at stake, which may ultimately result in food insecurity of enset dependent households and loss of its cultural values. It is thus vital to integrate and document indigenous knowledge of farmers and the use of the formal methods such as morphological or molecular marker techniques. Together, these will provide adequate information for designing an efficient strategy for conservation, and efficient utilization of genetic resource of the crop.

12.2 Recommendations

- *On research towards enset*: if agricultural research and development efforts are to succeed and be of service to the farming communities, it should be problem-oriented and be acquainted with the needs and priorities of the farming communities. It should consider low-input farmers as active participants and not only as recipients. As far as enset research in the country is concerned, there has been little attention given to it so far. There is no coordinated research in any aspect of the crop including management practices, conservation and evaluation, disease resistance, socio-economics, post harvest handling and nutritional studies. In most of the cases, research regarding enset is not problem oriented. Farmers' needs and priorities are focussed on solution towards acute production problems such as tolerance to the bacterial wilt disease, better yield, quality or addressing issues related to food security. The research agenda should be aimed in areas such as these.

  Whatever production problems exist, enset farmers will continue to grow enset as they depend on it for multiple uses and since it is highly integrated into their culture. The formal sector should strengthen its research towards solving the major problems of enset growers. It should accept the fact that enset is and continues to be the major staple for a large population of the country. The national agricultural research program should prioritize research focussing on its most crucial production problems and closely work and listen to the farmers. The recent initiatives by the Ethiopian Agricultural Research Organization in considering enset as a national commodity crop and in allotting funds for enset research are encouraging. However, much remains to be done.

- *On extension services*: In a country such as Ethiopia, where 85% of the population earns their livelihood in agriculture, an appropriate and transparent agricultural extension service, which leads to food self-sufficiency, is indispensable. Agricultural policies in the country should aim at improving production and productivity of the resource-poor farming communities. Efficient extension services and technical assistance are vital in order to communicate information and sustainable resource management to farmers and to bring back farmers needs and priorities to researchers. Despite its importance to million's of people, enset has been disregarded from the existing extension system and as far as we can see, there is no technology available to improve production and productivity of the crop. In order to attain efficient agricultural development and food security, there is a need for an extension service that can understand the production problems of farm households and provide proper information, advice and other vital and improved farm inputs against an affordable price. The Ministry of Agriculture who controls the extension activities in the country should revise its current top-down extension approach and establish a strong linkage between farmers, extension and research. Extension workers should be trained in order to transmit adequate agricultural information to farmers' and advice on the conservation of natural resources in order to sustain rural livelihoods. As far as enset is concerned, farmers should at least be made aware and advised on issues such as on preventing the transmission of the threatening bacterial wilt disease until a sustainable solution to the problem is found.

- *On the role of genebanks in conservation and utilization:* The conservation and use of plant genetic resources can be encouraged more effectively through developing links between farmers, breeders and genebanks. As shown in this research, enset farmers have problems getting sufficient planting materials of desired clones, which are either lost or not grown in their fields. While germplasm stored in genebanks as seeds or *in vitro* materials can serve as backup collections for farmers, curators from genebanks can also play a vital role in screening the existing collections, for accessions, which are promising for low-input agriculture. Therefore, genebanks can play a vital role in supporting farmers' access to plant genetic resources. Collection and maintenance of enset landraces both as seeds and *in vitro* materials in genebanks may also serve as a base for further research and improvement of the crop. Furthermore, the materials kept in the genebank can be reintroduced to the farmers whenever the need arises. The complementarity of the two approaches i.e. *ex situ* and on-farm management of plant genetic resources will facilitate effective conservation and strengthen the link between conservation and use. As seen from our survey, on-farm management is a system that cannot be separated from utilization and farmers realize maintenance through continuos cultivation and use. What they need is support from the formal system in providing them with advice and inputs such as planting materials or clones of their interest. Currently the Institute of Biodiversity Conservation and Research lacks such facilities to fulfil the demand of enset growing farm households as well as the research community and these deserves special attention.

- *On women's access to market and credit facilities:* Particular attention should be paid to the needs of women farmers who are responsible for most of the production, processing and marketing of enset. The majority of the farm households are located at more than half a day walking distance from the nearest market place or any road (all-weather). As villages that reach the nearby markets are relatively small in number, the marketing of their products is low or difficult. For farmers to market their products, they have to carry their produces or use animals to get to the nearest market. This severely constrains the total production that can be marketed especially for women who are fully responsible for the sale of enset products. The market demand for enset products nowadays has increased including in metropolitan cities such as Addis Ababa. However, as most enset producers are living far from market places (e.g. enset farmers in the study area), it is currently not possible for them to benefit from the production and marketing of the crop.

  Next to logistic problems, lack of rural credit may be another constraint to improving the cash flow position of Ethiopia's rural farmers. In most of the cases, farmers, especially women, do not have access to credit services. According to our survey, none of the farmers in the study area have access to credit facilities. The credit delivery in the country in general is restricted to the urban areas. Surveys from the 1980's period, for instance, has indicated that only 1% of bank lending went to the small-scale farming sector which comprises 95% of the country's agricultural production (USAID, 1995). The existing credit facilities in the country, which mostly are confined in the urban areas, need to be improved and should reach the rural poor.

