Tadesse Kippie Kanshie

Five Thousand Years of Sustainablity?

A Case study on Gedeo Land Use (Southern Ethiopia)

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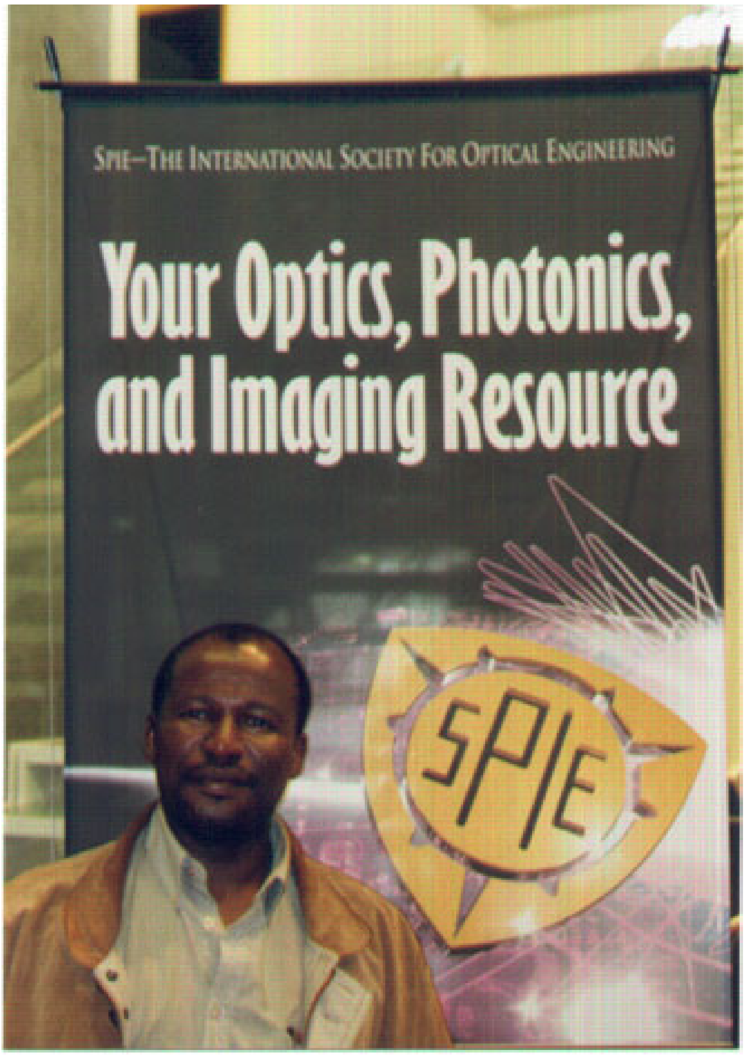

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About the cover: *A view of midland Gedeo "agroforest".*

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To Degefech Murtti Obese

With Love

Preface

The idea for the present work was initiated in 1993, in the period between February and April, when I was following the MSc course Forest Ecology, delivered by Professor R.A.A. Oldeman, of the Department of Forestry, Wageningen Agricultural University. While following the course, I was pondering upon a would-be subject and almost too late when I came up with the idea of studying the age-old “agroforestry” system of the Gedeo. My supervisor, Ir. van Baren, specializing in Forest Protection, thought that the topic was not her field of expertise and recommended me to Professor R.A.A. Oldeman, who at the time was heading the Silviculture and Forest Ecology Lab.

I phoned the professor and made an appointment for a week ahead. But I missed the appointment, for I made a mistake, reckoning time as we used to in Ethiopia. I had to take another appointment for a week ahead, at 3 in the afternoon. There I was in time to present my 30 pages proposal. The professor told me that he had no time to read those pages and suggested to reduce it to one A4 page, within a week’s time. I was sparkled by the incident and went to my lodging with a heavy load of thought. For a few days, I put aside the whole idea. Soon I began to work again. It took me two full weeks, including the week-ends, to bring the pages down to three. The latter in turn required a whole morning's work on the day of my appointment to become the required one A4 page. The professor began working through the page, his blue pen on hand. On coming to an end, he sighed a bit and looking into my eyes told me that from that moment onwards I was one of his students, who, he said, worked mostly by themselves. The skeleton of the material in the A4 page, being subsequently fleshed, formed the basis of what was reported in my M.Sc. Thesis and also of the present book.

Tadesse Kippie Kanshie

Acknowledgement

Many persons and institutions have supported the present study. I would like to express my sincere appreciation first to Prof. Dr. Ir. R.A.A. Oldeman, who wide - opened my intellectual eyes to the complex world of forest ecology. Prof. R.A.A. Oldeman is my intellectual father. Prof. R.A.A. Oldeman guided the present study from its initiation to its completion. Finding a sponsor for the fieldwork proved very formidable. However, financiers were found through the efforts of Prof. R.A.A. Oldeman.

I would like to convey my gratitude to Prof. Dr. Ir. E.A. Goewie, my second promoter, who also worked very hard in finding financiers for the fieldwork. His comments on the manuscript and discussions conducted with him greatly improved the quality of the work discussed here.

I am also grateful to Dr. Ir. P. Romeijn, my co-promoter. He made the satellite mapping program happen and arranged the associated training program. His comments on the manuscript improved the work reported here. My thank also goes to Dr. Demil Teketay, Director of the Forestry Research, Ethiopian Agricultural Research Organization (EARO), for his support during the fieldwork and his constructive comments.

My special thanks also go to the Fred Foundation, to the '*Stichting Thurkow Fonds*' and The Agricultural Bureau for the Gedeo Zone (Ethiopia), for their financial assistance at different stages of the fieldwork. The Agricultural Bureau for the Gedeo Zone also provided technical support, by availing its human resources to the conduct of the present study. The Privateers are cordially acknowledged for their major support in making a map of the Gedeo Zone from Radar Satellite images. Finally, Wageningen University awarded me a sandwich fellowship, and both the Indonesian-Dutch project Hutan-Lestari International and the Chair of Social Aspects of Biological Agriculture provided important means, which made this dissertation possible. My thank goes to them. All these were possible through the organization of my promoters, Prof. R.A.A. Oldeman and Prof. E.A. Goewie.

I am also thankful to the following families in The Netherlands: The family of Prof. R.A.A. Oldeman, the family of Prof. Dr. Ir. E.A. Goewie, the family of Dr. Ir. Paul Romeijn and the family of Dr. Ir. Iwan Supit, for their support in the present study, in one way or another. I am grateful to the family of Dr. Edmond Nezry and the family of Dr. Francis Yakam for their support during my stay with the Privateers N.V. in Toulouse (France), studying how to use the map of the Gedeo zone and later in the SPIE Conference. I am grateful to Mr. E.A.P. de Bruijn, for making the illustrations ready for the press, to Marthy Boudewijn for her administrative support, and to the Wageningen Ethiopian Protestant Church group, for their moral support and sharing the Truth of the Lord with me.

The following organizations in Ethiopia rendered support at different stages of this study: the Administrative Council for the Gedeo zone (Dilla), the Administrative Council for the Southern Nations, Nationalities and Peoples' Region (Awassa), the Agricultural Bureau for the Southern Nations, Nationalities and Peoples' Region (Awassa), the Ethiopian Agricultural Research Organization (EARO, Addis Ababa), the sectorial departments of the Gedeo zone(Dilla), particularly, the Department for Economic Planning and Development, the Department for the Development of Mines and Energy, the Department for the Development of cooperatives, the Department for the Development of Trade and Transport, the Department for the Development of Works and Towns, the Department for Culture and Information, the Municipality for the Dilla town, the South Synod of the Ethiopian Evangelical Church Mekaneyesus (Dilla). My thank goes to all of them.

I am grateful to Gedeo farmers for sharing their experience with me and for their support in the fieldwork. My thanks also go to the members of the field group, particularly, Mr. Dawit Moges/Kiphee/, Mr. Girmma Goochcha, Mr. Kabbadaa Shunxxuu, Mr. Kiflee Birhaanee, Mr. Kabbada Gammadee, Mr. Mokkonnen Roobaa, Mr. Samuel Dhaqqaboo and Mr. Anddualem Shiifarraw. Their hard work in gathering data is highly appreciated.

Many persons in the Gedeo zone rendered support during the fieldwork. I plead for their understanding that this is no place to list all of them by name. My particular thanks go to my former teachers and advisors, Mr. Alamuu Baalli, Mr. Berhanuu Horddofa and Mr. Shibbiruu Sirrii. I am grateful to Mr. Yohannes Gebeyehu, Head of the Administrative Council for the Gedeo zone, for his support to me and to my family. I am also grateful to Rev. Alamu Shetta, Director of the Evangelical Department, Ethiopian Mekane Yesus Church and President of the South Synod and his wife Mrs. Amarech Batti, and their family for the relentless support particularly during my stay in Addis Ababa. I am grateful to Mr. Worku Goollee, president of the Kale-Hiywot Church (Dilla) and his family for their advice and support. I am also grateful to Mr. Gamachu Bariso, Mr. Kefalew Roba and Mr. Bekele Mengesha, for their personal advice and intellectual support. Mr. Birruu Badhaaso and his family, Mr. Birru Hanffatoo and his family for their support to my family while I was in the course of the present study. I am also thankful to Mr. Degemu Koree and his wife Mrs. Worknesh, Assir Aleqa Wondwosen and his family, Mr Haile Boraa, Mr. Baallii Mokke and his family, Mr. Shibrru Birre and his family, Mrs. Dasta Dukkee and her family, Mr. Abarra Kiphee and his family, Mr. Alamu Jarjarssa and his wife Mrs. Aster, Mr.Woldemariam Ararsso and his family, Mr. Sileshii Kooree and his family, Mr. Iyasuu Waaqoo, Mr. Gammadee Baallii and his family, Mr. Horddofa Dayyaaso and his family, Mr. Hirbbe Kudhaa and his family, Mr. Elelluu Buudhaa, Mr. Mammoo Juá, Mr. Jaalaa Barrichcha, Mr. Mokkonna Shardde, Mr. Hirbbe Abbayyi, Mr. Dhaqqaboo Shotaa, Mr. Ulataa Tobee, Mr. Dassallagnii Doggoma, Mr. Maammiruu Mnaggashsha, Mr. Gaddo Mangasha, Mr. Alamuu Shammanna, Mr. Taaddasaa Barisoo, Mr. Ayyalaa Dagguu and Mr. Baalchchaa Boree for their support during the fieldwork. I am grateful to auto-mechanics Mr. Alamu Dayaso, Mr. Motor Mokonnen, Mr. Keffalew Xeeko, Mr. Asseffa Baatii, Mr. Ayalew Dayaso and Mr. Binyaam Dayaso, for their assistance with transport in the course of the fieldwork.

I am grateful to my father, Mr. Kippie Kanshie, now in his seventies, and my mother Mrs. Badhaatuu, now in her sixties, who, being illiterate themselves, encouraged my schooling but who are also worried a lot, as my extended schooling coincided with their old age. I am also grateful to my in-laws, Mr. Mokke Obsse, Mr. Qaanqqee Obese, Mr. Moges/Kiphee/ Jiloo, Mrs. Muluu Xeeko, Mr. Hayilemaarmi Goobana, Mr. Janbbaree Dheekko, Mrs. Aster Worku, Mr. Alamayoo Zallaqa, Mr. Bekele Makuraa and Mr. Kiflee Qaanqqee, for looking after my family, while I was out in the study. I am grateful to my brothers Mr. Raabo Kippie and Mr. Maaruu Kippie for their assistance in the fieldwork.

The time I worked on this thesis, from September, 1998 till September 2001, unfortunately coincides with the time I have suffered painful losses in life. I lost my aunt (father side) and uncle (mother side) to death. In neither of the burial ceremonies I could participate. My father got a stroke twice and when I was out in the field for this study.

I am grateful to my children, to whom I have done injustice, many of whom suffered my absence without knowing why.

I am grateful to Degefech, my wife, who shouldered the responsibility of our family and extended family, which, as a first-born, I had to shoulder. Degefech took care of my daily life. She also participated in the fieldwork, assisting me with *ensete* research. Her contribution was all the more important, because, *ensete* among the Gedeo is a woman's crop, from the knowledge of which men are barred. If it were not for Degefech's assistance, I could not have started this study, in the first place. And once started, I could not have completed it.

To Degefech Murtti Obese, my wife, whom I found true to her parents' intention, in naming her *Degefech*, literally meaning be a pillar, I dedicate this book.

Tadesse Kippie Kanshie

May, 2002
Wageningen

Table of Contents

Chapter 1. General Introduction: Ecology and History

1.1.The agricultural environment

Ethiopia is located in the Horn of Africa, between 3.24 and 14.53 degrees North and 32.42 and 48.12 degrees East (Woldemariam, 1972; Wolde-Aregay & Holdinge, 1996; Eth. Mapping Authority, 1988; Mersha, 2000). Topographically it ranges from below sea level (at Dalol) to above 4000m above (at Ras Dashen). Climatologic diversity also is great, ranging from tropical deserts to tropical rainforests and tropical montane vegetation (Woldemariam, 1972; Ethiopian Mapping Authority, 1988; Mersha, 2000). More than 80 different languages are spoken (Dillebo, 1985). It has a population of 65.3 million, growing at 3% per annum, more than 86% of which is engaged in agriculture (Central Statistical Authority, 1996b). It is currently subdivided into eleven regional states (Table1.1).

Table 1.1. Distribution of the total Ethiopian population (65.3 million) by regions

No.	Region	Capital	Total population %	Annual growth rate (%)
1	Tigray	Mekele	5.8	2.8
2	Afar	Aysaita	1.9	2.4
3	Amhara	Bahir Dar	25.7	2.9
4	Oromiya	Nazreth	35.5	3.1
5	Gambella	Gambella	0.3	2.6
6	Benishangul[1]	Assosa	0.9	2.6
7	Somalia	Jijiga	5.8	2.6
8	SNNP[2]	Awassa	19.7	3.3
9	Harari	Harar	0.3	3.5
10	Addis Ababa[3]	Addis Ababa	3.9	2.9
11	Dire Dawa[4]	Dire Dawa	0.5	4.0
	FDRE[5]	Addis Ababa	100	2.9

[1] **Benshangulgumz,** [2] **Southern Natuions, Nationalities and Peoples' Region,** [3] **Addis Ababa City Council,** [4] **Dire Dawa Administrative Council,** [5] **Federal Democratic Republik of Ethiopia.**
Source: Central Statistical Authority, 1996.

The Great Rift System dissects the country into two parts, i.e., the Central-Northern and the South-Eastern highlands (Mersha, 2000). The lowlands and low plains lie to the West of the North-Western highlands (the Sudan plains) and to the East of the South-Eastern highlands (Somali lowlands). The Rift Valley, together with its lakes forms another system of lowlands and valleys (Ethiopian Mapping Authority, 1988). The highlands peak above 4000m *asl* at Ras Dashen in the Semien Mountains (ibid).

The highlands, constituting about 30% of the country's total surface, are the home of most sedentary agriculture with perennial crops such as *ensete* (*Ensete ventricosum* (Welw.) Cheesman) MUSACEAE, coffee (*Coffea arabica* L. RUBIACEAE) and chat (*Chata*

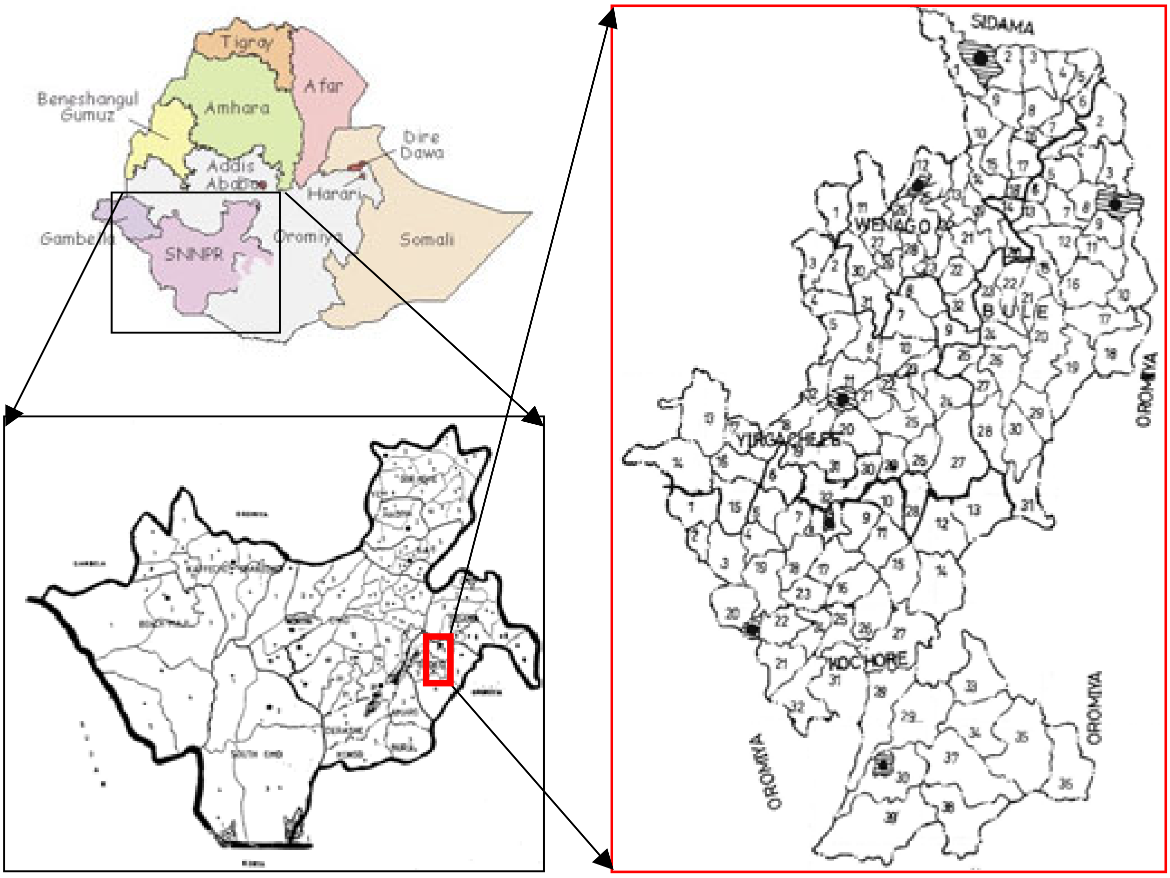


Fig. 1.1. The Gedeo in Ethiopia. The Gwedeo country is located in the escarpment of the Rift Valley, facing Lake Abaya, between the region of Oromiya (to the south), east and west and the Sidama zone (to the north).

Edulis CELASTRACEAE) and annual *teff* (*Eragrostis teff* L. GRAMINEAE), maize (*Zea mayas* L. GRAMINEAE), barley (*Hordeum vulgare* GRAMINEAE), and wheat (*Triticum vulgare* GRAMINEAE) (see Wolde-Aregay & Holdinge, 1996). The dry, sub-humid zone covers 12% of the country and supports drought-tolerant crops like sorghum (*Sorghum vulgare* GRAMINEAE). The semi-arid and arid zones cover about 41% of the country and are currently used as pasture and range lands. The desert zone covers about 16% of the country, and is the home of the nomadic pastoralism (e.g., the Afar, Boran and Somali). However, only 30% of the estimated 30 million livestock population is kept in the lowlands (Wolde-Aragay & Holdinge, 1996), the rest being animal components of mixed farming in the highlands.

Due to its large rivers and several lakes (e.g., the Abay, the Tekeze, the Wabe Shebele, the Baro) traversing long distances, Ethiopia is known as the water tower of northeastern Africa (Woldemariam, 1972). The capacity of the numerous rivers is estimated at 105.5 billion m3 of water with an irrigation potential of 3.5 million hectares (Mersha, 2000). The hydroelectric and thermal power potential of the rivers is estimated at 100 to 165 billion kwh per annum. There are eleven lakes, most of which in the Rift Valley, with a total area of 740 km^2, (Mersha, 2000).

The country once was also endowed with natural vegetation. The forest cover has shrunk from forty to four percent, within less than a century (Breitenbach, 1963). Remnants of natural forest are located in the South-West and South-Central parts of the country and these are officially protected. Indigenous acacia forests in the Rift Valley and other open woodlands are other natural remnants. Man-made forests consisting of eucalyptus and other exotic trees are estimated to cover 200,000 hectares (Mersha, 2000). Ethiopia stands out in Africa in the area of wildlife and natural conservation because of its exceptionally high levels of endemism, i.e., species only occurring in small, well circumscribed localities and nowhere else in the world. It is also the region of origin of many plant species now widely spread, the best known certainly being the coffee shrub (*Coffea arabica* L.). The country has nine wildlife parks, 4 sanctuaries, 11 reserves and several controlled hunting areas (Woody Biomass Inventory and Strategic Planning Project, 1996).

The soils of Ethiopia are much varied (Murphy, 1968). The most important are *Regosols* (11%),*Vertisols* (10%), *Nitosols* (12%), *Fluvisols* (5%) and *Arenosols* (5%), according to the Ethiopian Mapping Authority (1988). The soil descriptions indicate limitations in phosphorus, nitrogen and organic matter (ibid.). The soils, particularly those in the highlands are susceptible to erosion by rainwater, largely due to the mountainous landscapes with over 30% slope, and exacerbated by the concentrated and intense rains (Wolde-Aregay & Holdinge, 1996). The average annual soil loss from croplands is estimated at 100 tons ha^{-1} (ibid.). The problem of soil erosion is further aggravated by cultural practices followed by those farmers who grow annual crops leaving the soil bare after harvest. In growing teff, for instance, the soil has to be intensively cultivated and left to be soaked with water prior to sowing, for about one month. Since mulching is not possible due to the extremely small seeds of the crop, the situation favors water erosion until the crop germinates and establishes a canopy. A completely different picture is observed in areas of perennial cropping, particularly *ensete* and coffee growing in the South (Gedeo, Sidama) and West (Keffa, Illubabor, Wollega); see Wolde-Aregay & Holdinge (1996). Here, too, erosion problems exist in areas of cereal farming (e.g., in the West and facing the Rift valley (table 1.5).

1.2. Subsistence: the basic theme of Ethiopian agriculture

Ethiopian agriculture is predominantly subsistence agriculture (table 1.2). This can be glimpsed from the proportion of agrarian people in the whole population, 86%, following the Central Statistical Authority (1999). On the other hand, this aspect is often seen as a problem by national and international organizations. Therefore, research and development in Ethiopia are geared towards changing or transforming this agriculture, casting it into the ideal mold of conventional "modern farming". On the other hand, the merits of subsistence agriculture such as sustainability and equity have in the main been neglected. Low yield is claimed to be the main drawback of subsistence agriculture, and has been unduly exaggerated (Diriba, 1995). Modern agricultural research started in the early 1970's (Almaz, 2001), but food security to Ethiopia still remains distant (Diriba, 1995). It rather decreased than increased over the last 30 years. Though environmental problems share the blame to some extent, neglecting the larger subsistence agricultural sector remains the main reason. Since agriculture is the backbone of the economy accounting for about 60% of the GDP and 90% of the foreign earnings (Almaz, 2001), the problem is not restricted to food security alone. Indeed, agriculture also is the main source of raw materials for the country's agro-industries (Almaz, 2001).

Subsistence farmers have been forced into a desperate situation. On the one hand, they cannot fully participate in conventional farming, as necessary infrastructures (e.g., roads, markets or storage structures) is largely lacking. Moreover, farmers are also hampered by the fragile environments, fragmented holdings and an unpredictable climate. In short, farmers cannot improve their socio-economic situation by the sole means of their own traditional farming, whereas they receive little support. *Ensete* is one of the crops hard hit (Brandt & al., 1997).

1.3. The place of *ensete* agriculture in Ethiopia

Ensete agriculture is "endemic" to Ethiopia. It is one of the four major agricultural systems in this country (Brandt & al., 1997). The other three are the seed-based systems of the northern and central highlands, shifting cultivation systems of subtropical rainforests in the west and the pastoral system of the dry lowlands and low-lying plains.

In terms of the total population engaged, the seed-based temporary systems come first followed by *ensete*-based permanent systems (see table 1.2.). *Ensete* systems support an estimated 10 to 15 million people, mainly in the Southern Nations, Nationalities and Peoples' Region (Pijls & al., 1995; Brandt, 1996).

Table 1.2. Cultivated area under temporary and permanent crops

Crop area/ha./ No. Households	Under 0.1	0.1 – 0.5	0.51– 0.69	1.0 – 2.0	2.01 – 5.0	5.01 - 10	> 10	Total/ha./
Temporary crops	1022190	2956400	1648930	2512380	648790	21120	2020	8688650
Permanent crops	2457010	1453990	116810	30570	-	-	-	4067330
Total/households/	3479200	4410390	1765740	2542950	648790	21120	2020	12755980
%total	27.28	34.58	13.80	19.94	5.09	0.16	0.02	100

Source: adapted from Central Statistical Authority, 1999 Table D-27, pp121-123.

Ensete is mainly grown by the southern and southwestern peoples, though some areas in the Oromiya region grow *ensete* too. At present, most of these areas are part of the Southern Nations, Nationalities and Peoples' Region, which can therefore be considered to be the home of *ensete* agriculture (Sandford, 1991; Brandt, 1997).

With a surface area of 117, 566 km^2 and a population of 13.5 million (projected from 10.4 million in the reference year (Central Statistical Authority 1996), this is the third largest region after the Oromiya and the Amhara regions (table 1.1). The Southern Nations, Nationalities and Peoples' Region embraces more than 48 nations and nationalities with a population of 10 thousand or over (Central Statistical Authority, 1996b). Based on ethnic lines, the Southern Nations Nationalities and Peoples' Region is subdivided into 9 zones* and 5 *special woredas* (*table 1.3). Words preceded by an asteric (*) are explained in the glossary).

Table 1.3. Sub-divisions of the Southern Nations, Nationalities and Peoples' Region (SNNPR).

Zone or special woreda	Capital	Population
1.Sidama	Awassa	2,044,836
2.Guraghe	Wolqixxe	1,556,964
3.Hadiya	Hosa'ina	1,050,151
4.Kembata-Alaba-Tambaro	Durame	727,340
5.Gedeo	Dilla	564,073
6.Semen Omo	Arabamich	2,605,435
7.Debub Omo	Jinka	327,867
8.Keficho-Shekicho	Bonga	725,086
9.Bench-Maji	Mizan	325,876
10.Yem	Fofa	64,852
11.Amaro	Kele	98,315
12.Burji	Soyama	38,745
13.Konso	Karati	57,585
14.Dirashe	Gidole	89,900
SNNRP Region	Awassa	10,377,028

Source: Central Statistical Authority, 1996.

Though some historians and botanists had earlier attempted to trace the origin of *ensete* to ancient Egypt, later writers (Smeds, 1955 and Simoons, 1960 both ex Westphal, 1974) have suggested that *ensete* is indigenous to Ethiopia. According to Smeds, *ensete* cultivation originated in highland Ethiopia, as this area was the only part of Africa to possess a more developed agricultural and pastoral economy. *Ensete* cultivation is traced back to Neolithic and even to earlier times (Simoons, 1965; Stanley, S. 1966, both ex Westphal, 1974). This theme is substantiated by later authors (e.g., Brandt, 1996; Pankhurst, 1996; Rossel, 1998). Brandt (1996) constructed a model for the origin of *ensete* agriculture in Ethiopia while Pankhurst (1966) traces historical evidence regarding *ensete* agriculture. In her study of African bananas, Rossel (1998) mentions *ensete* as one of the oldest African food plants.

Irrespective of whomever first domesticated *ensete*, the *ensete* culture is destined to diffusion both ways, due to the closer ties between ancient Egypt and Ethiopia (Murray, 1964). The Ethiopians were one of the claimants of the Pharaonic Throne (ibid., p. 4 9). It is also mentioned that the Egyptians adopted their God *Setekh* from the aboriginal peoples from the South, presumably Ethiopians.

Although there is no question on the age of the *ensete* agriculture, authors differ on which of the two groups, i.e., the Cushitic group, represented by the Sidama peoples (Gedeo, Sidamo, Hadadiya, Kambata), and the people of Bako, Keffa, Maji highlands, represents the people who first cultivated *ensete*. Both groups are members of the Southern Nations, Nationalities and peoples' Region. The Cushitic Caucasoids are believed to have controlled the area from eastern Sudan to the former British East Africa from late *pleistocene** into the *neolithic** times (Simoons, 1965 ex Westphal). The latter view, i.e., that the Caucosoid Cushites are native to the Ethiopian highlands is supported by Murdock (1959 ex Westphal, 1974), according to whom this group was occupying eastern Africa at some time before 3000 B.C. Negroid peoples penetrated the Ethiopian plateau from the west, bringing with them advanced agricultural practices, which were later absorbed by the Caucasoid Cushites. We will come back to the issue of the people responsible for *ensete* domestication in the later chapters of this book.

The area of *ensete* cultivation is thought to have been much more extensive. One of the proofs lies in the writings of travelers. The well-known historian Pankhurst (1996) takes notes of two Portuguese Jesuits, Manoel de Almeida and Jerome Lobo, who mentioned the prevalence of *ensete* in the general area south of the Blue Nile as early as the 16th century. Almeida in 1954 is also said to have written that the plant was the sustenance of most of the people while Lobo on his part had described *ensete* production and utilization around *Damot*, an area north of the Ghibe River. According to Almeida, the *ensete* tree is eaten either sliced or boiled or crumbled and ground into meal, which is put in pits in the ground where it is kept for many years. Almeida is also said to have declared that the plant was the most productive and useful of any he had ever seen, for no part of it is discarded (Pankhurst, 1996). Pankhurst (ibid.) also mentions the writings of James Bruce, the 18th century traveler, in connection to *ensete* cultivation in the Ethiopian highlands, which we know today as centers of cereal farming.

Ensete agriculture itself is not a uniform system. Westphal (1974) mentions four subsystems within it, *the tuber crop dominant* area supplemented by cereals and *ensete*, *cereal crops dominant* area supplemented by tubers and *ensete*, areas with *ensete* as a co-staple supplemented with cereals and tuber crops and areas having *ensete* as their only staple. The first subsystem is practiced by the subtropical shifting cultivators in the southwest. The second subsystem is practiced by the *Oromo* people of Western *Keffa*. In the third subsystem, *ensete* is grown along with cereals and tuber crops, for example by the omotic-speaking peoples in north and south *Omo*. The fourth subsystem is practiced by the eastern Cushitic- speaking peoples, e.g., the Gedeo, Sidamo and the Semitic-speaking Guraghe. The latter area is the home of *ensete agriculture* (Westphal, 1974).

Sandford (1991) identified three main linguistic groups associated with *ensete* agriculture. The two having *ensete* as a central crop in their diet and culture are the Omotic (some 20 different groups including the *Ari*, *Basketo*, *Dime*, *Dizi*, *Gamo*, *Gimira*, *Goffa*, *Keffa*, *Kontta*, *Kullo*, *Maji*, *Mao*, *Sheko*, *Wolayita*, *Yem*, *Uba* and *Zala*) and Cushitic (the Gedeo, *Sidamo*, *Hadiya*, *Kambata*, and some *Oromo* groups), (see table 1.4). The third group is Semitic and is represented by the *Guraghe*. All of these groups grow a mixture of crops according to elevation but depend on *ensete* as their basic staple (Olmstead, 1974; McCabe, 1996). McCabe (1996) notes that all groups but the Gedeo make extensive use of manure and crop rotation in order to ensure a continuous use of the same agricultural plots indefinitely. He also mentions the high value attached to livestock by some *ensete* peoples such as the *Sidamo* among whom a person without cattle is not regarded as a fully-grown social person, but as an outcast.

Most cereal growers and some pastoralists are reported to have a negative attitude towards *ensete* and the people dependent on it (Sandford, 1991; Smeds, 1955; Simoons, 1960 ex Westphal, 1974). Pankhurst (1996) mentions that contempt for *ensete* evolved from historically deep-rooted prejudices including the notion that 'it makes people weak". This in fact is in contrast to the real situation, as *ensete* peoples are very sturdy and generally of good health (Sandford, 1991). Moreover, *kocho*, the main *ensete* food, is being served in the best restaurants in Addis Ababa and towns in the southern region, which do not simply cater for migrants from *ensete* areas (*ibid*.).

On the other hand, some evidence is accumulating that shows the expansion of ensete in in parts of Oromo west of Addis Ababa, traditionally not an *ensete* area (Sandford, 1991). Brandt (1996), on the other hand offers, an explanation for the demise of *ensete* agriculture from northern Ethiopia that was mentioned by the Jesuits and James Bruce (Pankhurst, 1996). According to Brandt (1996), pressure from warlords and nobility on the peasants in the late *holocene* (A.D. 500 to 1900) to grow surplus/cash crops, led to the abandonment of *ensete* and other subsistence crops. The royal court of Keffa is said to have passed a decree forcing farmers to abandon *ensete* and instead grow the prestigious *teff* (*Eragrostis teff* L. GRAMINEAE). As will be explained below, the Gedeo have benefited in unexpected ways from the dislike for *ensete* by the former feudal lords.

Table 1.4. Major land use systems in the Southern Nations, Nationalities and Peoples' Region (SNNPR).

Major land use systems	Representative component (s)	Location within the SNNPR
Ensete-based	*Ensete,* coffee, multi-purpose woody perennial species	Highlands to east of the Rift Valley (Gedeo and Sidamo), and to west of the rift valley (e.g., Guraghe, Hadiya, Kambata)
Cereal-based	Cereals, e.g., maize, wheat, *teff*	Central Rift valley (e.g., Dalocha and Silte), Eastern and southern lowlands and Southern Rift Valley (e.g., Alabda Burji uplands, Konso-Gidole, Gamo lowlands)
Shifting cultivation	Annual grains and root crops	The Omo River plain, the *Majangir* (*Masango*) of southwestern forests
Agro-pastoral	Livestock (mainly cattle) and crops	Omo flood plain (the Dassenetch and Nyangatom, Omo upper lands (the Hamer), Omo (eastern) valley (the Mursi and Bode)), Lower Omo valley (the Me'en and Surmi), Sagan valley (the Arbore)
Pastoral	Livestock (mainly cattle and goats)	Omo valley (the Dassenech and the Nyangatom)

Source: Adapted from the Woody Biomass Inventory and Strategic Planning Project (1996).

Ensete cultivation is often seen as a response to land shortage (Brandt, 1996). Thus, diverse *ensete* cultures have high carrying capacities where 1.5 hectare suffice for a household subsisting on *ensete,* against 40.5 hectare for a household subsisting on cereal crops like *teff* (Bezuneh, 1970); also see table 1.2), both in an environmentally friendly way (Wolde-aregay & Holdinge, 1996). That *ensete* is called a "tree against hunger" (Brandt & al., 1997; Tigot, 1986) is explained by the fact that *ensete* areas have rarely experienced starvation (Pankhurst, 1985).

The versatility of *ensete* (Olmestead, 1974) allows farmers to grow diverse crops (grain crops and vegetables, coffee and diverse fruit crops) or engage in diverse activities such as keeping livestock or engaging in off-farm activities, further increasing the food security of an *ensete* household (Tigot, 1986; Diriba, 1995; table 1.6).

Table 1.5. Export of clean coffee from the Southern Nations, Nationalities and Peoples' Region (SNNPR).

Year (Eth.C.)	Clean coffee /ton/ supplied to market	Share of Sidama	Share of Gedeo
1985	39,333.50	10,580.70	13,727.40
1986	39,854.80	10,720.90	13,909.30
1987	37,457.20	10,076.00	13,072.60
1988	66,912.00	17,999.30	23,352.30
1989	52,054.80	14,002.70	18,167.10
1990	52,054.70	12,842.60	15,920.60
1991	57,667.40	16,178.30	21,254.90
1992	72,247.70	20,134.70	26,847.10
Total	417,582.1	112,535.2	146,251.3
Mean	52,197.8	14,066.9	18,281.4

Source: Adapted from Bureau for Agricultural Development, SNNPR, 1998.

Thus, the southern Nations, Nationalities and Peoples' Region is the second largest coffee producer, after the Region of Oromiya, (Agricultural Bureau for the SNNPR, 1998). On average, the SNNPR supplies over 52 metric tons of clean coffee to the Central Coffee Market in Addis Ababa per year. Sixty percent of this is contributed by the Gedeo and Sidama zones (table 1.5). Coffee growing alongside *ensete* therefore increases the food security of *ensete* households (Tigot, 1986). One of the best Ethiopian Coffees (e.g., *Yirga-Chaffee* type, Gedeo zone) is obtained from coffee trees intercropped with *ensete*. Though most Ethiopian coffee is organic, produced without industrial chemicals, the market makes no distinction between this organically produced coffee and one being produced using farm chemicals. The stringent procedures involved in the certifying process are therefore a big challenge for small coffee farmers (Kotschi, 2001).

1.4. Biophysical and social context of the study

1.4.1. The Gedeo country

The Gedeo live between 5 and 7 degrees North latitude and 38 and 40 degrees East longitude in the escarpments of the southeastern Ethiopian highlands overlooking the Rift Valley, in the narrow strip of land running from North (Sidama zone) to South (Oromiya region). In altitude the area ranges from 1200m asl in the vicinity of Lake Abaya to 2993m asl at *Haro Wolabu* Pond, Bule woreda (Ethiopian Mapping Authority, 1988). Formerly, they were referred to as Darassa and their country Darassa *awuraja*[*], one of the districts of the former imperial Sidamo province. The present arrangement of administrative regions (fig.1.1.) divides the Gedeo population between two regions, to wit the Southern Nations, Nationalities and Peoples' Region (about 700,000 inhabitants in the Gedeo zone (Central Statistical Authority, 1996b and 1996c) and Oromiya region (about 300,000 inhabitants), according to the Central Statistical Authority, 1996c, 1998b).

Geographically, the Gedeo country lies in the inter-tropical convergence zone (Lundgren, 1971). As a result, the Gedeo highlands benefit from both equatorials and the monsoons, the two most important trade winds in the region. Thus, the climate of Gedeo country is characterized as warm humid temperate (Ethiopian Mapping Authority, 1988). Mean annual temperature ranges between 17 º C and 22.4º C and mean annual rainfall between 1200 and 1800 mm (fig. 1.2. and fig.1.3). The Gedeo country is thus endowed with two rainy seasons, from March to May and from July to December, with interruptions of 3 to 4 dry months. However, the truly dry months are only January and February, others count with intermittent rain showers. The climate is suitable for abundant forest cover (Ethiopian Mapping Authority, 1988). Logan (1946) who traveled through the Gedeo country advanced the same idea, that the original vegetation of the Gedeo region cannot be otherwise than a highland forests of some kind. This was based on his observations of remnant vegetation and favorable climatic and edaphic conditions (Logan, 1946), a view also supported by other authors (Breitenbach, 1960; Lundgren, 1974; Westphal, 1974).