- *In areas of agricultural biotechnology*: Appropriate agricultural biotechnology can contribute to food security in developing countries provided that it focuses on the needs and priorities of the poor farmers and if based on problems identified in consultation with them. The application of tissue culture to address constraints such as the availability of adequate planting materials to farmers and rapid improvement in crop production is now common in several countries. As proven in this research, the demand for planting materials of various clones of enset is demonstrably high. Tissue culture in this regard may eventually lead to higher productivity and changes in household income. The use of DNA marker techniques can be applied to the characterization and improvement of enset, e.g. in enhancing disease resistance such as bacterial wilt and in improving crop quality where conventional approaches seem difficult.

- *On enset processing techniques*: Some research institutions during the last few years have attempted to develop an appropriate processing technology for enset. However, the technology has not been successful in reaching enset growers so far. It is still in the experimental phase and enset farm households are not yet benefiting. Moreover, rather than integrating efforts, the institutions involved in research of such devices are not collaborating which makes results difficult to achieve, at least in the short term. It may be wise to involve the private sector so that equipment can be produced which satisfies the farmers' demands. If need be, the institutions in charge can monitor the situation so that the needy will benefit. The existing traditional methods of enset processing are tedious, time consuming and may also have an impact on the quality of the product. It is true that enset remains to be the most important and dependable food crop of the people in the south and southwestern part of Ethiopia. In the long term, the cultivation of enset may also be adapted in other areas in the north or central part of the country, which exhibit an ecosystem appropriate for enset culture as long as recurrent drought and food insecurity remains a problem in the country. Research towards the production of appropriate and demand-oriented processing technology focussing on cost effectiveness is vital. It should be able to meet women's needs and preferences, as they are the ones who are the sole processors of the crop. This will definitely improve quality and marketability of the product. Furthermore, it will reduce the workload of women.

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SUMMARY

Agriculture in Ethiopia is characterized by diverse farming practices. Farmers with various ethnic background and cultural diversity living in the country's diverse agro-ecological zones have developed farming systems, characterized by a high degree of species diversity. The enset based farming system is one of these. It can be found in South-western part of the country. The research, on which this thesis is based, was carried out in the Kaffa Shaka zone among 240 households.

The domestication, production and use of enset is restricted to Ethiopia. Enset is a crop with multiple uses both for food and non-food applications. It is the most widely used staple food in the country, feeding millions of people. It plays a central role in the economic, social and cultural life of the diverse ethnic people in the south and south-western part of the country. Although it forms the core of the cropping system of many farmers, available information on the crop is limited, and largely descriptive and anecdotal.

The research, which is the subject of this thesis, was aimed at exploring issues of enset genetic diversity as related to use at a household level and its relevance for food security and sustainable livelihoods. It seeks to make an assessment of the diversity that exists in the crop and to identify of linkages between conservation and use based on the primary data on socio-economic and conservation issues collected at a household level. It attempts to test the following hypothesis: *by maintaining enset diversity, a subsistence farmer can secure food self-sufficiency and therefore a positive relationship exists between conserving the diversity in enset and household food and livelihood security*. The hypothesis constitutes the central theme of the study and the collection and analysis of the primary data converged upon it. While putting these issues in the wider context of the livelihood system of enset farmers, a number of research questions were raised and answered in the different chapters of the thesis.

The first research question dealt with whether enset diversity contributes to household food security and livelihoods of farm households. Our results confirmed that enset is a food security crop and also a status symbol in the study area. The ownership of a large number of enset plants and a diverse number of clones are major criteria for farmers in categorizing households

according to different wealth status. Over a third of the studied households were found food insecure with little or no land, relatively few enset plants and with insignificant clonal diversity. On the basis of the research findings, this thesis argues that although households are food secure as long as they have enough enset plants and sufficient clonal diversity, they are not necessarily secure in terms of income and livelihood. Hence, food secure households, as indicated by enset wealth, are not always livelihood secure. The ownership of other resources such as livestock and land for the production of other crops for additional income is vital for livelihood security.

The second research question focused on valuing of local knowledge, i.e. how farmers encourage diversity in enset, and how they select or classify clones for various use aspects. Enset farmers since the domestication of the crop allegedly some 10,000 years ago, have used their traditional knowledge to maintain and enrich the diversity in the crop. The diverse ways in which the crop is used for (food, fiber, animal feed, construction, etc.) are examples of the use of the diversity by local farmers. Identification and selection of the various clones are done by both men and women farmers. The criteria for selection by men and women vary slightly. Men usually select for higher yield, longer maturity and disease resistance, while the women select for early maturity, good taste and quality of the product and disease resistance. However, both men and women are keen on maintaining as much diversity as possible regardless of the preferred characteristics. They also classify clones into male and female ones according to their characteristics. The female plant is selected by the women for daily household consumption or for sale. The number of female plants maintained is also slightly higher than the male plants, which confirms the characterization of enset as women's crop. As a tradition, farmers in Kaffa also exchange clones and knowledge associated with the crop with neighbors, relatives or kin to increase the diversity in their backyard.

The role of gender in the production, processing and marketing of enset was the focus of the third question. Our study shows that there are clear gender differences in the management of enset genetic diversity. Women play a dominant role in the production, processing and marketing of enset. They have a tremendous knowledge of the diversity in the crop. There is a slight difference between men and women when prioritizing clones according to uses, which is indicative of the difference in interest for different qualities of the crop. When data on the division of labor were analyzed, women clearly dominate in the production, processing and marketing of enset. Men are involved in land preparation, planting and transplanting. As regards decision-making, women are less involved in major decisions made at the household although they dominate most of the production activities in enset. Women decide on the harvesting time and on the use of income from the sale of enset products. Decisions on the purchase of agricultural equipment, adoption of new cultivation techniques, income from the sale of other crops and livestock are made by the men. Other decisions, such as purchase of clothing and additional food for the household, are shared. In general, men have more decision-making power and also control over the greater portion of the household's income.

The fourth question dealt with the impact of population increase on the cultivation of enset. Our results show that there is a high rate of population growth in the study area. Due to the existence of high forest coverage in the region, farmers up until now are hardly affected by land shortage as compared to farmers in other areas, because they extend their farmland by clearing the nearby forests. The availability of cultivable land has encouraged polygamy and having many children. Thus, we found a positive association between household size and landholding in the area. However, this situation is unlikely to continue as resources are limited and there are more and more new households formed each year claiming land. In one of the two *woredas* studied, which is also characterized by having more polygamous households and where there is more forest degradation, farmers are complaining that there is shortage of land. This result shows that the area devoted to enset and other crops is declining, exposing farmers to food and livelihood insecurity. We also recorded that there is lack of awareness about family planning and limiting the number of children in each household. This thesis concludes that: (i). The increase in family members should coincide with land availability; (ii). Farmers should be aware of family planning in order to limit their family size; (iii). Polygamous marriage should gradually be avoided; (iv). Farmers should be aware of conserving forests instead of burning to extend their farmland.

Research question five dealt with the use of tissue culture techniques such as micro-propagation and *in vitro* conservation for enset growing farmers. The importance of enset to Kaffa farmers from a social, cultural and food security perspectives , has been stressed in earlier chapters of this thesis. However, there are many problems surrounding enset production and farmers have lost a fairly large number of clones because of disease, selection pressure or to changes in land use systems. Our results show that over 95 percent of the farmers demand planting stocks of various clones. They need a backup system, which can complement the traditional methods of propagation and conservation. In our study the use of tissue culture was thus found indispensable to meet those needs. *In vitro* conservation through slow growth and rapid propagation protocols for enset were successfully developed. This will allow the conservation and rapid propagation of enset for the production of disease free germplasm and for efficient breeding programs. It will also allow farmers to get sufficient planting materials of interest, which will enable them to produce more and increase their selection options. When materials are stored *in vitro*, farmers will have an insurance against man-made and natural erosion, which threatens their production.

The last research question dealt with how farmers' classification of clones correlates with results of a scientific method based on molecular marker techniques. Farmers' methods of classification and selection have formed the basis for collections maintained so far, be it in farmers' or researchers' fields. Most of the genetic diversity in the crop is maintained *in situ* (on-farm) by farmers. The farmers' characterization system is functional and serves to characterize and maintain clones in view of their various purposes (food, fiber, medicine, etc.). Characterization and use are thus closely related. As part of this theses, the correlation between the farmers' characterization system and a molecular genetic study were analyzed. A mildly positive correlation was obtained between the two classifications providing the necessary information for an efficient strategy for the management of enset diversity. More duplication of clones (given in Chapter 11) was observed in the molecular analysis. In most of the cases, the names given by farmers based on the attributable characters of the crops are consistent and matched the molecular analysis. Lack of complete matching of the two systems might be attributed to the way farmers characterize the crop in more detail and the use criteria they apply in selection of the various clones. As the farmers' characterization system is functional, they select for specific genetic traits, whereas molecular approach scored neutral diversity as well. This thesis thus emphasizes that indigenous knowledge plays a vital role in selection, characterization and maintenance of enset genetic diversity in direct relation to its use.

SAMENVATTING

Ethiopië kent een grote variëteit aan landbouwpraktijken. Er is rijkdom aan biodiversiteit, gekoppeld aan culturele diversiteit. De verschillende etnische groepen in de verschillende ecologische zones bewaren en ontwikkelen deze biodiversiteit in hun *farming systems*. Een van deze *farming systems* wordt gekenmerkt door de teelt van het voedselgewas *enset*, een plant die er uitziet als een bananenplant maar dat niet is. Van deze plant wordt het binnenste van de 'stam' genomen en verwerkt tot brooddeeg. Hoewel *enset* alleen in Ethiopië als voedselgewas wordt geteeld, maar daar aan miljoenen mensen voedsel verschaft, is de kennis over het gewas slechts beschrijvend en weinig systematisch van aard. *Enset* als voedselgewas is met name te vinden in het zuidwestelijke deel van Ethiopië. Het onderzoek waar dit proefschrift op gebaseerd is, werd uitgevoerd in de Kaffa streek, in Zuidwest Ethiopië.