1.4.2. Gedeo history

Gedeo ancestry is not well known. The Gedeo trace their origin to the aboriginal tribe called *Murgga-Gosallo** (Kiphee Kanshshe; Dhaqaboo Shotaa; Ulataa Tobee, pers. comm. 1998), perhaps the earliest people to have lived in the area (Dillebo, 1985). The elders also maintain that Gedeo installed their own *baalle**, a tradition similar to the gada tradition of the Oromo. This is a system of government based on grades and ranks according to age classes. *Baallee* remained an effective system of government until the

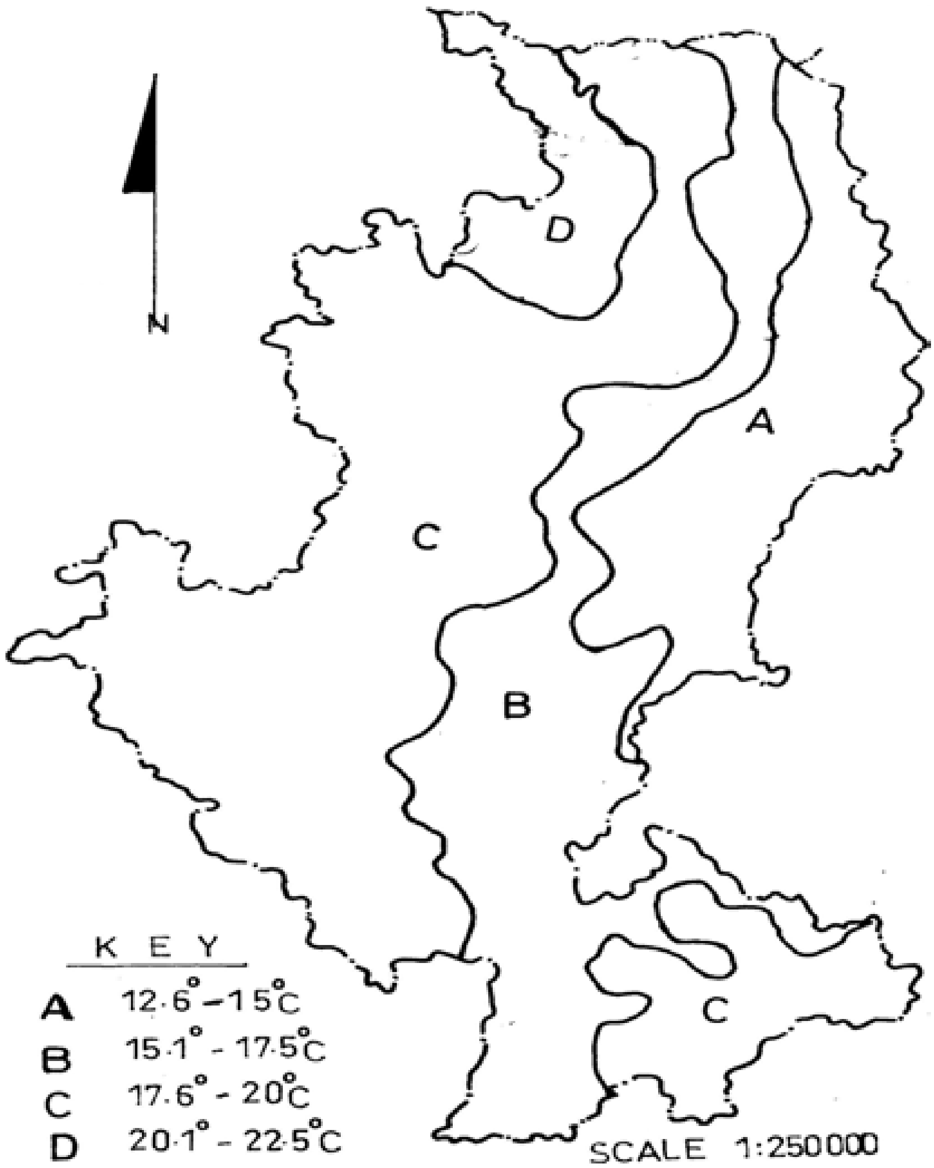


Figure 1.2a. The Average Annual Temperature Map of the Gedeo zone
Source : The woody biomass inventory project, 1996.

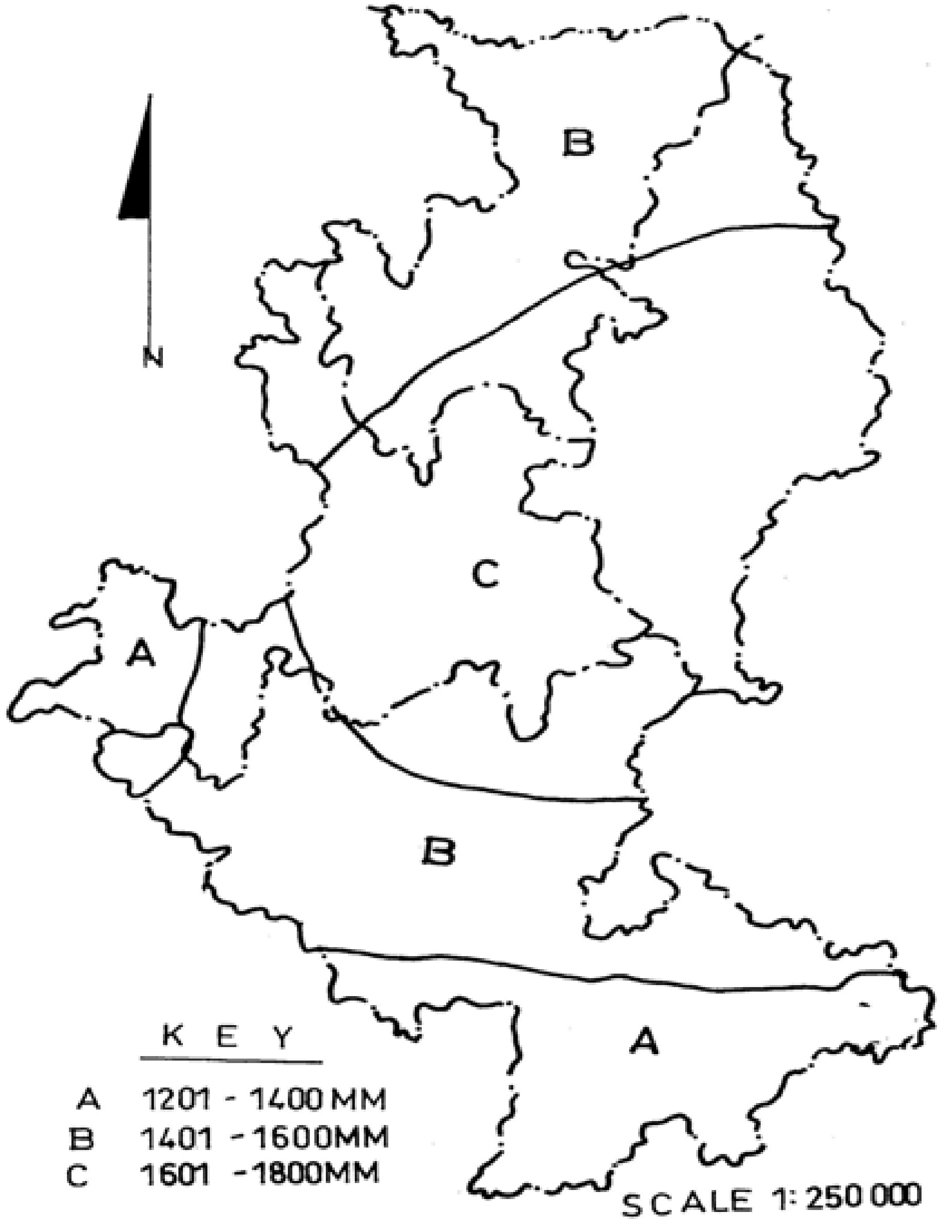


Figure 1.2b. The Average Annual Rainfall Map of the Gedeo zone
Source : The woody biomass inventory project, 1996.

The Gedeo were incorporated into the Ethiopian Empire. *Baallee,* though stripped off its political hegemony, is still intact in the lives inside Gedeo society, which it permeates with its principles and philosophy. Gedeo tradition also maintains that *Daraso* was their ancestor. Daraso is also believed to have been a senior brother to the ancestor of the Guji Oromo, a pastoral group living in the neighborhood of the Gedeo, in the lowlands. The Gedeo are also related to the Sidamo, another people of *ensete* culture.

Daraso, is said to have had seven sons from two wives. From these were descended the seven Gedeo tribes. These are *Doobba'a*, *Darashsha*, *Gorggorshsha, Hanuma*, *Bakarro*, *Henbba'a* and *Logoda*. These are organized into two classes or "houses" *shoole baxxe* (the senior) to which the first four belong and *sase baxee (*the junior*)* to which the last three belong. The *shoole baxxee* comprises more than twenty-five sub-tribes whereas the *sase baxxe*, consists of ten sub-tribes. Marriage within the same sub-tribe is forbidden. Before their incorporation into the Ethiopian Empire, the Gedeo lived in a federation of three zones, *Suubbo*, *Dhiibata* and *Riiqata* ruled by a council of elected elders, according to the *baallee* tradition.

The foregoing thesis on Gedeo ancestry is also supported by linguistic evidence (Dillebo, 1985). All of the three groups (the Gedeo, the Guji and the Sidamo) speak languages of Cushitic stock (Dillebo, 1985). The Guji speak the Oromo language. The Gedeo however have their own language, Gede'uffa and the Sidamo speak their own language, Sidamo**.** These three also have similar traditions, for instance, the *Gada* tradition permeates the lives of the three groups of people.

This mainly oral history corresponds well with the preliminary findings of the Ethiopian Institute of Nations and Nationalities (Dillebo (1985), a decade ago. This is an area with meager research efforts in which at present the Addis Ababa University is engaged (ibid.).

The *Gedeo* have maintained close cultural and economic ties with their neighbors, the Guji and the Sidamo. The Gedeo also had economic relationships with the Wolaita and the Gamo, who used to supply the Gedeo with cotton cloth. The economic interrelation between the Gedeo and the Guji is even stronger. The Gedeo supply the Guji lowlanders with *ensete* food and coffee in return receiving livestock and livestock products. In dry seasons, the Guji with their cattle used to seek refuge among the Gedeo who in return practiced share cropping with the Guji from the lowlands. This interdependence is also heightened by the streams and rivers flowing from the Gedeo highlands into the rift valley connecting the quality of life of the two peoples. It is unfortunate that misunderstandings in the recent past have lead the Guji and Gedeo into conflicts.

The Gedeo, along with their neighbors, were incorporated into the Ethiopian Empire only in the late 1890's (Tolo, 1989). However, this process of nation-building initiated by Menelik the Second of Ethiopia has not been peaceful and smooth, as it is often portrayed (Dillebo, 1985; Tolo, 1989). It had devastating consequences on the social organization and lives of Gedeo people. For instance, the Gedeo were barred from using their *gada* tradition in their day-to-day lives, except in religious rituals. This brought disintegration of the society, and loosened the social ties among different tribes. Developments in the *ensete*-based land use are not without connection to this social event. The Gedeo also saw their land confiscated and themselves reduced to *gabars* (Dilebo, 1985), the Ethiopian equivalent of serfs.

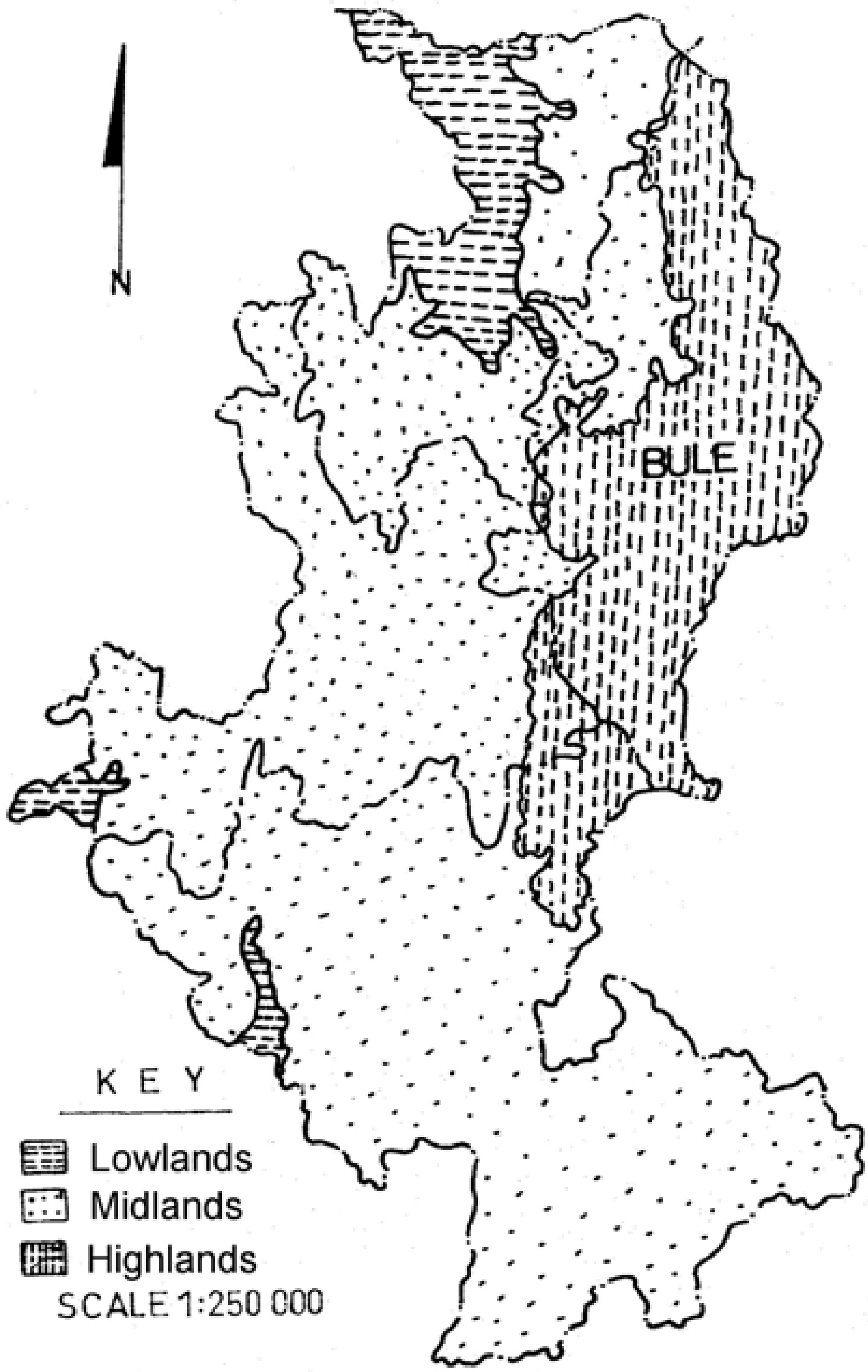


Figure 1.3. The Three Agro-ecological Zones (highlands, midlands and lowlands)
Source : The woody biomass inventory project 1996

Treatment of the Gedeo as no more than subhumans at the hand of the feudalists is described by Dillebo (1985) and Tolo (1989). For instance, feudal lords were entitled to take from one-third (*siso*) to one-half (*gama*) of whatever the *gabars* produced. This was excluding the service the *gabars* and their families had to render. The *gabars* had *also to* contribute *asrat* (one-tenth of the total produce) to the Orthodox Christian Church, though they were not allowed to become full members. The landlord also controlled the social life of a *gabar* to whom it was for instance obligatory to seek permission from his landlord before proposing a marriage for his children or to send his children to school. Moreover, the *gabar* had to be careful not to offend his landlord by behaving in ways the landlord might consider improper. To sum up, the *gabar* system made the Gedeo to live not for themselves but for the landlords.

Survival of a *gabar,* who had to surrender three-fourth of his produce, to a large extent depended on the crop the lord was not interested in, i.e., the *ensete* plant (Kiphee Kanshshe, pers. com., 1999). Therefore, *gabars* had to produce two types of crop, one for the lords and the other for themselves. But, for the latter they were not given time, and the *gabars* had to work during holy-days, in the sense of religious days, when the lord's fields were not to be touched. Holy days were not lacking, for most of the landlords were followers of the Ethiopian Orthodox Church.

1.4.3. Gedeo religion

The Gedeo believe in *Mageno**, the one and only one Supreme Being. They also believe that *Mageno* manifests Himself in His works of creation. Therefore, the Gedeo have high respect for nature in general. The Gedeo recognize the role of the intermediaries between *Mageno* and man. These are the elderly men and women. The Gedeo believe in life after death. Ancestral spirits are regarded as the legitimate intermediaries between *Mageno* and the people. There are few people among the Gedeo who are regarded as saints (*Wabeeko**). These are believed to be able to predict future events. People troubled about their relationship with *Mageno* consult the *wabeeko* who give advice on these matters.

There are certain places, such as riversides, hillsides, or large trees, where individuals present heir petitions to *Mageno*. The Gedeo often present their petitions together with *xeero*,* offerings presented to *Mageno*. A piece of food and/or a mouthful of honey sprayed over the area comprise the *xeero*. In doing so, the Gedeo always refer to the *Mageno* who created these *beings* (rivers, hills or trees). Most outsiders misunderstand this as a pagan approach. Each Gedeo village has its own *songgo**, the place for mass prayer (*qeexala*).

Christian missionaries came to the Gedeo in the early 1950's. They established two churches, i.e., the Ethiopian Kalehiywot Church and Ethiopian Evangelical Church Mekaneyesus. Of these, the Ethiopian Kalehiywot Church (EKC) attracted the bulk of the Gedeo population and exerted a far-reaching influence. According the Central Statistical Authority (1996a), today, 43.2 % of the Gedeo population is protestant Christian, i.e., largely followers of either of the two protestant churches, whereas followers of the original Gedeo religion make up 24.6% of the population. Orthodox Ethiopian Christians, Catholics Christians and Muslims comprise 22.1, 2.8, and 2.8% of the population, respectively. The latter three religions are predominantly professed in the towns. The majority of the rural population (more than 83% of the total) either follows the indigenous religion or is protestant Christian.

The missionaries found their evangelical work among the Gedeo quite easy, as they had only to substitute the Christian God for the *Mageno* of the Gedeo. Moreover, the Gedeo were not new to the concept of the Christian God, as they had been introduced to it earlier by the Orthodox Ethiopian Christians (Hirbbe Abbayyi, pers. Comm. 1999) What was new, however, was the way the missionaries related this concept to the situation of the Gedeo, i.e., to their oppression by the feudalists who professed Christianity themselves. Equality before God of all races of man, of all nations, of all men and women, as emphasized by the missionaries, was all the more appealing to the Gedeo (Rev. Alemu Shetta, pers. Comm. 2000). The same situation is reported for Christian missionaries among other peoples, e.g., the Ethiopian Evangelical Church Mekane Yesus (EECMY) among the Sidamo and the Oromo (Tolo, 1989).

1.4.4. Formal education among the Gedeo

Before the coming of the Christian missionaries, there was virtually no formal education among the Gedeo. The handful of government schools were in the towns (Dilla, Wonago, Chaffee, Bule, Fissagenet or Cheleletu), from which most of the Gedeo were barred (Hordofa Dayyaso, pers. Comm. 2000). The missionaries quickly identified this gap and used it to their advantage, as a channel for their evangelical work. The missionaries soon established Bible and elementary schools, which opened their doors wide to the Gedeo (Elelluu Buudhaa, Dharro Jachchaasoo, pers. Comm. 2000). People were so eager to learn how to read and write, that children schools had to offer evening classes for the adults, in the light of kerosene lamps. These schools not only taught religious cadres but also cadres of change. Some of the children, completing church school began to walk back and forth a distance of 10 to 20 kms a day attending public schools in towns (Hirbbe Kudhaa, pers. Comm. 1999).

The feudal lords, well aware of the consequences, were vehemently opposed to any education of members of the Gedeo people. Therefore, they made the work of the missionaries very hard, by limiting their movement in the rural Gedeo land in several ways (Tolo, 1989).

Therefore, the missionaries had to depend on local recruits, members of the Gedeo society with some education (Jaalaa Barrichca, pers. Comm. 1999). The recruits had limited capacity to instruct Gedeo children and adolescents, as they had barely completed grade six. This also was related to the limitation imposed by the feudalists on the teachings of the missionaries not to offer more than elementary education to the Gedeo (Tolo, 1989). Nevertheless, the Gedeo attended the courses in the literacy campaign *en masse* and soon a large section of the population was awakened. The feudalists also tried to curb the activities of the recruits but failed, as these were backed up by the whole population. Some recruits such as Evangelist Murtti Obese, one of the first converts to spread the Good News to the Gedeo south of Dilla town, lost his life in 1970, when on assignment in the remote areas of Hageremariam *woreda* and Evangelist Tesfaye Argaw was slain when on a similar mission in the lowlands.