Het onderzoek dat het onderwerp vormt van dit proefschrift richtte zich op het relateren van de genetische diversiteit van *enset* aan het huishoudelijke gebruik van de plant en aan de rol ervan in het creëren van voedselzekerheid en bestaanszekerheid. De centrale hypothese van het onderzoek was de veronderstelling van een positieve relatie tussen *enset* biodiversiteit enerzijds en huishoudvoedsel- en bestaanszekerheid anderzijds. Op basis van deze hypothese werden een aantal onderzoeksvragen geformuleerd die empirisch werden onderzocht in een onderzoek onder 240 huishoudens in twee *woreda's* (sub-districten) in Kaffa.

De eerste onderzoeksvraag betrof de bijdrage van *enset* aan huishoudvoedsel- en bestaanszekerheid. Het onderzoek bevestigde dat *enset* niet alleen als status symbool fungeert, maar ook een cruciale rol vervult in de voedselzekerheid van de rurale huishoudens in het gebied. Het aantal planten dat men heeft en de genetische diversiteit daarbinnen zijn criteria voor welstand, zowel in de ogen van de boeren zelf (subjectief) als gezien de correlatie met andere indicatoren van welstand (objectief). Ongeveer een derde van de onderzochte huishoudens beschikt over te weinig land en te weinig *enset* planten en genetische diversiteit in de planten om voedselzekerheid te bieden. Huishoudens die, gemeten naar *enset* rijkdom, wel voedselzekerheid kennen, kunnen echter toch gebrek aan bestaanszekerheid hebben, omdat ze over te weinig hulpbronnen beschikken om inkomen te genereren. Voor bestaanszekerheid zijn bezit van land, vee, en alternatieve bronnen van inkomsten van belang. Slechts 18 procent van de onderzochte huishoudens scoort hoog op de laatst genoemde indicatoren en leeft in relatieve welstand.

De tweede onderzoeksvraag betrof de waarde van de inheemse kennis over *enset*. Sinds de domesticatie van *enset* (waarvan wordt aangenomen dat die al vele duizenden jaren geleden is begonnen) hebben de boeren de genetische diversiteit van *enset* bewaard en verrijkt. Het selecteren en propageren van klonen gebeurt op basis van de gebruikswaarde van de verschillende variëteiten. *Enset* wordt namelijk niet alleen als voedselgewas gebruikt, maar ook voor medicinale doeleinden, verpakkingsmateriaal, touw, e.d. In de selectie van klonen met bepaalde kenmerken bleken mannen en vrouwen verschillende voorkeuren te hebben. Mannen selecteren vooral op hoge opbrengst, langere periode van wasdom en resistentie tegen ziekten, vrouwen vooral op kenmerken die belangrijk zijn voor de verwerking van *enset* tot voedsel, namelijk smaak, kwaliteit van het deeg en ook weerstand tegen ziekten. De inheemse classificatie van variëteiten in mannelijke en vrouwelijke planten is gebaseerd op respectievelijk door mannen en door vrouwen geprefereerde kenmerken. De 'vrouwelijke' variëteiten zijn in het algemeen iets talrijker dan de 'mannelijke' variëteiten. In het algemeen wordt er echter naar gestreefd om een zekere balans en voldoende variëteit in de eigen collectie te hebben.

In de derde onderzoeksvraag werd meer specifiek gekeken naar de betekenis van *gender* in de teelt en het gebruik van *enset*. Het onderzoek wees uit dat mannen en vrouwen hierin verschillende rollen vervullen. Vrouwen zijn dominant in de productie, de verwerking en het vermarkten van *enset*, mannen in het prepareren van de grond, het planten en verplanten. Als het gaat om besluitvorming kunnen vrouwen alleen zelf besluiten nemen over het tijdstip van oogsten van planten en over het inkomen uit de verkoop van planten. Mannen domineren de besluitvorming in andere zaken, zoals besteding van de inkomsten uit de verkoop van andere gewassen en van vee en aanschaf van werktuigen.

In de vierde onderzoeksvraag werden demografische ontwikkelingen aan de teelt van *enset* gerelateerd. Uit het onderzoek bleek dat de bevolking in het gebied snel groeit. Ook bleek een significant positief verband tussen huishoudgrootte en grootte van landbezit. In het algemeen worden boeren nog nauwelijks geconfronteerd met landschaarste omdat er nog veel bos in het gebied is dat ontgonnen kan worden. Het is opvallend dat er in de *woreda* waar land relatief schaarser is minder polygame huishoudens werden gevonden en de huishoudgrootte ook gemiddeld lager was dan in de andere *woreda*. In het algemeen is men niet op de hoogte van moderne methoden voor geboortebeperking en ziet men kinderen als arbeidskracht in het boerenbedrijf. Zo lang er nog land ontgonnen kan worden wil men graag grote gezinnen om zo veel mogelijk arbeid te kunnen inzetten. Hierbij realiseert men zich onvoldoende dat de hoeveelheid te ontginnen land eindig is, hoewel dit besef in één van de twee *woreda's* van onderzoek door begint te dringen. Daarnaast is men zich niet bewust van de ecologische consequenties van het plat branden van het bos.

De kwestie van het belang van het gebruik van weefselcultuur technieken, zoals micro-vermeerdering en *in vitro* conservering, voor *enset* telers, was het onderwerp van de vijfde onderzoeksvraag. *Enset* telers in Kaffa hebben genetische diversiteit verloren als gevolg van ziekte, selectiedruk en veranderingen in landgebruik. In het onderzoek bleek er bij meer dan 95 procent van de boeren vraag te zijn naar plantmateriaal van diverse klonen. De boeren hebben behoefte aan een back-up systeem en het gebruik van weefselcultuur is hierbij een belangrijk hulpmiddel. In het kader van het onderzoek werden protocollen ontwikkeld voor snelle vermeerdering en lange termijn koude opslag van *enset*. Hiermee kan uitgangsmateriaal beschikbaar worden gemaakt dat vrij is van ziekten, op basis waarvan tevens een efficiënt veredelingsprogramma kan worden opgezet. Als deze materialen *in vitro* bewaard kunnen worden, hebben boeren een verzekering tegen de productie bedreigende erosie van de genetische diversiteit van *enset*.

De laatste onderzoeksvraag betrof de relatie tussen de inheemse classificatie van enset klonen en de wetenschappelijke classificatie op basis van een analyse met behulp van moleculaire merkers. De classificatie door boeren is tot nu toe gebruikt voor de inrichting van collecties, zowel in het veld bij de boer als door onderzoekers. Een groot deel van de genetische diversiteit in *enset* wordt *in situ* (on-farm) in stand gehouden. De karakterisering van boeren is functioneel en dient een indeling van klonen in het licht van de verschillende gebruiksdoelen (voedsel, vezels, medische toepassingen, e.d.). Met andere woorden, karakterisering en gebruiksdoelen zijn nauw verweven. Als onderdeel van dit promotie-onderzoek is de correlatie tussen de classificatie door boeren en die op basis van een moleculair-genetische studie geanalyseerd. Een beperkte positieve correlatie tussen de twee classificaties werd waargenomen en deze heeft de noodzakelijke informatie verschaft voor het behoud van *enset* diversiteit. Duplicatie van klonen werd vaker waargenomen met behulp van moleculaire analyse. In de meeste gevallen bleken de namen die door boeren werden gegeven op basis van door hen waargenomen eigenschappen te leiden tot een indeling die overeenstemde met die van de moleculaire analyse. Het ontbreken van een volledige overeenstemming kan worden verklaard uit het feit dat boeren de klonen meer in detail indelen, daarbij kijkend naar de gebruikswaarde van de klonen. Boeren concentreren zich sterk op bepaalde eigenschappen, terwijl een moleculaire benadering neutrale DNA sequentie verschillen registreert.

Dit promotie-onderzoek benadrukt de rol die inheemse kennis speelt bij selectie, karakterisering en behoud van *enset* in directe samenhang met het gebruik van het gewas. In het onderzoek komen tevens de verschillen tussen mannen en vrouwen in de teelt en het gebruik van *enset* alsmede in de kennis over *enset* duidelijk naar voren.

ACRONYMS

BOPD	Bureau of Planning and Economic Development
CBD	Convention on Biological Diversity
CGIAR	Consultative Group for International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CIMMYT	Centro Internacional de maize y Trigo
CSA	Central Statistical Authority
ECA	Economic Commission for Africa
GEF	Global Environmental Facility
EUCARPIA	European Society for Research and Plant Breeding
FAO	Food and Agricultural Organization
IARC	International Agricultural Research Centers
IBCR	Institute for Biodiversity Conservation and Research
IBPGR	International Board for Plant Genetic Resources
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
IPGRI	International Plant Genetic Resource Institute
IRRI	International Rice Research Institute
K.S	Kaffa Shaka
NGO	Non Governmental Organization
PGRC/E	Plant Genetic Resources Center/Ethiopia
PGRFA	Plant Genetic Resources for Food and Agriculture
SNNPR	Southern Nation, Nationalities and Peoples Regional Government
SUPAK	Sustainable Poverty Alleviation for Kaffa Shaka
UNDP	United Nations Development Program

APPENDIX

Survey of Enset farming households in South-Western Ethiopia:-Kaffa-Shaka zone

Name of Interviewer	
Date of Interview	
Location	
HH members	
Name of HH head	
District	
Peasant association	
Village	
Time/duration of interview	from.......... to ....
Checked and approved	name............................ signature............... date............

Questions to be completed by household heads

Identification data

1. Name of respondent (if different from the HH head)
   1=head
   2=wife
   3=son
2. Language of interview
   1=amharic
   2=oromigna
   3=keffigna
3. To what ethnic group do you belong ?
   1=amhara
   2=oromo
   3=kaffa
   4=sheko
   5=bench
4. Religion of the household
   1=orthodox Christian
   2=catholic
   3=protestant
   4=moslim
   5=no religion
5. Did the head of the household has more than one wife ?
   1=yes
   2=no

6. if the answer to question no. 5 is yes, did the other wife live in the same peasant association or in different places. Give details.