The dispute between the Protestant Christian churches defending the oppressed peoples on the one hand, and the feudalists on the other hand was noteworthy (Tolo, 1989). The feudalists, for instance, wanted to ban the Kale-Hiywot Church, a step they refrained from taking because of the popular support the church enjoyed. Violence is against the Gedeo traditions, and this was strengthened even more by the teachings of the Church. Thus, the Gedeo were taught to bring to bear a maximal legal effort to the task of reclaiming their land rights.

"Knowledgeable men" were selected from the elderly (Dhaqqaboo Shotaa, pers. comm. 2000) and sent to present a petition to the Emperor in Addis Ababa, but to no avail. The Gedeo clashed with the feudal army in 1960 at Michille, a hill above Dilla town. This battle instigated persecution of the Church (Daaka Seerii, pers. comm. 1998). Church leaders were accused of inciting the people against the feudal government and church gatherings were banned (Baalchcha Boree, Ataaraa, pers. comm. 1999).

The fall of the feudal system in 1974 was a triumph for the Gedeo. However, they soon realized that the misdeeds committed to them did not end with the fall of the feudal system. They were even looted by armed guards (Worqquu Goollee, pers. comm. 2000), during the Dergue era (1974-1989). Cheating and deceiving had become "normal" ways used by most town merchants in dealing with Gedeo peasants. The Gedeo were not free to use even their own farm produce. For instance, they were told by the "Peoples' Commissars" when to harvest and when to sell coffee or to whom to sell. They were even told to plant cereals like wheat or maize instead of *ensete*. Collectivization and villagization programs of the Dergue were contradictory to the self-sufficient life of the Gedeo. The Dergue was so determined in its policy to confiscate Gedeo land in the name of collectivization that farmers engaged in a battle against the Dergue in 1981 around Rago-Qishsha (Moges/Kiphee Jiloo, pers. comm., 2000).

With the coming to power of the Ethiopian Peoples' Revolutionary Front most of these misdeeds have ceased. Farmers are now their own masters once more.

1.4.5. Gedeo cultural heritage

The Gedeo have a rich culture that fosters hard-work and egalitarian principles. Begging for money or food, even for the blind and physically disabled, is forbidden. Until very recently, the Gedeo loathed working for money. This is still true in a large part of the countryside. Violence is also discouraged, as the Gedeo believe violence only breeds violence. Therefore, killing a human being is not a mere crime, but a curse (*munddo*) among the Gedeo. Those who commit this act in whatever way, are excommunicated. A special purification process has to be performed to re-integrate those who had to kill during war times. The Gedeo present offerings (*xeeroo*) or prayers (*Mageno kadhata*) before killing animals for food. Theft, lying and adultery are regarded as socially evil and evil before God. Individuals committing these acts are punished in public.

Baallee, the Gedeo *gada* tradition (see 1.4.2), is also a cultural heritage.

There are different manners, in which these prescriptions and principles are passed down to the young. Songs (e.g., *olkka*, *sirbba*, *were'o*, *qeexala*, *googoree*, *wi'dhishsha*, *gadda*, *boochchisaa*, *weeddo*, *dookko*, *meella*) and mass meetings (*haagana*) where public debate is engaged, can be mentioned. The Gedeo have drums with which they accompany these songs. The drum (*okolee*) is so important in Gedeo culture that there are specialists for its manufacture.

The Gedeo also have a rich sport culture with jumping (*utaalchcha*), running (*gongga*), throwing (mogido), or hockey (*qallee*). The game played with two persons with stones on a wooden board or stone (*saddeeqaa*) is still popular.

Very little archaeological and/or anthropological reports referring to the Gedeo are available. This, however does not mean lack of evidence. It shows lack of research. Some attempts are now being made by French archaeologists studying in the Gedeo Zone (*Tutu-Fela* site). There are numerous megaliths distributed all over the Gedeo country. These are claimed by some to predate the Egyptian pyramids.

Unfortunately, these cultural heritages from which there is much to be learned and gained are not recorded, and they are fast disappearing with the elderly. This is one area where the Kale-Hiywot church, wrongly considering all that is traditional as satanic, has inflicted heavy damage.

1.4.6. Gedeo land use

Gedeo land use still remains a mystery. What is known is its output (coffee, honey, one of the best rams (male sheep), *ensete* food). It is not either purely agriculture, purely cattle raising of purely forestry. This remained a formidable problem for many agricultural specialists who were assigned to the Gedeo zone with a cereal crop agenda. As a result, promotion and increases of salary, based on field performance reports, bypassed many of these specialists (Annual Reports of the Agricultural Bureau for the Gedeo Zone (unpublished)).

To the farmers, *ensete*-based land use was a survival strategy. Many of the landlords, who were uninterested in *ensete* food, found only the coffee appealing. The fact that farmers were able to intercrop these two was important to them. The landlords did not interfere with this intercropping. The approval of the intercropping by the feudalists benefited both the farmers and the feudalists, as sustained yield was possible. The feudalists were ignorant of the way coffee was produced by the Gedeo farmers and they had to accept it. Had they known that coffee could be grown in monoculture, they would not have hesitated to force farmers towards taking steps that maximized yield from coffee by eliminating everything else.

This was made evident, when the landlords learned how to grow coffee themselves, but it was too late for them to force their new policy on the *gabars*.

Farmers' benefit from coffee was almost nihil, as much of it went to the landlords, who intentionally extended the tax from previous years. For every one unit of coffee unpaid in the previous year, the landlord received two units a year afterwards. This was one of the major ways by which farmers were forced into indebtedness. Therefore, it was better for the *gabar* farmer to give all the coffee there was as tax in kind to the landlord. The landlord, having received all produce as tax in kind, then had nothing to extend to the next year.

The *gabar* farmer was also taxed in labor. As said before (see ch. 1.4.2.), he therefore had no much time left to concentrate on his *ensete*. The fact that, as will be shown in later chapters of this book, *ensete* is a little demanding crop, hence was very important for the survival of the *gabar* farmer and his family.

1.5. Outline of the book

The present book is a synthesis of several years of fieldwork and case studies of Gedeo land use. It aims to provide a comprehensive ecological understanding of Gedeo land use. It also traces the social bases with which these ecological principles are inseparably enmeshed.

Objectives, problems pursued and justification for the study are presented in chapter two and the reader will find the methods chosen for tackling those problems in chapter three. The remaining chapters (four to eight) treat the major findings in more detail and with necessary data to underpin them.

Fundamental aspects of agro-ecosystem architecture, i.e., agro-ecosystem components and their spatial and temporal organization, are presented in chapter four. An instance of the use of agro-ecosystem architecture in the designing of sustainable agro-ecosystems is presented in chapter five.

Material presented in chapter five includes diagrammatic drawings, of the basic design (ch.4), using *ensete* as an illustration to demonstrate how living agro-ecosystem components interact with each other and with their immediate biophysical environment in providing sustained yield. In particular, it shows how production of useful biomass is integrated within maintenance of the production base, i.e., the future capacity for continued functioning.

In chapter six, major constraints under which farmers operate are highlighted. It is also shown how natural resource management by the Gedeo fits into the general setup of the farm design. This chapter also shows how the Gedeo manage agro-ecosystem complexity.

Chapter seven deals with organic soil maintenance, with emphasis on vegetation. Besides, soil physical and chemical properties and the nature of the inputs are treated. How the principles and practices of farmers' management relate to soil properties is discussed.

Chapter eight examines the carrying capacity of Gedeo land-use, applying the principles discussed in the preceding chapters.

Chapter nine finally synthesizes material presented in the preceding chapters, so as to derive a totally integrated overview of the design and functioning of the Gedeo gardens. Certain aspects, such as the origin and development of *ensete* agriculture, its sustainability, its past development due to interventions by outside experts and by reaction to these interventions among the Gedeo are discussed. Scope of future development potential is examined. General conclusions and recommendations are finally drawn.

Chapter 2. Statement of the problem

2.1. Scope of the study

The scope of the present study was roughly sketched by Kippie (1994), with the design and functioning of more than five thousand year-old Gedeo land use. The latter perhaps represents the only remnant of *ensete*-based land use, from which simpler forms of *ensete* mono-cropping practised by other southern and south-western peoples of Ethiopia, emerged. Gedeo land use is also considered an indirect progenitor of conventional agriculture, forestry and agroforestry.

Gedeo land use rests on two basic principles. The first principle is concerned with an integrative design, combining components with both the production and the protection functions. Within the production components, two types, i.e., core and subsidiary, are distinguished. The set of core components contains elements that regulate both production and protection rhythm of the agro-ecosystems. Their function is both ecologically and socially comprehensive. These elements are represented by *ensete* and diverse multi-purpose tree species. These act as cornerstones, holding the whole agro-ecosystem intact. Elements from the set of subsidiary components act as "fillers", as these fill gaps, be it ecological or social, as needed. The "fillers" are represented by crops grown for sale including coffee. Farm animals also belong to the latter category. The "weedy" herbaceous vegetation represents a special component meant for the maintenance of the ecological base of production, the soil.

The second principle relates to management or regulation of the interrelations among the diverse components. This is arranging or organising the diverse agro-ecosystem components in space and/or time. This is done through two interwoven systems of crop rotation, i.e., single and multiple rotations. A rotation is here the time span between planting and harvesting. This scheme makes a continuous harvest possible. Therefore, only necessary biomass is harvested, the rest is being stored in the live components. The scheme also ensures maintenance of the production base, e.g., soil, since only a small proportion of the farm area is harvested and replanted, and damage that results to the site by rainwater or scorching heat of the sun is minimised. The integrative design makes use of the "weeds", for soil maintenance, in two main ways. First, by their physical presence, as farmers do not touch these during rainy seasons. Second, by sharing soil nutrients and other site resources with "crop" plants and conserving these in their biomass. The nutrients contained in the weedy biomass are returned to the soil by mulching. Weeds therefore have the same function as the fallow vegetation in shifting cultivation. The soil is also replenished by the leaf litter from the multi-purpose trees, crop by-products and farmyard manure and household refuse.

Therefore, Gedeo land use is self-regulating and self-regenerating. What is required of the farmer therefore is only reciprocal optimising of these protection and production functions. Why did farmers decide to maintain their agro-ecosystem design from less informed development interventions, which tried to dismantle the system and replace it with much inferior simpler systems? This study concentrated on the ecological aspects of the land use.

However, for the best understanding of these systems the complex historical, socio-economic, cultural and political factors behind their development should be appreciated.

Thus, the study being the first kind in *ensete* agriculture offers a theoretical as well as practical framework and baseline data for redesigning and designing ecologically sound land use in marginal areas such as mountainous regions beset with problems of soil erosion. The study also offers a theoretical background for the study of other *ensete*-based systems in Ethiopia. It also shows how the built-in high productivity and high maintenance quality of *ensete* can even be enhanced by a cropping design that favours better expression of these qualities.

2.2. Research objectives and goals

2.2.1. At landscape Level

a. The design of living systems is more complex than the most complex of physical structures (Goewie, 1995; Oldeman, 1998, 2001). As in the design of the physical structures, the design of living systems to a large extent determines their capacity to resist destabilizing forces such as pests and diseases or other unpredictable natural hazards. Gedeo land use design should give more insight into their functioning as noted by Kippie (1994). Examination of design would also reveal the nature and characteristics of the components used.

b. It is now widely accepted that *ensete*-based systems are environment-friendly (Amare, 1984; Diriba, 1995; Wolde-Aregay & Holdinge, 1996) and have higher carrying capacity (Pijls & al., 1995; Brandt, 1996; Asnaketch, 1997; Central Statistical Authority, 1996a; Tsegaye & Struijk, 2001). This is often externalized, by attributing the higher carrying capacity to farmyard manure applied to *ensete* (Sandford, 1991; Pankhurst, 1996; McCabe, 1996) or to the natural endowment of the agricultural environment. Farm design and crop architecture, which play fundamental roles, are largely neglected. Aspects of farm design and crop and agro-ecosystem architecture are of even more relevance to a better understanding of Gedeo land use because of their use in the production and as well as in the maintenance of the agro-ecosystems.

c. Gedeo “agroforests” are least studied among *ensete*-based systems in Ethiopia. In order to generalize about these land use systems, characterization of the agro-ecosystem diversity and establishment of effective zonation of the Gedeo country is essential. This will facilitate research appropriate for designing and development interventions.

d. Most of the development interventions into Gedeo land use have failed (Agricultural Bureau for the Gedeo zone, unpublished archives). This is not surprising as the interventions were initiated without a basic understanding of the land use system. Investigation of the whole Gedeo land use therefore will yield better approaches and guidelines for future research and development interventions.

e. To investigate farmers' management of the natural resources (both spatial and temporal) and how principles and practices fit in the design and functioning of the "agroforests".

f. To elucidate the educational and/or demonstrative value of Gedeo "agroforests". This is a value already realized, as many farmers from different parts of the country and students from different Ethiopian colleges and universities are paying one or two visits each year. Widening this scope of the "agroforests" to the global level so as to facilitate a common understanding to the humanity requires research.

g. The study of Gedeo "agroforests" should provide sound theoretical grounds to the newly emerging discipline of Agroforestry.

h. The study into Gedeo "agroforests" will facilitate an option to fight hunger and land degradation using *ensete* in the erosion-prone Ethiopian highlands and other mountainous areas.

2.2.2. At zonal Level

a. As mentioned earlier, soil maintenance by the Gedeo largely rests on the use of the vegetation. However, how this is achieved is not well researched. The same is true of the nature of the vegetation used for the purpose. How is the input from the diverse components organized? What is the role of farmyard manure and the "weedy" herbaceous vegetation, in soil maintenance? It is also important, to see whether there are crop species with an extraordinary role in such aspects.

b. The capacity to provide sustainable yield of useful products and services is the goal of all domesticated ecosystems (Oldeman, 1983). This is of more importance in the case of Gedeo land use where many people are fed from a small area of land. How the highest carrying capacity is achieved by Gedeo "agroforests", without external (i.e., purchased inputs), needs enquiry. This may have far-reaching implications.

c. Development interventions have been going on for three decades in the Gedeo highlands. The effects of these interventions on the fundamental aspects such as design and functioning as well as in the management practices of the farmers is not known. Studying why farmers have been averse to the new technologies is also important. Likewise, knowledge of the constraints under which farmers operate is important, as these constraints may serve as points of focus in the planning of future interventions.

d. To analyze and describe the current farm potentials and constraints as well as the relevance of current management strategies vis-à-vis the existing potentials and constraints of the local environment.

2.3. Hypotheses

1. The functioning of Gedeo agro-ecosystems can be explained by a few key components, enabling farmers to operate at a higher level of both ecological and socio-economic efficiency. Therefore, judging from their performance, all "agroforest' components are not of the same rank.

2. Other conditions being constant, the ecological and socio- economic stability of the Gedeo land use depends on the balanced interaction among their components, including the human component.

3. Farmers' management is harmonisation among the functions of diverse "agroforest" components.

4. Though farmers are responsible for the selection and "manipulation" of components in their agro-ecosystems, a proper functioning of the latter demands corresponding adaptive strategies from the farmers. Co-adaptability is important.

5. "Agroforests" in different altitude-based agro-ecological zones do not differ in their level of efficiency, because changes in the biophysical factors are nullified by the corresponding changes in the farmers' adaptive strategies*.

6. The balance between biomass exported and biomass recycled in Gedeo "agroforests" optimises the balance between production and sustainability*.

7. Gedeo "agroforests" represent the most ancient, i.e., more than at least five thousand years old, *ensete*-based systems in Ethiopia.

8. Gedeo "agroforests" represent a repository of complexity which is well expressed in the correspondingly rich diversity of agro-ecosystems as well as diversity of life forms (Kippie, 1994).

9. The buffer within Gedeo "agroforests" consists of the integration of components with production and protection functions.

10. Selection of components for inclusion into the "agroforests" and their spatial and temporal arrangement are essential aspects of farmers' management practices.

11. With better understanding of their design and functioning, Gedeo "agroforests" could be improved.

12. Grounds to the ecological and social sustainability of *ensete*-based Gedeo land use can be found by research.

13. The Gedeo manage agro-ecosystem complexity instead of specific agro-ecosystem properties, and achieve higher levels of biodiversity and productivity.

2.4. Justification of the study

The International Centre for Research in agroforestry (ICRAF) looks for systems that offer base line data to improve or replace shifting cultivation systems in the humid tropics threatened by population pressure (Mongi & Huxley, 1979, pxxvi; Huxley, 1983; Raintree, 1990). There is also a need for data on more holistic systems, i.e., systems conceived as a whole, to redesign agricultural systems in industrialised countries (Goewie, 1995). With their higher integration of the agricultural and forestry aspects, Gedeo "agroforests" fall in the domain of these holistic systems. K.F. King, Director-General of ICRAF once noted that food aid, though not to be rejected out-of-hand, should be regarded as an emergency measure on which a nation or part of it should not be forced to depend (Mongi & Huxley, 1979, pxxi). The latter statement particularly refers to Ethiopia, a country fairly known for recurring food shortages. While enhancing the theoretical framework of agroforestry designing, the present research also aims to contribute towards solving the food problem in Ethiopia.

Many past development interventions in many parts of the globe have failed (van Helden, 2001). One of the widely known examples is soil conservation work in Ethiopia (Amare, 1984; Wolde-Aregay & Holdinge, 1996; Mersha, 2000). Though several reasons could be identified for this, the main cause is associated with the disregard for the indigenous natural resources management (Van Helden, 2001). This has raised much concern and prompted re-evaluation of the past agricultural assistance to Ethiopia which were often geared towards imparting modern agricultural technologies (Kippie, 1994; Diriba, 1995; Abate & al., 1996). On the other hand, there is resurgence of interest in knowledge of indigenous resource management for designing agro-ecosystems better fit for the present age (Gomez-Pompa, 1991; Pinto-Correia, 1996; Neugebauer & al., 1996; Faust, 1996; Van der Wal, 1998). There is also need to consider traditional crops such as *ensete,* well adapted to the local environment (Tigot, 1986; Brandt & al., 1997). The fact that areas practising *ensete* agriculture have often been able to stave off hunger (Diriba, 1995; Brandt & al., 1997) has aroused much interest in this crop (Abate & al., 1996; Brandt & al., 1997). *Ensete* is being called the tree against hunger (Pankhurst, 1985, 1996; Bezuneh, 1996; Hiebsch, 1996; UNDP/ECA, 1996; Brandt & al., 1997), showing that interest in the crop is being revitalised after long time negligence. There is consensus that *ensete* offers a unique opportunity to easily avert the precarious food situation in Ethiopia (Brandt, 1997; Tigot, 1986, Asnaketch, 1997; Almaz, 2001; Tsegaye & Struijk, 2001). But, data are lacking to substantiate these claims on *ensete*-based systems.

For instance, little is known of *ensete* and peoples dependent on it (Kippie, 1994; Westphal, 1974; Sandford, 1996; McCabe, 1996), although *ensete* areas have the highest carrying capacity in Ethiopia (Pijls, 1995; Abate & al., 1996; Sam-Godfrey-Aggrey & Tuku, 1987; Central Statistical Authority, 1996; Brandt, 1997; Asnaketch, 1997; Almaz, 2001; Tsegaye & Struijk, 2001). Most studies on *ensete* are exploratory, i.e., focusing on surveying different *ensete* cultures for such agronomic parameters as biological diversity (Bayush, 1991; Almaz, 2001) and yield (Pijls & al., 1995; Taboje, 1997; Tsegaye & al., 2001). There are few studies integrating diverse attributes, such as ecology and production, of *ensete* agriculture (Kippie, 1994; Asnaketch, 1997). For a deeper understanding of *ensete* agriculture, in-depth case studies are recommended (Neugebauer & al., 1996; Gomez-Pompa, 1991; Hladik, 1993). This is particularly important for *ensete*, a crop which is not backed by research and development for a long time (Abate & al., 1996; Godfrey-Sam-Aggrey & Tuku, 1987) and also though currently supporting about one-fourth of the 65 million Ethiopian population (Central Statistical Authority, 1996a) and also with high potential to avert the precarious food as well as environmental situation in Ethiopia (UNDP/ECA, 1996).