Demographic characteristics;

7.1. Household composition (wife 1 to...)

No (1)	Name (2)	relation to HH head (3)	age (4)	sex (5)	marital status (6)	residen tno/yes (7)	occup ation (8)	educa tion (9)
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								
10.								

Definition of codes

relation to household head (03)

01=wife/husband
02=son
03=daughter
04=grand son
05=grand daughter
06=brother
07=sister
08=brother- in -law
09=sister- in -law
10=son in law
11=daughter in law
12=father
13=mother
14=niece/nephew
15=cousin
16=step father/mother
17=step mother
18=adopted child
19=hired farmer
20=others specify

Sex (05) 1=male
2=female

Marital status (06)

1=single
2=married
3=divorced
4=separated
5=widowed
6=others specify

8. During the past year, has any member of the household migrated?

1=yes
2=no

9. If yes to question 8 answer the following

No.	name	duration of stay	reason for migration	place of migration	remittances	
					in cash	in kind

10. Does it happen regularly, how often is it taking place? (e.g. once in a year, twice, etc.)

11. Was the income earned during migration spent in the household?
    1=yes (if yes, go to question 12)
    2=no
12. If yes to question 11 for what purpose was the money used? and who decides on the money earned during migration ?

13. Is there anybody who is not in the household now but is regarded as a member?
    (give name/number, relation to HH head and reasons for being away)

Household resources

14. **Land resources** (both owned and rented land)

Type of land	status(owned, rented/contract	size of land (in sq. m)	distance from res.	Crops planted
Residential and enset field				
Other crops				
Grazing				
Others				

15. Do you feel that there is shortage of land in your area?
    1=yes
    2=no

16. If yes to question 15, what do you think are the reasons?

Livestock resources

17. Do you own livestock?
    1=yes
    2=no
18. If yes to question 17 answer the following

no.	type	quantity	purpose (use)
1	ox		
2	cow		
3	sheep		
4	goat		
5	chicken		
6	hores/mule		

19. Do you use manure? and if yes, does that increase the yield of your enset plots?
    1=yes
    2=no

20. For which crops do you use organic manure? If not why?

Other assets

21. Type of the house of the household;
    - 1=tin roof with mud plaster
    - 2=tukul (grass) and mud plaster
    - 3=tukul plastered with cow dung
    - 4=tukul with wooden wall only
    - 5=1 and 2
    - 6=1 and 3
    - 7=1,2 and 3

22. Availability and type of appliances in the household (eg. radio, chairs, tables, etc.)

23. Availability and type of farm implements (list the type of equipment and quantity)

no.	type of implement	quantity

24. Type of storage facilities (describe the kind of storage for all crops you grow)
    - 1=gotera
    - 2=pit
    - 3=pile
    - 4=1 and 3

Labour input

25. How is the work in the production of enset divided between men and women?
    - 1=men do the major work
    - 2=women do the major work
    - 3=both participate equally
    - 4=each have specific task
    - 5=other specify

26. Which of the following farm operations are performed either by men or women (say M or F) and indicate in every operation in case where both men and women participate.

    - 1=land preparation
    - 2=selection of clones/varieties
    - 3=planting
    - 4=weeding/cultivation
    - 5=harvesting
    - 6=processing

No.	M-F 50:50	M most	F most
1.			
2.			
3.			
4.			
5.			
6.			

27. Who fetches water from its source for the household uses?
    - 1=the man
    - 2=the woman
    - 3=the children
    - 4=all members
    - 5=2 and 3

6=1 and 3

28. Who fetches fuel wood for the household?
    1=the husband
    2=the wife
    3=daughters
    4=sons
    5=2 and 3
    6=1 and 4
    7=2, 3 and 4
29. Who does the care for children?
    1=mother/wife
    2=father/husband
    3=both
    4=younger daughters
    5=younger sons
    6=1 and 4
    7=2 and 5
    8=1,4 and 5
30. Who does the cooking in the household?
    1=usually the women
    2=usually the men
    3=usually the daughters
    4=usually sons
    5=1 and 3

Access to and control over resources

31. Does a woman in this area has access to land either through inheritance or land distribution
    1=yes
    2=no
32. If the answer is to question 31 is yes state by which means
    1=inheritance
    2=through land distribution
33. If no to question 31, what is the possible reason?