2.5. Statement of the problem

Ensete-based Gedeo systems date back from the *neolithic* times (Simoons 1965, Stanley 1966 both *ex* Westphal 1974). With an approximate surface area of 5980 km^2, the Gedeo Highlands are one of the most densely populated regions in the country (Central Statistical Authority, 1996a). According to Simoons (1965 ex Westphal 1974), *ensete* agriculture is believed to have entered the Ethiopian highlands before 3000 B.C. by Negroid peoples from the west. The Bushmanoid original inhabitants of southern Ethiopia represented by the Gedeo are considered to have accepted the new agriculture and in their turn advanced it.

However, *ensete* agriculture as practised by the Gedeo is unique in its design as well as in its functioning (Kippie, 1994b). While other *ensete* peoples concentrate on *ensete* which they grow in the homestead to practice mass harvesting, the Gedeo maintain a complex mixture of crops (grain and vegetable annual and perennials such as coffee and multipurpose tree species and shrubs) with *ensete*. This scheme of *ensete* cultivation gives the agro-ecosystems more than a superficial resemblance to forests. These are aspects that make Gedeo *ensete* agriculture a most likely candidate as a representative of the original *ensete* agriculture under the forest canopy.

Many people still see *ensete* as an odd crop intermingled with coffee (Kippie, 1994). At times, farmers were told to replace their *ensete* plants with coffee in areas suited for coffee or with cereal crops like maize or wheat where the local environment suits the latter (Agricultural Bureau for the Gedeo Zone, unpublished). This has been notwithstanding devastating crises of the cereal-based farming systems in some parts of the Ethiopian Highlands. This can largely be attributed to ignorance as Barker (1990) has noted discussing socio-economic constraints facing complex agroforestry systems in Highland Tropics in general.

In his preliminary study of the midland zone Gedeo land use, Kippie (1994) made an inventory of the main plant species. He found the basis of the “agroforest” design to lie in the scattered tall trees up to 35 m high associated with *ensete* plants and coffee bushes both up to 10 m high under which a mixed community of shade-tolerant plants thrives. He drew architectural profile diagrams and maps of representative fields (*ensete*, *ensete* and coffee; *ensete*, coffee and woody perennials). Based on the data he collected he developed a diagrammatic model depicting the dynamics of the fields using *ensete* as a *pacemaker*

(Neugebauer & al., 1996). Thus he forwarded a hypothesis that the "agroforests" in the medium altitudes are analogues of the pre-existing natural forests.

Since Kippie's study (1994), several works appeared (Pijls & al., 1995; Abate & al., 1996; Aasnaketch, 1997; Tsegaye & Struik, 2000; Almaz, 2001). However, of particular significance are the proceedings of the workshop on *ensete* held in Addis Ababa in 1994 (Abate & al., 1996) in which several authorities, from agronomists to historians, propounded on the potential of *ensete* agriculture to Ethiopia, particularly in ensuring its food security. As a result of this workshop, the attitude of many intellectuals towards *ensete* seems to have changed, as reflected in the number and diversity of research projects on *ensete*. However, most of these focus only on the agronomic practices of *ensete*. An integrative work is essential so as to obtain a complete picture of *ensete* agriculture. Farm design is one major aspect neglected in *ensete* agriculture. This has precluded understanding of the essential aspects of the *ensete* crop, as many people see *ensete* as any other crop plant. The same is true with Gedeo land use, which markedly differs from other *ensete* systems. Given this background, it is not therefore surprising to see many a research project focusing on purely agronomic practices. Even the agronomic practices of Gedeo *ensete* agriculture remain unstudied. Thus, little is known of the technologies used by the Gedeo in processing *ensete* biomass as well as in the storage of *ensete* food. Moreover, soil maintenance by purely organic means particularly using vegetation is a completely untouched aspect. So is the influence of *ensete* on its immediate environment such as in erosion control by harvesting rainwater and conserving it for later use. This aspect is of extraordinary importance for countries like Ethiopia that suffer from heavy soil losses by rainwater erosion (Amare, 1984; Wolde-Aregay & Holdinge, 1996).

Thus, Kippie's (1994) suggestion to extend work done in the midland zone to the closely related highland and lowland zone Gedeo land use systems has come at the right moment. The need for such a study as a basis for the design of stable and more productive agroecosystems fit for the present age is also highlighted by Neugebauer & al. (1996).

Therefore, work done in the midlands was extended to highlands and lowlands. In addition, an in-depth study of the midland zone "agroforests" was carried out. Whether or not changing biophysical factors along these zones elicit corresponding changes in the farmers' adaptive strategies and hence to the stability and productivity of the "agroforests" was also assessed.

In line with the foregoing, the main strategy has been examination of farm design and dynamics together with the associated management practices, having in view the level of ecological and socio-economic efficiency attained by each one of them. This obviously required determination of the kind and amount of ecological and socio-economic benefits derived and the ecological and socio-economic costs involved. Therefore, selected farms within each of the three agro-ecological zones were investigated as to their resources and constraints and how these two were brought together by management. Farm organisation was studied and mapped in four consecutive stages. In the first stage, elements of farm design and the manner these were organised were studied. In the second step, the performance of these was assessed. In the third step, contributions to the system from each of the components were investigated. The role of trees as pacemakers*, spacemakers* and placemakers* of forest ecosystems (Michon, 1983; Oldeman, 1995) has largely been taken over by *ensete* in harmony with woody components in midlands (Kippie, 1994). Components with comparable or similar roles were assessed in the highlands and lowlands. Finally, in the fourth step, conclusions were drawn as to the farm design in each of the three zones. Since, it is almost impossible for any of the zones to produce all of its requirements and be self-sufficient, interactions among them and also between these and neighbouring communities was also assessed. In this way, data on ways of obtaining a balanced productivity and stability were obtained.

The study on farm design also focussed on farmers' objectives and strategies. This is important, as the efficiency of the farm design can only be known in this way. Besides, possibilities to extend the present link between ecology and socio-economy, in the face of increasing constraints and stresses, was also assessed.

Architectural and physiological strategies of crops selected are important as these facilitate farmers opportunities to steer in the performance of the crops (Oldemnan, 1983; Neugebauer & al., 1996). *Ensete* plants in the midlands intercepts large amounts of rainwater with their giant leaves. This means either water conservation and erosion control or as their giant leaves intercept a larger amount of light, they jeopardise the supply of light to the crops growing in the understorey, precluding the possibility of intercropping.

The "agroforests" in the midland zone were found to be very biodiverse and data were presented showing this for the tree version (Kippie, 1994) but not for the herbaceous weedy vegetation, *ensete* and coffee. The latter type of data are very important for crops like *ensete* which are only vegetatively propagated, as a narrow genetic base means higher risk if extensive *ensete* cultivation were to be envisaged for other parts of Ethiopia or the world.

Kippie (1994) associated the omnipresence of *ensete* in all Gedeo land use to its function as a skeleton to be fleshed out with other crops. What crops besides *ensete* are grown in the higher and lower Gedeo land use versions? How are these linked with *ensete*? How do they help to maintain the stability of the resource base? *Ensete* plants are reputed for their rainwater collection and conservation (Kippie, 1994b; Nezry & al., 1999). This is an important aspect as it provides a hint as to ways in which soils are maintained without terracing and also supporting higher biological diversity.

Farmers' ecological knowledge is studied indirectly, from their principles and practices of natural resources management. The possibility to enhance the designing capability of the farmers using the resulting data is explored as well as their potential to the conduct of institutionalized agricultural development and research work in the Gedeo zone.

Kippie (1994) mentioned that the place of both domestic and wild animals was well secured in Gedeo "agroforests" but did not give their contribution to the agro-ecosystem. These aspects were also studied. In assessing the place of wild fauna, the capability of the "agroforests" to provide biotopes for these animals was stressed in the study. The same was true for the weedy vegetation, which the Gedeo regard differently. In fact the use of the term "weed" here is due to lack of another term in agriculture or forestry. Thus, biodiversity is regarded as an output of agro-ecosystem complexity.

The problem of maintenance, as in most domesticated ecosystems, is very important. This is emphasised in the study, as the agro-ecosystem design excludes use of industrial inputs, such as mineral fertilisers or pesticides. Gedeo land use exclusively rests on the reciprocal optimisation of two agro-ecosystem functions, i.e., production and protection. The ways in which the various components work together in order to keep this balance was important for explaining the ecological sustainability of the agro-ecosystems. The same was true with principles and practices of yield accounting. Proportion between biomass recycled and harvested was assessed. Kippie (1994) mentioned the use of the weedy herbaceous vegetation in soil maintenance. Whether the same attitude to weeds was held in the highlands and lowlands was assessed. Moreover, the amount of the weedy biomass recycled and the time "weeds" occupy the land are also important aspects as they are directly related to soil conservation.

The efficiency of the farmers' management practices in steering the interactions among the components towards sufficient and stable production of “useful” biomass was studied. The prospect for farmers who continue choosing not to subscribe to agricultural extension (Kippie, 1994) was evaluated, in relation to changing ecological, economic and social environments, i.e., increasing influence form the national and global communities.

The synthesis of the data from the foregoing increases the understanding of the agro-ecosystems and hence their appreciation. Besides, the resulting data are helpful in reconstructing Gedeo land use history which provides more insight to the designing of more flexible and sustainable agro-ecosystems to face population growth and global change.

Chapter 3. On Materials and Methods

3.1. Introduction: choice of methods

No standard methods exist for the study of traditional land use systems. The enormous complexity in many such systems makes most methods developed for conventional agricultural systems inappropriate. Furthermore, research on traditional systems calls for interdisciplinary thinking, difficult to achieve in most cases. Given their high complexity, even more comprehensive methods are needed for *ensete*-based Gedeo "agroforests" (see ch. 2 for the general background to the present chapter). Kippie (1994) used an architectural analysis in studying altitude-based midland *ensete*-based Gedeo systems, because of their high similarity with natural forests.

Kippie's midland data resulted in a descriptive model, which the present study aims to develop into an explanatory model. An explanatory method explains a system in terms of both its subsystems and its super system (Oldeman, 1990) while descriptive models give only the properties of a system as seen from the outside (Leersnijder, 1993 ex Kuiper, 1994). The explanation of a system in terms of interaction between its subsystems (e.g., C.T. de Wit, 1978) means reducing the scale (to smaller units). The explanation of a system as member of a supersystem is often called "wholism" and means explanation by expanding the scale. Oldeman (1990) proposed a sandwich explanation, considering these levels: a supersystem, the system to be explained, and the subsystems.

This does not conflict with Conway's (1985) concern that every level should be analyzed in its own right and that the behavior of higher level systems is not readily discerned simply from the study of lower level systems. This concern is less relevant to the present study, which employs closely linked hierarchical levels and an adapted hierarchy.

Since the present work builds upon the material discussed in Kippie (1994; see also ch. 2), the same method was used. It is supplemented with FAO's criteria for land evaluation (FAO, 1976; Touber& al., 1989) and farming systems analysis (Conway, 1985; Dent & McGregor, 1994) in order to account for the inclusion of the human component. However, architectural methods are being recently preferred to others in studying semi-natural systems (see Michon, 1983; Oldeman, 1983, 1990, 2001; Louman, 1986;Vester, 1997; Van der Wal, 1999). Involvement of the human component, modifying the agroforest according to its objective necessitates data on the carrying capacity of the agroforests, thus the need to supplement the architectural method with agronomic ones (counting and weighing, Conway, 1985; Dent & McGregor, 1994).

Architectural analysis employs measuring. It also involves counting (floristics and population dynamics) and weighing (production ecology) (Oldeman, 1990). The latter two approaches are generally speaking methods used in studying agro-ecosystems while architectural analysis up till now was most often applied in the study of forest or agroforest ecosystems.

There is also a need to combine these three approaches. Kuiper (1994) argues that allround ecosystem research should incorporate elements of these three. This is all the more important because it yields more comprehensive understanding of the *ensete*-based Gedeo systems which are midway between natural and industrial systems.

The obvious problem of such an all-round approach is the need for interdisciplinary work. In the present study this is less of a problem because of the collaboration with the Agricultural Bureau for the Gedeo Zone (ABGZ) with the use of its human resources.

The background of the investigator (agronomy, forest ecology) also contributes to reducing the problem.

3.1.1. Architectural analysis

Architectural analysis imperatively requires a clear and well-defined choice of appropriate system levels (Oldeman, 1990). In natural ecosystems, these can be distinguished by their natural limits, drawn by the architectural arrangement of organic components. Van der Wal (1999, p.9) defines *architecture* as “spatial distribution of the interacting components and their forms in the system, expressing its organization”. In the present context, the term is used as encompassing the temporal aspect of the organization as well (Oldeman, 1990). This temporal aspect is essential, as the organization of living systems is dynamic. System components or parts appear and then disappear in time, a good case being the interacting honeybees and flowering trees in Gedeo “agroforests”.

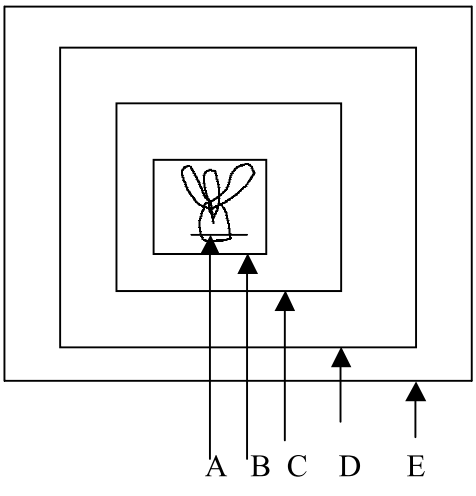


Fig.3.1. Agro-ecosystems and levels of analysis employed. A = organismic system, B = agro/eco-unit, C = agro/eco-unit mosaic, D = site, E = Landscape.

Honeybees, an integral component of these systems, come and go, following temporal variations in the availability of nectar food and other conditions such as warmth. The same is true with fields planted to annual or perennial crops, which are laid bare after harvest. This temporal aspect of systems brings the concept of land *use pattern* into focus which is defined as spatial and temporal regularity in the distribution of the use of fields over *a landscape* (Van der Wal, 1999), italics added. It has spatial (distribution of fields) and temporal (the time the fields are used) aspects.

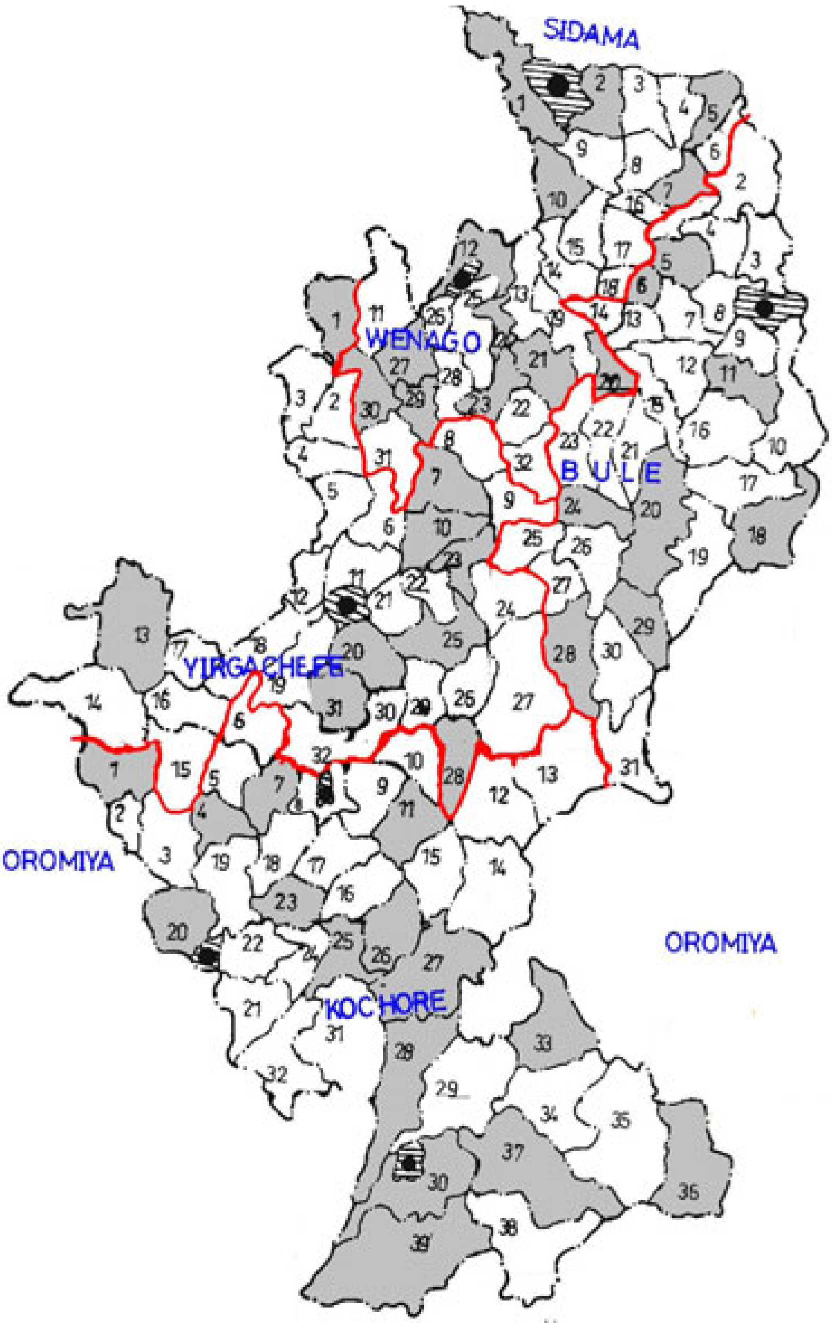


Figure 3.2a. Farmers' associations (shaded) from which the study sites were selected. The listing is annexed.

In the following structure-based system hierarchy, the major focus has been on the *agro/silvatic* mosaic and *agro/eco-unit* levels. This is to fulfil the principle in system studies, i.e., a system studied should both fit the framework of the system at a higher hierarchical level and be fit to be explained in terms of its subsystems (Oldeman, 1990). Therefore, data collected at *agro/eco-unit* level are used to generalize about the *agro/silvatic* mosaic level and data collected at organsimic level (higher plants and animals) are used to explain the architecture and dynamics of *eco-units* (see fig.3.1). However, all structural data collected at each of the three levels are used for generalizing at the *agro/silvatic-mosaic* level, to align with the system level of management used by the households (fig.3.2a)

Households in Gedeo "agroforests" are treated as part of the living agro-ecosystems, as are non-human components, both together building a naturally functioning system. Therefore, the principles and practices of Gedeo land management were integrated into the systems studied.

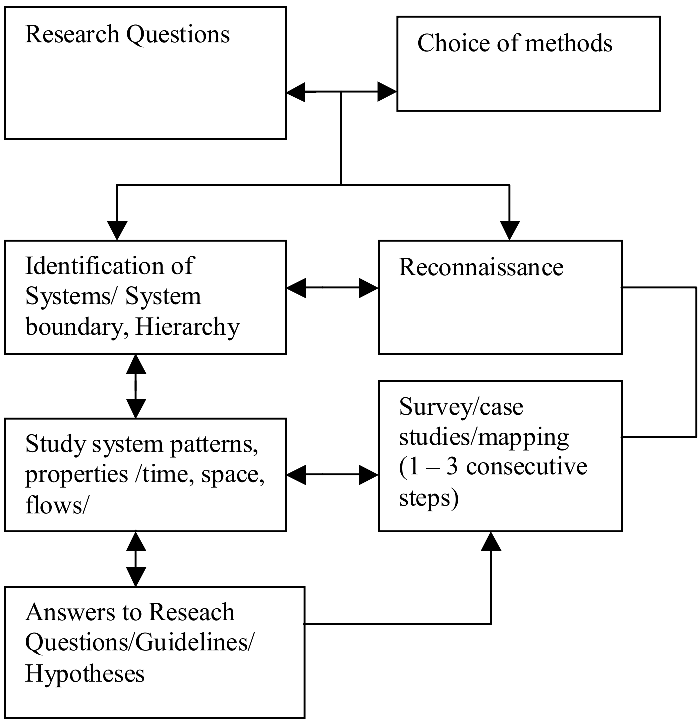


Fig. 3.2b. Iterative steps in field data collection.