34. Who decides on income from sale of enset ?
    1=husband
    2=wife
    3=both
35. Who decides on the income from sale of other crops?
    1=husband
    2=wife
    3=both
36. Who decides on the income obtained from sale of livestock?
    1=husband
    2=wife
    3=both

Food consumption

37. How many enset plants do you need to sustain the household for a year?

38. Do you use enset as a major food or do you substitute other food crops?
    1=yes as a main food
    2=as a supplementary food
39. List the other food crops, which you eat together with enset

40. Forms of enset product used as food
    1=bulla
    2=kocho
    3=amicho
    4=all

5=2 and 3
6=1,2 and 3

41. How many meals per day do you usually have?
    1=once in a day
    2=twice a day
    3=three times a day
    4=other specify
42. Do you always eat like this, or do you eat more or less in other season /other days?
    1=yes, I always eat same type of food
    2=no, it depends on the season

43. Explain the situation, why you eat same type or different foods?

44. List the types of food you ate yesterday
    breakfast ....
    lunch ....
    dinner ....
    others (if there is morning or afternoon snack);

45. Do you include livestock products (meat, milk, cheese, etc.) with enset in your daily diet ? if so list the type of products you get

46. Do you drink milk everyday?

    1= never
    2=sometimes
    3=often

HH head	children	men	women

47. Do you eat meat every day?
    1=never
    2=sometimes
    3=often

HH head	children	men	women

48. Does the household have enough food to eat throughout the year?
    1=yes
    2=no
49. If no to question 48, what is the main reason for not having enough food in the household?
    1=no enough land
    2=no enough clones of enset
    3=not able to purchase additional food
    4=not able to plough the land
50. Do all members of the household eat from the same dish?
    1=yes
    2=no
51. Does each member of the household get same portion of food? (Is food shared equally among the household members)?
    1=yes
    2=no
52. If no to question 50, who is given more than others
    1=the husband (head)
    2=the wife
    3=children
    4=elderly
    5=the sick
    6=other specify
53. What is the reason for not letting equal portion of food for each member?

54. Do all household members share food from the same kitchen? (if members cook in separate kitchen)
1=yes
2=no
55. If no to question 54, explain the situation

56. Do you exchange foods with neighbors or other relatives?
1=yes
2=no
57. If your answer to question 56 is yes, what are the terms of exchange?

58. Do you feel that you always have the food you need so that you are able to work and feel healthy?
1=yes
2=no
59. If your answer to question 58 is no, when was that situation or season?

60. Who decides on the additional food items to be purchased for the use by the household?
1=husband
2=wife
3=both
61. Have you ever been faced with seasonal food shortages when the members of your household were not able to eat enough?
1=yes
2=no
62. If yes to question 61, what was the reason and how do you overcome it?

Storage and marketing

63. What are the different storage facilities you use for storing enset products?
1=leaf lined pit
2=cemented pit with cow dung
64. Does storage (short term or long term) have an effect on the quality of enset food?
1=yes
2=no
65. If your answer to question 64 is yes, how does your stored enset gets affected?

66. Do you have any problem in the processing of enset products after harvest?
1=yes
2=no
67. If the answer to question 66 is yes, what are the major problems?
1=it is tedious
2=the processing technique is backward
3=no enough manpower
4=1 and 3
5=all are answers
68. How do you think it will be solved?
1=look for additional labor
2=need improved processing technique
3=1 and 2
4=have no idea
69. Where do you sell your products?

Crop type	market place	distance from the house

70. Do you bring more or less halve of the products you consume to the market, or less or more?
1=about equal
2=more for consumption
3=more to the market
4=all for consumption
71. What are the sources of the household income as a whole?
1=crop sale
2=sale of livestock
3=both
4=sale of coffee and spices
5=non farm activities (sale of mats, local beer and malt, weaving)
6=working for others
7=get pension/assistance from others
72. Which members of the household contribute to the income of the household? (specify name and position in the HH)
1=husband/head
2=wife
3=both
4=son/daughter
5=all
73. What is the total amount of money you spent to buy basic household needs during the last week?

74. Who takes enset products to the market for selling?
1=husband
2=wife
3=both
4=children
75. Do you usually keep reserve food (crops, enset products) in cases of emergencies? and if so explain the situation
1=yes, we do keep
2=no we don't
76. What are the different uses of enset other than food?

77. Has any member of the household felt ill during the last month?
1=yes
2=no
78. If the answer to question 77 is yes, how did he/she get treated?

79. Was there enough money to be paid for medication (if the person who is ill has been taken to clinics) ?
1=yes
2=no
if no to question 79,

80. Where do you get the money?
1= sell assets (goods)
2=borrow from neighbors
3=others specify
81. Are any of the household members chronically ill?
1=yes
2=no
82. Which of your children in the family are going to school? (give names)

83. Are there any children who are of school age but do not go to school?
1=yes
2=no
84. If the answer is yes, what is the reason for not going to school?

85. Who decides on the purchase of clothing for members and paying for medication?
1=husband

2=wife
3=both

Cropping system

86. How long is it since you started cropping of enset

87. Is the yield (harvest) from enset enough for own consumption?
    1=yes
    2=No
88. If yes to code 87, do you sale some of the surplus products to the market?
    1=yes
    2=no
89. How much money do you earn from the sale of enset? (per month, per year, etc.)

90. How do you fulfill your household requirements if you don't sell your enset products?
    1= grow other food crops
    2= grow cash crops such as coffee and spices
    3=buy additional foods
    4=sell domestic animals and their products
91. What other crops do you produce other than enset and for what purpose? (for this question, answer the following)

crop	area under cultivation	production (qt/ha)	intercropping	consumption (amount consumed)	sell (amount sold) (in qt. or kg.) price
1.					
2.					
3.					
4.					
5.					
6.					

92. In your opinion, do you think that the production of enset is increasing or declining?
    1= increasing
    2= decreasing
    3= no change
93. If your answer to question 92 is 1 i.e. increasing,
    What do you think of the possible reasons?

94. If the answer is 2 i.e. declining,
    What is the possible reason for decline in production?

95. How many clones of enset do you grow in your farm (backyard) and name the different clones?

no.	Local name	no.	local name	no.	local name	no.
1		10		19		28
2		11		20		29
3		12		21		30
4		13		22		31
5		14		23		32
6		15		24		33
7		16		25		34
8		17		26		35
9		18		27		36

96. What is the total number of your enset plants? (interviewers may have to verify figures)

97. What is your selection criterion of clones?
1=high yield
2=tolerance to drought
3=disease resistance
4=taste/quality
5=early maturity
6=1 and 3
7=all

98. Which type of clones do you prefer most and want to preserve/conserve?

99. What are the major production problems you encounter? (more than one answer is possible)
1=disease
2=drought
3=premature harvest due to food insecurity
4=wild animals
5=1 and 4
6=1, 2 and 4
7=1 and 3
8=all

100. How do you overcome the problem in question 99?

Ethnobotanical data

101. When do you plant your enset clones (cycles of enset plantation)
1=at each planting season
2=alternatly planted
3=have specific season

4=other specify

102. Types of planting material (preference)
1=seed
2=sucker
3=other specify

103. What is the reason for not using seed as a planting material?
1=difficult to germinate
2=difficult to get seeds
3=we are not used to the use of seeds
4=traditionally not accepted
5=we don't wait until the plant fruits

104. Do you have (face) problem in producing enough planting material every season?
1=yes
2=no

105. If yes to question 104, what is your main reason and how do you think it will be solved?

106. Do you traditionally exchange planting material (seeds, suckers, etc.,) with neighbors or relatives?
1=yes
2=no

107. If yes to question 106, who do you exchange with and explain the processes
1=with neighbors only
2=with relatives or kin
3=with both
4=with anybody

108. Name the different stages of transplanting and how frequently you perform it

stages...... local name

1.
2.
3.
4.
5.

109. What is the average life span of your enset plant?

110. Do you require additional input such as pesticides, fertilizers and if so how do you overcome it ?

111. Do you use intercropping for the following reasons?

1=to increase yield
2=economical (to minimize risk through diversification)
3=to save space
4=for shade
5=to increase soil fertility
6=all are answers

112. Do you recall of some clones that you use to grow but not any more?
if so list all clones that you lost

113. Do you think that the introduction of new and improved varieties of other crops has replaced the production of enset (in % of farmers)

1=yes
2=no

114. If the answer to question 115 is yes, do you replace your dietary habit to the use of other crops?

1=yes
2=no

115. What is the response of enset plant to shortage of rainfall as compared to other crops?

1=higher tolerance
2=medium
3=low tolerance

116. What is the optimum time/season of harvesting enset?

1=during dry season
2=during rainy season
3=at any time of the year

117. What is the optimum stage of harvesting enset for food? and why?

1=before flowering, because...................
2=after flowering , because.....................
3=at both stages

118. Yield of enset clones

1=poor in general
2=intermediate
3=good/enough

119. which of the clones are said to have medicinal value both for humans and animals ?

type of clone	medicinal use

120. Who decides on what type of clone to plant and when to plant?
1=the man/husband
2=the wife
3=both decide
121. Who is deciding the harvesting time i.e. when to harvest, which clone to harvest first and at what stage of the plant?
1=husband
2=wife
3=both decide
122. Who decides on the adoption of new cultivation techniques, change of cropping patterns, etc.?
1=husband
2=wife
3=both
123. Who decides on the purchase of agricultural equipment?
1=husband
2=wife
3=both
124. Have you ever been faced with total crop failure?
1=yes
2=no
125. If yes to question 124, how did you cope with the situation? What did you do ?

126. Did/do you take measures to prevent crop failure in the future ? if so what are the measures?
1=maintain as much diversity as I can
2=keep reserve from other crops
3=both
4=reserve domestic animals for sale
5=1 and 4
6=2 and 4
7=3 and 4
8=1,2 and 4
9=I have no idea

CURRICULUM VITAE

Almaz Negash was born on 07 November 1961 in Arbagaugu, Ethiopia. She joined the Alemaya Agricultural University in Ethiopia between the years 1983-1986 where she obtained a BSc degree in the field of plant science. After graduation, she joined the Plant Genetic Resource Center/Ethiopia (now the Institute of Biodiversity Conservation and Research) and worked for three years as a research officer.

In 1989, she got a fellowship from the International Plant Genetic Resources Institute and got her masters degree from Birmingham University in the UK in Conservation and Utilization of Plant Genetic Resources in 1990. She worked for the same institute and joined Wageningen University and Research Centre in 1997 for her PhD research on a fellowship from the Global Environmental Fund. Almaz is married and a mother of two.