3.1.2. Land use studies

Like with architectural analysis, these deal with ecosystems but with an emphasis on natural resources in the context of human use. In fact, the usefulness, often narrowed down to single products or services, is the basic point of view in such studies. Land evaluation in its broadest sense includes the process of data gathering (inventory and mapping of natural resources), identification and classification of tracts of land and interpretation of the resulting data in terms of suitability of all individual tracts of land for a specified use. In a strict sense, land evaluation encompasses only the interpretation of gathered data into suitability levels for actual or potential use (Touber & al., 1989, p14).

Land is defined as an area of earth's surface the characteristics of which embrace all reasonably stable or predictably cyclic attributes of the biosphere vertically above and below this area (Touber & al., 1989, p14) including those of the atmosphere, the soil and underlying geology, the hydrology, the plant and animal populations and result of past and present human activity to the extent that these attributes exert a significant influence on present and future uses of the land by man. These aspects are exemplarily synthesized in the study by van der Wal (1999).

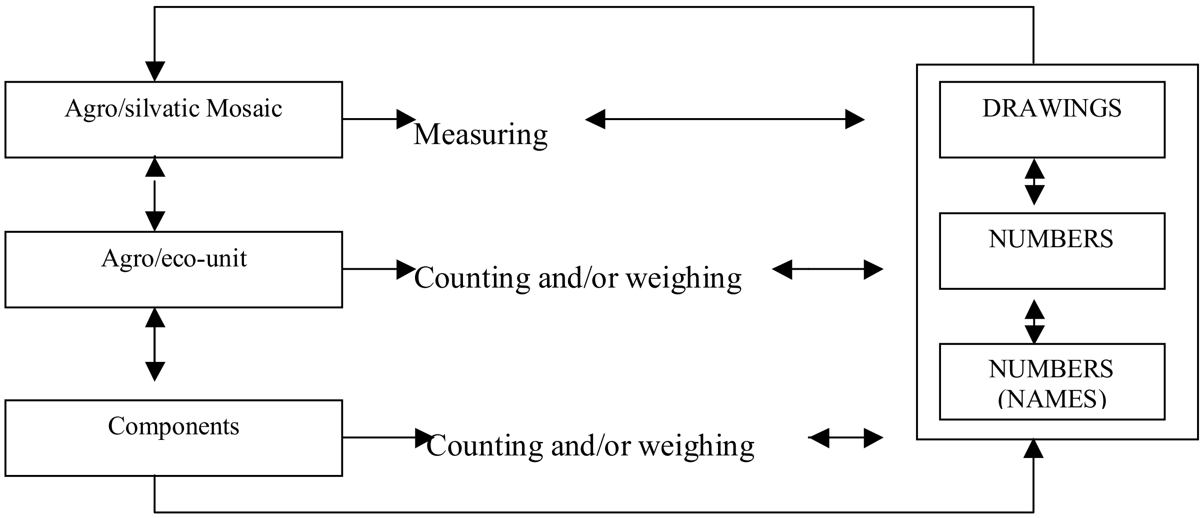


Fig.3. 3 Pathways for the integration of data. Data from the agro/eco-unit level are used to explain those at the immediate higher level (agro/silvatic-mosaic) and data from organismic systems (higher plants or animals) are used to explain the data at the immediate higher level (agro/eco-unit).

This method is particularly relevant because there is a need in the present study to check the extent the natural endowment of the area, to which the success of these systems is often ascribed by some authors (e.g., Amare, 1984; Wolde-Aregay & Holdinge, 1996). Gedeo "agroforests" highly resemble the original forest in component diversity and structure, and in tangible and intangible products obtained on a sustainable basis without purchased input (see ch. 8). It must be checked whether or not it does fulfil this criterion.

3.1.3. Farming systems analysis

This method specifically deals with agro-ecosystems, and hence its name "farming systems analysis". The main reason for including it in the kit of present methods was its focus on the farm household as the central subsystem, i.e., as a decision making unit (Dent & McGregor, 1994). It also pays greater attention to more detailed system levels, such as crops and/or animals.

These three methods, i.e., architectural analysis, land use evaluation and farming systems analysis, complementing one another, resulted in a set of comprehensive data on Gedeo "agroforestry" systems. Architectural analysis, focussing on the temporal and spatial patterns of the system structure was the main method used. Others were employed to check its outcomes. One main aspect it barely covers, however, is treatment of the human component, which cannot be ignored in the present context.

3.2. Research sites

Sites were selected to fully represent diversity in *ensete*-based Gedeo agro-ecosystems. These were widely distributed in the three landscapes (fig. 3.5, 3.6). Each of the three, highland (*suubbo*), midland (*Dhiibata*) and lowland (*Riiqata*) correspond to one *agro (silvatic) moisaic* (figs. 1.3, ch. 1; 3.2a). Each of the latter were subsequently studied at two lower levels, i.e., *agro (eco)-unit* and component organism (higher plants and/or animals).

Height (MSL)	Site's Name
2800	Daro
2000	Dodoro
1680	Chirrachcha

Table 3.1. Characteristics of the three sites chosen for transect sampling.

For transect sampling, sites with typical features of the level studied were selected. For instance, in the midland zone where agro-ecosystem complexity was highest, sites showing the same were selected. On the other hand, in the highland zone where the complexity was lowest, sites showing these were selected though there were also sites approaching in complexity those in the midland zone. In other words, the general rather than the particular in each of the zones was selected. However, numerical and weight data were collected from all sites widely distributed over the study area (fig. 3.2a).

Subsequent fieldwork was carried out in two separate steps. In the reconnaissance phase, points requiring further clarification were identified. These were so worded in the questionnaire that was administered to the farm households by the field assistants (3.2). For the refined work such as transect sampling, eight agricultural professionals were selected among the thirty participating in the reconnaissance phase.

3.3. Field work

Field data were collected in four iterative steps (see fig.3.2b; fig3.3). The first step was reconnaissance (fig.3.2a), which yielded general data by means of a comprehensive questionnaire, protracted participatory observation as well as formal and informal discussion. This step took longer than generally allowed in most studies. The investigator had to converse with the few elderly people living at quite dispersed localities. Moreover, he had to visit markets, the *songgo* (village meeting place) and burial ceremonies. The last two in particular proved of extra-ordinary importance, as farmers unlike in other places had time to concentrate and discuss. Information coming from these informal discussions with farmers had to be verified in the field, through discussion with farmers in action. Not only each farm was different from all others but also farms belonging to the same farmer differed. Therefore, a visit or two had to be paid to each. Visits had to be planned according to the farming calendar and also according to the farming schedule of individual farmers. With the farmer by his side, the investigator found the farms as useful as a well-shelved library.

Notes from the preceding observations and discussions were integrated into the study questions. The latter were checked and rechecked. Based on this preliminary work, a comprehensive questionnaire was organized. Administering these to farmers, through the development agents of the Agricultural Bureau for the Gedeo zone took, about three months. This is not extraordinary, as farmers had their own schedule and nothing can be done without their co-operation. The forthcoming data were the topic for discussion among the agriculturalists of the Agricultural Bureau.

After condensing forthcoming data in the light of the research questions, a checklist of points (annexed) focusing on few chosen points was formulated, aimed mainly at collection of quantitative data, again in farmers' fields. Implementation of various sampling regimes such as transect sampling, soils sampling, samples to estimate the carrying capacity of the "agroforests" was followed. At each step, forthcoming information was evaluated, against the research objective and questions, and integrated with the existing data.

Looking at the resulting data from the perspective of the iterative steps, i.e., reconnaissance, farm households and field, is helpful in the understanding of the text.

3.3.1. Reconnaissance

A map made by Privateers N.V. and Treemail using points and landmarks available from the reconnaissance and radar data covering Gedeo zone met the need for accurate maps. Stereo radar images (S2/S7 beam) were procured from the Canadian RADARSAT satellite. The raw data was processed by the Privateers N.V. into a digital elevation model with accuracy within 25m (x, y and z) and several derived products, including a contour map and an anaglyph. These maps proved to be of sufficient precision for executing and planning the field-work. The investigator received a one-month training at the European offices of Privateers N.V. in Toulouse, France and Treemail in The Netherlands. The mapping project was duly reported and presented at international space conferences (Kippie, 1994; also see annex) and in a final report to the funders of the mapping project (Nezry & al., 1999). The satellite maps (e.g., plate 8.3), together with locally available maps (fig. 3.2a) were of extraordinary importance in locating our study sites.

Reconnaissance was carried out over 36 Farmers' Associations of the Gedeo zone (see appendices for the list of farmers' associations from which research sites were selected).

In preparing the questionnaire, extensive use of the archives of the Agricultural Bureau for the Gedeo Zone (ABGZ) was made. Moreover, Ethiopian libraries, Dilla (the Library of Dilla University College), Wondo-Genet (the Library of the Forestry College), Awassa (the Libraries of Debub University), Library of the Ethiopian Agricultural Research Center, Library of the Agricultural Bureau for Southern Nations, Nationalities and People's Region), Addis Ababa (Libraries of Addis Ababa University, The Library of Forestry Research Center, The Library of Ethiopian Agricultural Research Organization, Main Office), were consulted. Moreover, several visits were paid to selected sites in the Gedeo zone. Discussions with elderly farmers, with professionals working for different departments in Gedeo Zone, with zonal administrators and other key informants were made before embarking further on the reconnaissance. Being a co-sponsor of the present study, the Agricultural Bureau for the Gedeo Zone made human resources available. Thirty field assistants well versed in Gedeo language and culture with high professional merit and knowledge of their working area were selected. These were given a week's training on the type of data to be collected and ways to collect these data. Then the field assistants were stationed at selected sites. Professionals (soil scientists, sociologists, home economists, agronomists, foresters, agro-economists, horticulturists, animal scientists) of the Agricultural Bureau assisted in supervision of the field assistants. Professionals from other Departments of the Gedeo zone (geologists, geographers, hydrologists, and cartographers) were also involved. To reduce both cost to the project, and disturbance of the work schedule of the professionals, fieldwork was synchronized with their official duties. The reconnaissance took three months. Seventy farm households in three zones were consulted in this phase.

For the location of the Gedeo country (figs.1.1; 1.3) and its climate (fig. 1.2a and 1.2b), see ch. 1.

Data on the limits as well as landmarks of three altitudinal zones (ch. 1, fig.1.3) were collected. In each of these three, representative sites were selected. Representativity was established using data from the pre-reconnaissance phase. It was discovered that Gedeo land use consisted of three tiers, following altitude, from the lowest point to the top. The midland zone hosted the most complex of the land use systems. Complexity decreased in either way, i.e., upwards or downwards. Therefore, sites representing these three levels of complexity were delimited. From each, a broad inventory of their resources, i.e., climate, landforms, geology, hydrology, soils, land use, settlement pattern as well as limitations were collected (fig.3.2a).

In the third step, detailed investigation of ecological characteristics like soils and drainage, wild fauna and flora, and focus of the agricultural land use, potential and constraints and regulatory processes (of ecological and economic constraints) at each of the three zones were collected. Moreover, the structure of man-made vegetation, crop performance (yielding potential) by visual observation and asking questions, principles and practices applied by the farmers in farm management, use of biological diversity, nutrient status of soils using indicators such as crops and weedy vegetation as used by the farmers and methods used in soil maintenance were assessed. Also, tangible and intangible products and services from the "agroforests". Gedeo land use is similar to forest land use, because of the preponderance of perennial components, which like in forests show a long initial period between planting and harvesting. Multiple use of the resources (food, fodder, wood, medicine, soil, water and biological conservation) is also similar to silviculture.

3.3.2. Data collection from farm households

Gathering information from farmers was not an easy task, as found earlier by authors such as Chambers (1985). The fact that field assistants were once farmers themselves, proved highly important in avoiding pitfalls such as professional and/or urban biases. The assistants were assigned to sites selected from the three altitude-based zones, three each in the highland and midland zones and two in the lowland zone. The assignment shows the relative importance of the study zones. More than 95% of Gedeo country is highland and midland zone and the lowland constitutes less than 5 %. A week's additional training, on the details of the data to be collected and approaches to be followed was given to the eight field assistants by the investigator at Dilla.

The assistants were provided with a checklist of questions, not a questionnaire. A questionnaire was initially intended, but changed into a set of checklists (annexed) because of lessons learned from the reconnaissance phase. Moreover, these assistants approached farmers, behaving in well-proven indigenous trust-building ways. Gedeo tradition requires certain obligations on the part of the seeker of information or knowledge seeker, such as respect for the informant, "*beeka*", literally meaning wise and intelligent. The information seeker, "*qodhaanjjo*", literally meaning "student" must heed what is said and must act less knowledgeable and be careful in the wording of his questions. The investigator has been of much help by virtue of his long-time acquaintance (more than twenty years) with the Gedeo society. Indeed, the checklist of key points was more appropriate for the Gedeo who would have become bored, and have lost interest, if a formal questionnaire had been used. Therefore, the field assistants had to walk in the fields with farmers or chat in their house or other meeting places such as the *songgo* or burials or markets where farmers could spare some time. The checklist also helped in avoiding the impression with farmers that they were being interrogated.

In this phase, twenty seven farm households, nine at each of the three zones, were consulted. At each zone, at least two categories of farm households were selected. Age-wise, young, middle-aged and old, resource-wise, poor, middle and rich, male and female, education, literate and illiterate. The criterion of age is important because experience depends on it. Resource endowment is important as it affects the farm households' strategy. Various parameters were used in finding the category to which a given farm household belonged. For instance, size of land holding was used in assessing resource endowment. In the study area, heads of poor farm households had a small area of farmland, had fewer mature *ensete* plants and trees and often participated in off-farm work. Reputation of farmers in their community was considered. Gender division of duties was important. Women had the monopoly in deciding on farm products except coffee, which is considered men's domain. The category of education (illiterate and literate) is important, as literate farmers differed in their attitude to change from their illiterate brothers.

3.3.3. Data Collection from the farms

After reviewing the data coming from the farmers, preparation for the final stage of data collection was made. The objective in this stage was to check how data coming from the farmers fitted into the field situation. Moreover, field data were needed to complete the picture of Gedeo "agroforestry" systems. To that end, representative sites, i.e., containing the basic features of each of the three agro-ecological zones, were selected. Farmers willing to allow measurement of their fields and crops were identified. Collection of these data was also distributed over the seasons.

Data collected at this stage focused on farm design and performance, such as data on cycle of planting and harvesting and on the level of agrobiodiversity. The latter was estimated from the general farm design. Data on the carrying capacity of the "agroforests" were collected from the farmers themselves, by direct measurement in the field and also indirectly from the literature and other informants. Combining direct and indirect observation was essential due to the sensitivity of the farmers in disclosing such data. Moreover, data on soil input-output dynamics and fertility status of the soils under different management regimes and data on principles and practices used by the farmers were collected. Farms for soil sampling were selected using the procedure of stratified probability sampling (Gomez & Gomez, 1984; Mead & Cornow, 1983; Kennedy, 1983). Other data were collected from the farm households selected for the case study and their farms.

Data were also collected to reconstruct the history of Gedeo "agroforests". To obtain such data, the investigator had to visit Gedeo farmers who were said to be in the process of establishing new farms near forests in Hageremariyam and Shakiso woredas of the Oromiya Region, about 150 kilometers to the southeast of Dilla. This helped, as will be elaborated later (ch. 9), to understand the pattern of development in the land use (cf. Van der Wal, 1999). This was important as it helps to appreciate the similarities and/or differences between Gedeo *ensete*-based land use systems and others. Placement of fields in relation to the residential area of the household gives a distinguishing element among *ensete*-based landscapes belong to different ethnic groups in Ethiopia (Abate & al., 1996).

Regarding the dynamics of the Gedeo "agroforests", Kippie (1994) stressed the point that a *silvatic mosaic* persists, similar to natural forests (Kippie, 1994, page 71). Oldeman (1990, page 401) defines a *silvatic mosaic* as "a forest area subjected to the same regime of climate and soil, which shows the same complex of silvigenetic dynamics, resulting in an eco-unit composition that oscillates around a specific state and determining the architecture and ecological functioning as long as the resource regime remains essentially unchanged". It is important to relate Gedeo "agroforests" to *silvatic mosaics*, because in the "agroforests", like in natural forests, a system of multiple rotations for the diverse crop components results in the formation of diverse eco-units ranging from one year to a century. Therefore, each of the three landscapes is capable of accommodating conditions for the formation and reproduction of such *eco-units*. The multiple rotation used by the Gedeo in order to ensure the sustainable flow of useful products is also to dynamics what *silvigenesis* is to forest dynamics. To check this, data on mixed and even-aged and mixed and uneven-aged plantations at diverse stages of development were collected.

Management of perennial crops necessitates their distribution according to their rotation time. This is the case among the Gedeo as in sustained yield forestry (Ciancio, 1997). Therefore, in order to substantiate the sustained flow of useful biomass, components in different development stages were enumerated. Michon (1983) defined this for agroforests in Indonesia, as "trees not yet producing" "productive trees" and "trees not producing any more". Hence, wood is taken from "trees that produce no more", wood being a secondary or minor forest product. In our case, the *class of the present* comprises plants that have reached their final expansion, the *class of the past* those in the senescent phase (such as flowering *ensete* plants) and the *class of the future* those components in between the seedling and the producing components. Data on the composition of the classes of the *future*, *present* and *past* were gathered. Data on components in different development stages were collected. So were data on crop mixtures, farming calendars, as well as size and lay-out of fields. Collection of such data involved long term participatory observation and discussions with farmers.

(1) Moreover, data on ecosystem architecture (arrangement and form of components in space and time) were collected. Also, data on farm density of perennial elements in each of the three zones, most frequent species of the perennial components, crops preferred, and management strategies applied were collected.

(2) The architecture of the vegetation was studied using transects. Three transects were made, one for each of the three altitudinal zones, highland, midland and lowland.

In order to substantiate the assumed higher carrying capacity of Gedeo "agroforests", data on the use efficiency of the available space (e.g., tree crowns, ground layer) were also collected.

(3) Data on the architecture of the vegetation (horizontal and vertical arrangement of the plants) were collected. Also, the use of the vertical space such "product layers", "horizontal product species" defined by *pacemakers*, *spacemakers* and *placemakers* were assessed (Neugebauer & al., 1996; ch. 2). And so were data on wild fauna and vegetation used as leafy vegetables, medicine or fodder.

3.3.3.1. Data on soil input-output dynamics

Gedeo "agroforest" soils represent another element of complexity. In most ecological studies, the soils are left out as a black box, i.e., they remain unexplained except in physical and chemical terms. However, "agroforest" soils like forest soils are maintained by an intricate system of interrelationships among the floral, faunal and microbial life forms. Thus, their study would make a subject for several fully-fledged theses. Therefore, what is attempted here is a precursory study, to show some of the trends in their dynamics.

The Gedeo know that soil maintenance is the key to sustainable agriculture (Carter & Dale, 1976). Much of their soil maintenance focuses on enhancing natural processes working towards their objectives. Therefore, an account of the principles and practices used by the farmers in soil maintenance is expected to yield clues as to what extent management goals are met. Moreover, a larger part of the Gedeo land use history lies in their soil use history. Therefore, data on Gedeo soils are essential to have a clear picture of Gedeo "agroforests".

Data concerned ways and time of working the soil, the tools and implements used as well as the nature of inputs used. Moreover, data were collected on the behavior of the multi-purpose tree species and shrubs as well as data on the prevalence and use made of the "weedy" herbaceous in soil fertility maintenance. Furthermore, data on types of animals kept as a source of farmyard manure were collected in different zones.

To see the effect of various management options, soil samples from the upper 60 cm as well as herbarium samples were collected and analyzed. The latter were taken from five multi-purpose tree and shrub species particularly used by the farmers in soil maintenance. *Ensete* root samples were also taken, in order to investigate the contribution of *ensete* plants in soil maintenance, due to their high number in the fields and due to their above-ground and below-ground architecture. Classical soil samples to a depth of 60 cm were taken by auger from annual crop fields, from fields of perennial crops, from arable lands, from *ensete* fields, coffee fields and mixed fields, following the usual procedure of soil sampling. Soil augers used had a 0-15 and 15-30 cm calibration. Field prospectors from the Awassa Agricultural research center in Ethiopia used them, with field assistance from the soil science experts of the Agricultural Bureau for the Gedeo Zone.

Soil samples were analyzed for parameters Fe, Cu, Mn (available), Zn (available) Nt (%), OM (%) and CEC (meq/100g soil), pH (H_20), K (available), P (available), by the National Soil Research Laboratory in Addis Ababa.

The Gedeo follow two major soil management strategies, the one based on farm yard manure and the other based on crop necromass coupled with "weedy herbaceous vegetation" and multi-purpose trees. As it has been assumed that these have the same effect in achieving the objective of the Gedeo farmers, i.e., soil maintenance, data were collected to check this hypothesis.

3.3.3.2. Data on the carrying capacity of the "agroforests"

The distinction between total or agro-ecosystem yield, i.e., yield from all agro-ecosystem components present and "single" yield, i.e., yield from a single or a few components available for harvest at any one moment, is important here. In perennial cropping systems as Gedeo "agroforests", "single" yield, being only a small fraction of the total yield, cannot explain the carrying capacity of these "agroforests". Therefore, it was essential to account for the total yield, as much as possible, as is done by the farmers. Moreover, total yield comprises, besides "useful" parts, other parts that are not tangible like benefits accruing to the general environment as a result of the system of cropping or its components. Though such comprehensive data are difficult if not impossible to collect, owing to the diversity of components involved which yield at different times of the year, data for their estimation were collected. For the same reason, farmers assessed data on individual crop basis, e.g., *ensete*, coffee, multi-purpose trees or shrubs. Hectare or acre-based accounting is unknown among Gedeo farmers. Thus, investigation, following farmers' method was carried out as it gives an indication of the total yield.

Obtaining quantitative data from farmers is difficult, as the latter do not keep written records. Farmers are also reluctant to reveal data on yield or income. Therefore, it was necessary to purchase some crops from the farmers and pay them to process these in their own way. *Ensete* and trees were studied in this way. Since *ensete* yield depends on the clone used, stage of development at which it is harvested and the environmental and/or management conditions, *gantticho* type, the most commonly used among the Gedeo, was used, at three stages, *daggicho**, *idago** and *beyaa**.

Normally, *ensete* plants are harvested at any of these three stages. Therefore, five plants from each development stage were purchased at each of the three altitudinal agro-ecological zones, highland, midland and lowland. Measurements of plant height, leaf length, circumference of the pseudo-stem at the thickest point, average root length and the weight of the parts harvested and processed including byproducts was taken. Roots were dug up and root weight within a one meter radius taken. *Ensete* mass before and after fermentation was also determined. Developments were recorded until the fermentation period of one month was completed. Finally, the fermented product was measured and 56% of it was subtracted from the result for 56 % of fermented *ensete* product is assumed to be moisture (Pijls & al., 1995; Hiebsch, 1996).

The resulting data were divided by the surface and period of time (in years) taken to grow the plant to derive the plant yield per year per m^2. This was divided by the average spacing used. Thus,

Plant yield per year per m^2 = yield (kg)/average spacing (m^2)/number of years

The resulting figure was multiplied by 10,000, (1ha = 10,000 m^2) to obtain yield (tons) per hectare.

Likewise, data on Gedeo uses of the crop components, e.g., multi-purpose trees for fodder, soil maintenance, wood consumption (fuelwood, construction, source of cash, cultural and others), were collected. Moreover, the nature of the crop components, e.g., multi-purpose trees used by the Gedeo (legumes, non-legumes), seasonal behavior of the trees and shrubs (leaf shedding, evergreen, flowering and fructification), crop association (beneficial or harmful to adjoining crops) and crop performance, e.g., rate of growth) were determined.

3.3.3.3. Data on agro-ecosystem diversity

Biological diversity is a structural property of living systems (Oldeman, 1990, 2001). The potential of living systems* to support other life forms is assumed to be indicative of their complexity. Thus, diversity which is the result of the complexity in tropical rainforests has received a lot of attention more than their complexity (Oldeman, 1990; Van der Wal, 1999). Thus, instead of organisms that are therefore only parameters of this complexity, it is argued in the present study that agro-ecosystem complexity be the focus of research and management. Moreover, these structures (numbers of species) cannot be managed but agro-ecosystem complexity can be managed (Oldeman, personal comm. 2001). This is not, however, to belittle the usefulness of the inventory of components (numeric) used to measure this complexity but also to appreciate it.

Therefore, data on biodiversity were collected as indicators of agro-ecosystem complexity. Therefore, survey of higher flora and fauna (mammals, birds, reptiles, amphibians, arthropods) known to farmers over selected fields, using Gedeo terminology, was carried out. Among the higher flora (flowering plants) and fungi, data on the diversity in major crop components (*ensete*, coffee, multi-purpose tree and shrub species, herbaceous crops and 'weeds") were collected. Since, these are well known to farmers because of their functions, e.g., honeybees for honey and beeswax, fungi for their food value, insects other than honeybees for their activities such as termites attacking wood, using farmers' terminology in the collection of data, was helpful.

3.3.3.4. Data on farm management

Data on all agronomic and forestry aspects of the agro-ecosystem components were collected. Thus, data on inducing reiteration in *ensete*, coffee and major multi-purpose trees, data on field planting and management of the preceding perennials and annual crops, data on harvesting and storage of diverse crops, data on crop protection were collected. Moreover, data on marketing (data on items bought and sold in markets and data on problems of exchange) were also collected.

3.4. Controlling the forthcoming data

This was achieved through the use of multiple approaches. Choosing field assistants with roots in the study area (Chambers, 1985) proved worthwhile. These acted as key informants themselves and they also knew how to approach farmers and efficiently gather necessary information. Besides, controlling the forthcoming data was achieved through conducting group discussions among farmers, by asking the same question using different approaches (Chambers, 1985) among the field group (at the end of each session), and among the field group and farmers. This also helped to clarify points. Most important, participatory observation, i.e., participating in farm work, earned the investigator and field assistants trust of the farmers facilitating avenues for more discussions.

Since harvest or any other field activity was under observation, the chance for misunderstanding was minimized and in this way controlling the forthcoming data was possible. Symptoms such as bulging *ensete* pseudo-stem indicate good soil fertility or abundance of flowers indicate good harvest of honey or abundant flowering in coffee indicates good coffee yield or abundance of mature *ensete* plants or trees in farms show relative wealth, water held in *ensete* leaf-sheaths indicate the amount of rainfall that fell not too long ago. But most importantly, distribution of the observation and data collection over seasons and years helped most in controlling the forthcoming data.

Manageable precision levels, at appropriate places, were maintained. Generally, the accuracy within a range of plus or minus 5% was assured in all measurements. For perennial components in transect plots 30 X 5m large, center of base was measured with an accuracy of plus or minus 30 cm, crown radius measured at 4 directions with an accuracy of 40 cm. Tree height was measured using a *Suunto* height-measuring device at flexible distances, taking into account corrections for the slope. Measurements are in the accuracy range of plus or minus 2 m. *Ensete* and coffee plants were measured directly, using graduated poles. For these measurements, the accuracy is plus or minus 0.5 m.

Chapter 4. Agro-ecosystem architecture

Abstract

The design of Gedeo "agroforests" is analyzed. Agro-ecosystem components are divided into core and subsidiary types. The first type has a pacemaker role (regulation of agro-ecosystem rhythm), a *spacemaker* role (provision of biotope space for other components) and/or *placemaker* role (provision of living space, or niche for other organisms). The core components are represented by *ensete* (*Ensete ventricosum* (Welw.) Cheesman MUSACEAE) and various species of multi-purpose trees and shrubs. These therefore act as cornerstones, holding the whole agro-ecosystem intact. Components with a subsidiary role represented by annual crops, coffee or farm animals are regarded as "fillers", to wit organisms with supportive role. Gedeo land use represents a pre-existing universal ancestor of which modern-day specialized forms of land use (forestry, horticulture or agriculture) are descendants. Farmers employ a holistic management keyed to this agro-ecosystem complexity. Thus, farmers manage agro-ecosystem complexity, in ways that increase biotopes for "useful" organisms and decrease biotopes favoring pest or disease organisms. This holistic management is different from the "management of biodiversity" as if it were a more or less independent agro-ecosystem property responsive to direct measures. By choosing *ensete* and trees as basic building blocks of their "agrogforests", farmers have made a crucial step that staves off hunger, in a mountainous terrain otherwise liable to erosion by rainwater, to drought or to famine.

4.1. Background

The present chapter deals with agro-ecosystem architecture, i.e., the spatial and temporal organization of interacting parts. Interacting parts consist of the domesticated biophysical environment at different levels, crop fields, populations of crop plants and individual crop plants and/or animals. The whole Gedeo zone having three altitudinal agro-ecological zones as subsystems is viewed as a landscape, the system at the highest level. Crop fields within each of the three agro-ecological zones together with the crop components are analyzed as systems at the lower level. How at each system level data are transmitted from a level below it to a level higher up or vice versa, is explained in chapter three. The present chapter as a whole defines agro-ecosystem complexity.

The document by Kippie (1994) shows the elements of the basic design for Gedeo land use. The all-inclusive nature of this design, integrating diverse farming systems, crops and animals into one indivisible whole (ch. 2), differentiates Gedeo land use from other *ensete*-based systems in Ethiopia (Westphal, 1974; Asnaketch, 1997; Bezuneh, 1996; McCabe, 1996). This complexity can only be explained by examining the farm design, using the systems outlined in chapter 3.

This approach is close to the viewpoint of Oldeman (1990), advocating management of agro-ecosystem complexity. Since crops like *ensete* are emphasized, Gedeo land use design also relates to unity in diversity. This is well illustrated in Kippie's system of multiple rotations. There is a selection of crops with above-average performance, to wit the building blocks of the agro-ecosystem. This in turn invokes such concepts as pacemaker, spacemaker and placemaker (Oldeman, 1995; Neugebauer et al.1996), all related to the functions of key species in domesticated ecosystems.

Crop performance on the other hand is associated with spatial and temporal organization. This in turn touches on the efficiency of use of natural resources, such as soil nutrients and energy from the sun (Oldeman, 1983; Huxley, 1983; Neugebauer & al. 1996; Rossignol & al. 1998).

A relevant concept in crop organization is architecture, explored in chapter 3. It was defined as the spatial distribution and form of the interacting components in a system, expressing its organization. As stated, this concept draws from systems' theory and can be applied at any hierarchical level chosen (Oldman, 1990). A related concept is an *eco-unit*, which was defined as one ecosystem developing on one surface cleared by one impact, from one specific moment on and by one development process (Rossignol & al. 1998). Agro-ecosystem architecture viewed on the level of a field refers to the spatial distribution and form of *eco-units* within the mosaic in the field (Van der Wal, 1999, p9). As mentioned earlier (ch. 2 and ch. 3), the whole agricultural field may be one large eco-unit, or a mosaic built and composed of eco-units of various sizes and/or development phases (time, age). These concepts form the basis of the present analysis of farm design.

With the resulting data, a comparison of farm design between any two zones will be possible. In particular, this refers to some topical questions. How are production of useful biomass and maintenance of the production base related to agro-ecosystem architecture? How does managing agro-ecosystem architecture help in enhancing and/or managing agro-biodiversity? This chapter reports.

4.2. Materials and Methods

The field work was conducted between June 1998 and May 1999.

Data were collected in two steps. First, a survey was carried out, with a checklist of questions presented to farmers (annex no.1). Second, case studies were carried out including the mapping of selected farms and farm components. Details of the procedures followed are given in ch. 3. General land use design, type of farm components (including biodiversity) and the spatial and temporal organization of the farm components, as well as farm performance (farming calendar) were assessed in the three agroecological zones.

In recording the diversity of life forms, folk taxonomy of the Gedeo was used. Without any preceding taxonomic work, not even a checklist, this was the only viable option. Wilson (1992) mentioned the use of the same strategy, in an ornithological study made by Ernst Mayr among the Arafak of New Guinea.

4.3. Results

4.3.1. Agro-ecological zones and the farming calendar

Mainly based on moisture and temperature (fig. 4.1), the Gedeo recognize four seasons (tables 4.1 and fig. 4.2) on which their farming calendar is based (tables 4.5a, 4.5b and 4.5c). These seasons are, *Bonoo,* from mid-August to mid-January, *Ba'leessa*, from mid-January to mid-March and *Haarsso,* from mid-March to mid-May and *Adooleessa* (from mid-May to mid-August. *Bonoo is a* warm and moist season about 150 days long. It is the main harvesting season. *Ba'leessa* is the driest season of all, with burning heat (qaamoo), and about two months long. Farm preparations are made in this season. *Haarsso* is a rainy season, about two months long. It is in this season that most perennial crops, including coffee, *ensete* and multi-purpose woody perennials, are planted in the field (table 4.5b). *Adooleessa* consists of intermittent rainy and dry days. With a duration of

Table 4.1. Farmers' use of climatic conditions. Both temperature and moisture as observed by farmers, given on a 1-to-5 gradient, in which 1 is very cold/wet and 5 is very hot/dry.

Season	Temperature	Moisture
Bonoo (warm, moist)	2.0	2.4
Ba'leessa (burning, dry)	4.0	0.4
Haarsso (mild, wet)	1.4	4.0
Adooleessa (cold, wet)	1.0	3.5

Source: Reconstructed using data presented in Ethiopian Mapping Agency (1979) and information coming from farmers.

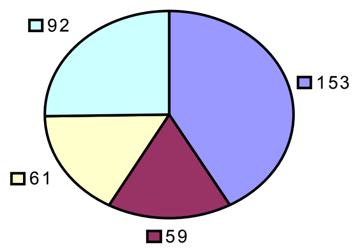


Fig4.1. Relative length of seasons (in days). 1 = *Ba'leessa*, 59 days (season for land preparation), 2 = *Haarsso*, 61 days (planting season), 3 = *Adooleessa*, 92 days (the long rainy season) and 4 = *Bonoo*, 153 days (harvesting season)

Source: based on table 4.1

about 90 days, it is the long rainy season. It is the season in which preparations for harvest are made. *Adooleessa* and *Ba'leessa* being transitional seasons, are used for transitional activities such as preparations for harvest or for planting (see fig. 4.1).

Crops come to maturity early in the lowlands, late in the midlands and latest in the highlands. The same is true in the behavior of arborescent species, which lose their foliage in the dry season and flushing in the wet season, followed the same pattern. *Ensete* on the average has a long rotation in the highland zone (up to 12 years), an intermediate on in the midland zone (up to 10 years), and a short one (7 years) in the lowlands. Vegetable and fruit crops follow the same trend. Farmers see this as an advantage, as this goes well with their principle of biomass storage in living plants (ch. 6 and ch. 8). This also facilitates interaction among the diverse agro-ecological zones. As a result, the Gedeo zone as a whole has the longest harvest season (*Bonoo)* see table 4.2). Major types of crops and their arrangement in the three major land use versions are reviewed in table 4.3.

Table 4.2. **Some geographic features of the Gedeo Zone**

Agro ecological zones	Altitude (*m. asl*)	Temperature (degrees Celsius)	Annual rainfall (millimeter)	%Area
Riiqata (lowlands)	<1750	*above* 25	*above* 800	*1.5*
Dhiibata (midlands)	1750 - 2500	*minima* 8.7 *maxima 26.4*	800 - 1000	83.3
Suubbo (highlands)	>2500	*less than* 16	1000 - 1200	*15.2*

Source: Reconstructed from Eth. Map. Agency (1988) and information from farmers.

4.3.2. Land use design

Agro-ecosystem diversity, expressed in the diversity of landforms and altitude, is both the condition for and the result of the high crop diversity. This is an important aspect of agro-ecosystem complexity. Agro-ecosystem design provides farmers with the opportunity to enhance this complexity if and when necessary. This is shown in the block transects (Appendix 4.2a, 4.2b and 4.2c). Three basic agro-ecosystem designs are distinguished, each corresponding approximately to one of the three agro-ecological zones. However, as with other aspects of Gedeo land use, there is unity. In the two designs, in the highlands and lowlands, outputs are similar or comparable to those from the midlands. This is achieved by sequential crop rotation.

This once more shows the cultural origin of these variations, which, though being founded on the same principles, are adapted in their operational aspects to the biophysical environments, of the three altitudinal combinations of climate and soil.

Table 4.3. Farmers' characterization of crops in the three agro-ecological zones.

Characteristic	*Major agro ecological zones*		
	Hot Lowlands	Medium Highlands	Cold Highlands
On farm vegetation diversity	high	very high	high
Enset (*ganticho type*)* age (years from suckering till flower-initiation)	4 to 7	6 to 10	9 to 12
Major crops grown in association (in sequence or simultaneously *with ensete)*	maize, banana, mango, avocado wheat, barley pulses, sweet potato, coffee	coffee, taro, *boyina*, (maize as vegetable), barley, sorghum	barley, wheat, pulses, onion, garlic, leaf cabbage, Irish potato
Major woody species used	*Ficus* spp *Milletia ferruginea* *Cordia africana* *Erythrina abyssinica* *Vernonia amigdalina* *V. auriculifera*	*Milletia ferruginea* *Erythrina abyssinica* *Albizia gummifera* *Vernonia amygdalina* *V. auriculifera* *Cordia africana*	*Erythrina abyssinica* *Milletia ferruginea* *Arundinaria alpina* *Vernonia amygdalina* *V. auriculifera* *Ficus*. spp.
Farm size (ha.)	up to 1.5	up to 1	up to 2
Farm inputs used in order of of importance	Farmyard manure Household refuse Recycling yield	Recycling yield Household refuse Farmyard manure	Farmyard manure Household refuse Recycling yield

* *Ganticho* is the name of the *ensete* type commonly grown by the Gedeo

Source: This study.

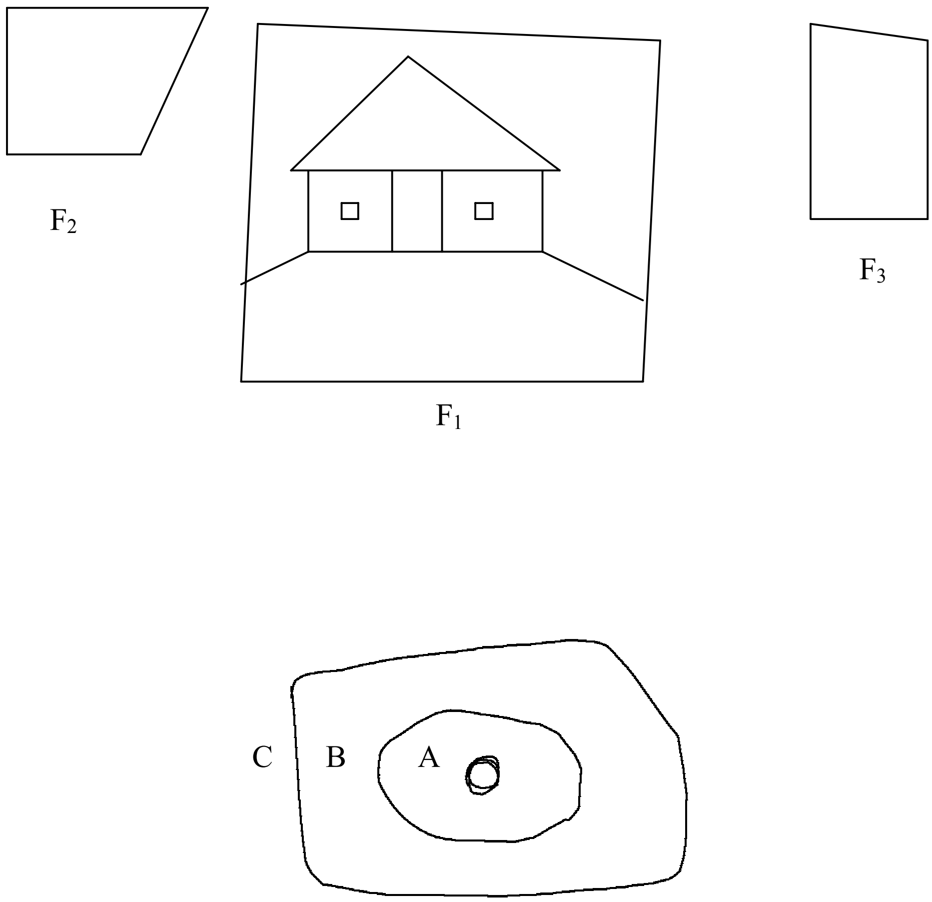


Fig.4.2. Farm lay-out among Gedeo farmers. Residential and farming area (top) and its plan (bottom). The household chooses a site (F_1) from its holdings (F_1,F_2,F_3). In the middle of the farm chosen, a dwelling is established. The three tiers, a hut (A), a yard (B) and ficha (C) are shown in the plan (bottom). A foreyard is used as a breathing space and backyard for leafy vegetable production and also as an *ensete* nursery. The yard is usually separated from the field by a fence. The latter is used for lianescent crops such as climbing pulses and/or pumpkins (table 4.5).

In all three zones, the Gedeo live in dispersed settlements. Each household sits in the middle of its holding (see fig.4.2). The settlement site is subdivided into three parts, the hut (*minee*), the yard subdivided into foreyard (*baxxee*) and backyard (*gatee*), and the field (*fichcha*). The latter comprises the planting area, which cannot exceed 2 hectares (see table 4.4) following the social rules and habits of the Gedeo.

Walls separate the kitchen, bedroom and living room in the house. The kitchen is the exclusive property of the wife. A store can be attached to the bedroom, or part of the living room can be used as a store if the hut is large. An animal shed may also be annexed to the hut. In the highland and lowland zones, animal sheds are built in the backyard. The verandah (*soro*) is used for the storage of fuelwood and *ensete* food.

Due to the ongoing fragmentation of land by heritage, households working with a large single field are few. Most households operate several fields, dispersed within a walking distance from the dwelling area. Households from related families, their heads being sons of the same farmer, often form a cluster of huts. However, each keeps a farmhouse (*uranee*) on his own plot. The latter is one way of soil maintenance (ch. 7). In former times the whole system yielded goods reason for a polygamous marriage.

Table 4.4. Land holding surface (S) in hectares among the Gedeo farm households, in the four administrative communities.

Sub-zone or woreda		S ≤ 0.5	0.5 ≤ S ≤ 1.0	1.0 ≤ S ≤ 1.5	1.5 ≤ S ≤ 2.0
Wonago	(ha)	24898	7524	5264	nil
	(%)	66	20	14	nil
Y/Chaffe	(ha)	12958	10309	6444	2577
	(%)	40	32	20	8
Kochorre	(ha)	28656	7185	1633	752
	(%)	75	19	4	2
Bule	(ha)	3029	3946	5923	6903
	(%)	15	20	30	8
Gedeo	**(ha)**	**69333**	**28964**	**19264**	**10232**
	(%)	**54.2**	**22.6**	**15**	**8**

Source: The Agricultural Bureau for the Gedeo zone (unpublished).
N.B. The average family size among the Gedeo is 7 persons.

Two basic models were followed in establishing crop fields. In the first model, mixed cropping with single rotation is used, whereas mixed cropping with multiple rotations is used in the second. A good example of the first one consisted of growing a single crop comprising various land-races or types in an even-aged plantation or population. Thus, fields of annual vegetables, grains or even-aged *ensete* plantations are managed in this way. Mixed cropping with multiple rotations involves mixing crops with diverse rotation times including annual ones (plate 4.1; plate 4.2; plate 4.3; plate 4.4; plate 4.6). The latter is the major model used by farmers in the midland and lowland agro-ecological zones.

Mixed cropping with multiple rotations involves multiple "storeys" (see plate 4.1; plate 4.2, plate 4.6), with emergent trees occupying the upper canopy and shade tolerant species the root floor (fig. 4.3; transects, annex 4.2a, 4.2b and 4.2c). The concept of "storeys" is a complex one (cf. Oldeman, 1974, 1990). These layers should not be imagined as neat horizontal layers. *Ensete* and coffee occupy biotopes around the mid-

Table 4.5a The farming calendar in the highlands (above 2500m asl). Planting and harvest of onion, the most important cash crop, maintenance of soil with farmyard manure, harvest of *ensete* and woody perennials are carried out throughout the year. Grains, include barley (*Hordeum vulgare* L.) and maize (*Zea mays* L), field pulses (*Vicia faba* L. *Pisum sativum* L. garden pulses (*Phaseolus vulgaris* L (climbing), *P. lunatus* L. (climbing) and vegetables (onion (*Allium* sp.). Kale (*Brassica* sp.) and garlic (*Allium* sp.) are important crops.

No.	Activities	J	F	M	A	M	J	J	A	S	O	N	D
1	Prepare land for onion, harvest barley and field pulses	X	X										
2	Harvest vegetables, plant garden pulses	X	X	X	X								
3	Plant vegetables			X	X								
4	Plant vegetables, transfer suckering *ensete* corms		X	X	X								
5	Field-planting of *ensete*		X	X	X								
6	Plant tree seedlings, bamboo, Maize				X	X							
7	Tending *ensete* suckers					X	X						
8	Plant barley, tend vegetables					X	X	X	X				
9	Plant field pulses, harvest garlic							X	X	X			
10	Harvest maize											X	X
11	Cut *ensete* for initiating suckers											X	X

height in the vegetation while the seedlings of the preceding components occupy the undergrowth. This arrangement provides conditions for the higher plants and animals, fully, partly or yet to be domesticated. In their turn, the complexity of the green vegetation of larger seed plants provides nested biotopes for ever smaller plant and animal species and microbes (Oldeman, 1983a, 2001).

The biotopes for weedy plants therefore are secured (plate 5.1). Weeds provide a "nursing" function for the seedlings of the diverse species (appendices), just like they do in natural forests. Therefore, "weeding" in the present context consists of selectively removing, or rather harvesting, individual plants. The "weedy" biomass is used either as a mulch or as fodder for livestock.

Table 4.5b. The farming calendar in the midlands (1750 to 2500m asl) for [1]*Colocassia esculenta,* [2](*Phaseolus vulgaris* L. *and P. lunatus* L.) and [3]*Discorea abyssinica*, these are climbing garden pulses.

No.	Activities	J	F	M	A	M	J	J	A	S	O	N	D
1	Slashing the undergrowth,	X											
2	Harvest and plant *godarre*[1], sweet potato, collect and sell fresh coffee	X	X										
3	Harvest honey, plant sorghum		X	X									
4	Field plant *ensete,* maize, pulses[2]		X	X									
5	Plant coffee, tend tree seedlings				X								
6	Transfer suckering *ensete* corms					X	X						
7	Harvest honey, *boyina*[3]					X	X	X					
8	Slash, plant sorghum,						X	X					
9	Sell sun-dried coffee, hang beehives						X	X	X	X	X	X	X
10	Tending plantations									X	X	X	X
11	Harvest maize, cut *ensete*, slash										X	X	X

Mixed cropping in the highlands or lowlands, with a single rotation per field, requires dividing available land into several parcels, one parcel per each crop type. Multi-purpose trees are interspersed, as required and possible, in each parcel (fig. 4.3). Trees are also planted at farm boundaries. This is the case for woody species such as eucalyptuses and bamboo, which are regarded by farmers as hostile to other crops. Thus, such woody species "unfriendly" to other crop species are maintained at widely separated spots in the 'agroforests" in all of the three agro-ecological zones.

Scarcity of grazing land forced farmers to use the same piece of land for both food and fodder production, "weed" biomass being used for the latter. Fodder from the weedy vegetation is supplemented with crop by-products and pollarded tree branches, a farmer's technique invented and applied worldwide (see Oldeman, 1990). The latter is particularly important in the dry season when the weedy vegetation dries up (see fig.6.8).

Table 4.5c The farming calendar in the lowlands (below 1750m *asl*). Harvest of *ensete* and woody perennials are activities carried out throughout the year. [1] *Colocasia esculenta,* leafy vegetables including kale, pumpkin (*Cucurbita sp.*), *Phaseolus vulgaris* L. (Bushy type). [3] *Discorea abyssinica*

No.	Activities	J	F	M	A	M	J	J	A	S	O	N	D
1	Harvest and plant *godarre*[1], *land preparation* for maize, *hang beehives*	X	X										
2	Harvest and plant *godarre*[1]		X	X	X								
3	Pant coffee, MP trees and shrubs				X	X							
4	Cultivate maize and leafy vegetables[2]				X	X	X						
5	Harvest leafy vegetables[2]				X	X	X	X	X	X	X	X	X
6	Harvest *boyina* [3]					X	X	X					
7	Plant barley, wheat (minimum tillage)						X	X	X				
8	Harvest maize							X	X	X			
9	Harvest coffee									X	X	X	X
10	Harvest leafy vegetables[2]									X	X	X	X
12	Harvest honey									X	X	X	X
13	Plant *boyina*[3]										X	X	X
14	Harvest barley, wheat											X	X

4.3.3. Differentiation within crop components

4.3.3.1. Crops used mainly for the production of "useful" products

Farmers are concerned with the maintenance of their production base, as they are concerned with sustainable production of useful biomass. Therefore, harmonization with a view to optimize both in a balanced way is the option taken by the farmers. Most of their crop components indeed perform both functions. *Ensete*, the leading production component, for instance, produces more for the maintenance of the production base than it does for current consumption (ch. 8). The same is true of multi-purpose woody perennials, which besides wood and fodder also provide much leaf litter. Maintenance is also one function of the "weedy" herbaceous vegetation.

Agro-ecosystem components can be divided into two, separated by a fuzzy limit. The first set contains components producing mainly food, wood and other commodities vital for human subsistence. The second set includes components producing commodities for support, such as cash crops. The first set strictly defines the core properties of the system. The second set allows considerable freedom in arranging the production of subsidiary means and/or extra economic support, interwoven with the first set.

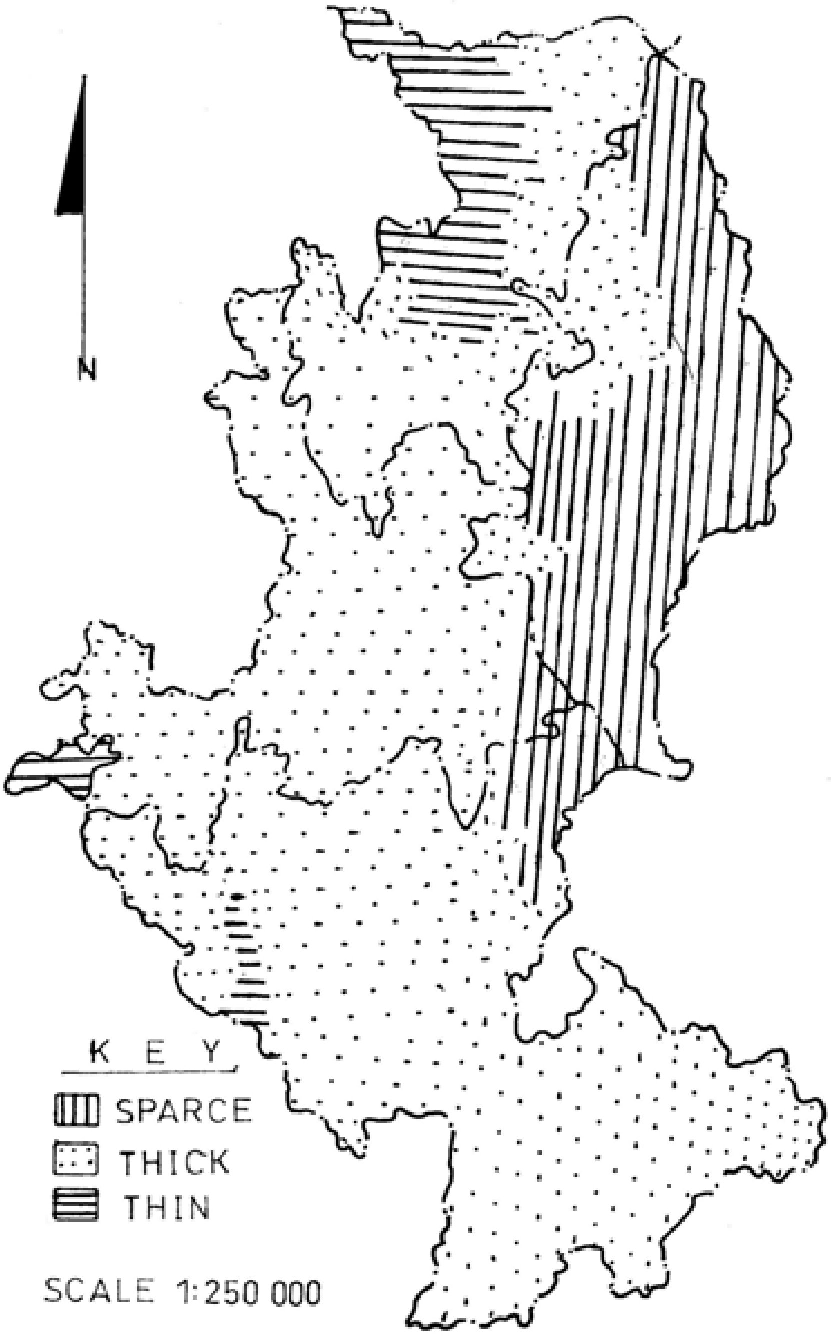


Figure 4.3. Map showing vegetation density of the Gedeo zone.

Source : This Study

Crop selection for the first set was remarkably constant in all three agro-ecological zones. However, considerable variation did exist in selection of species for the second set in each zone. This proves the point that free selection of subsidiary crop plants serves both adaptation to the zonal agro-climate and adjustment towards actual market prices and trends in local uses of subsidiary products.

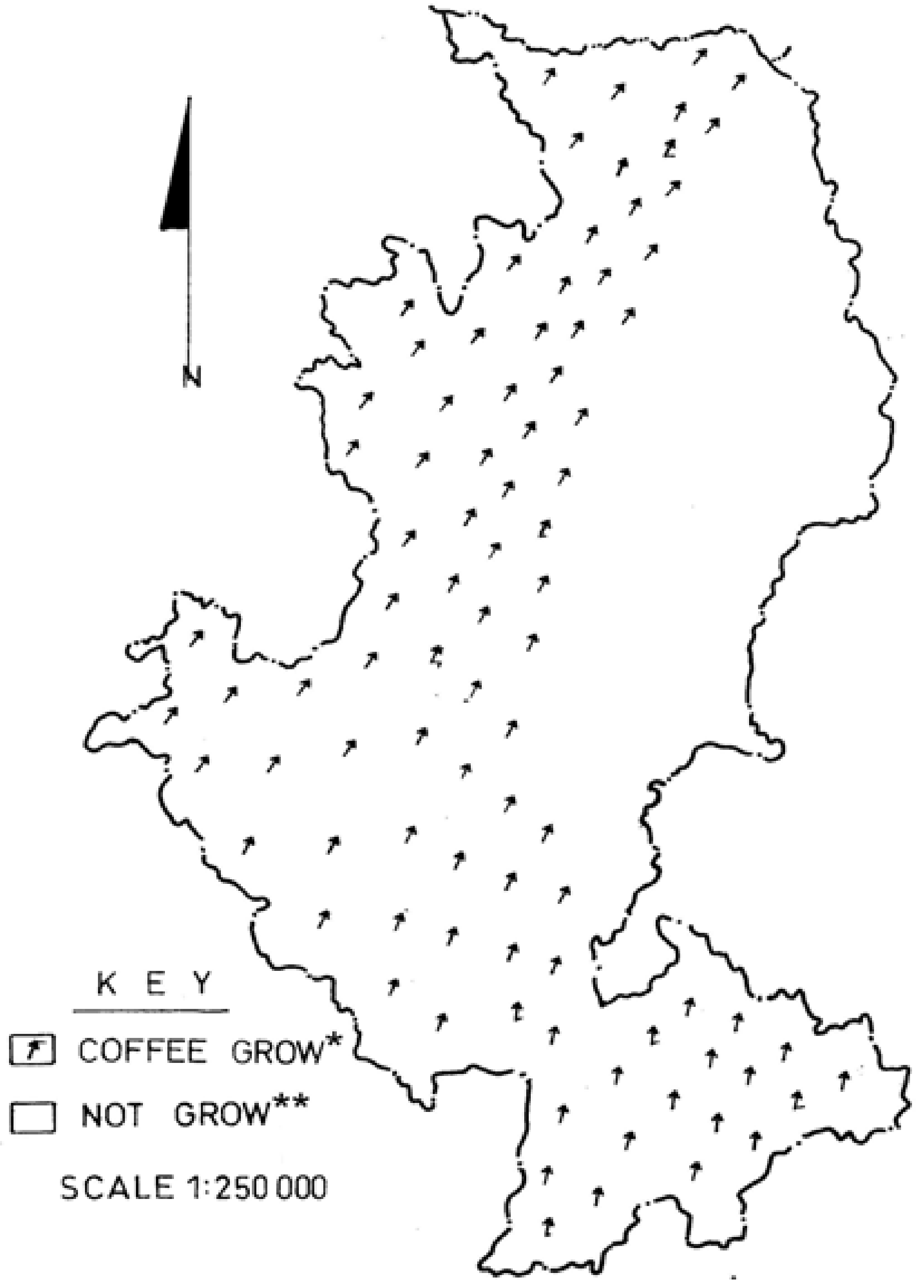


Figure 4.4. Map showing areas in the Gedeo zone considered as coffee belt zone.

* **Suitable for coffee**

** **Not suitable for coffee**.

Source : This Study

In order to satisfy their expectations from their crops, farmers had to be very careful with establishing spatial and temporal arrangements of the components. In other words, farmers have to know which species, given its growth habit and its relation to other crops, fits best in each of the many biotopes, originating within or below the crown and hence determined by the architecture of trees and other green plants, and/or from interaction between these (Michon, 1983; Sansonnens, 1995; Oldeman, 2001). The particular biotope required is not always present or frequent enough in natural circumstances (see plate 6.7). Farmers therefore resort to lopping and/or pollarding branches or removing some of the roots (fig. 6.8). In this way, harvesting products such as firewood is combined with the desired modification of the number and/or characteristics of desired biotopes. Of course, farmers do not express it in these terms, but this is what is tacitly done.

Generally, trees with spreading crowns and roots, such as *Ficus* and *Acacia* spp. are preferred in the lowlands. On the one hand, dry deciduous fig trees, locally known as *qilxxa,* are used as coffee shade, whereas, *ode'e*, another species of fig, retaining its foliage in the dry season, is used as *ensete* shade. On the other hand, trees with compact crowns which filter the light , such as *Albizzia gummifera*, (MIMOSOIDAE*)* and *Millettia ferruginea* (PAPILIONOIDEAE), are preferred as multi-purpose trees in the midlands and highlands. At still higher altitudes, *Erythrina abyssinica (*PAPILIONOIDEAE) and *Hagenia abyssinica* (CONVOLVULACEAE) gained in abundance, as multipurpose tree species. *Vernonia amygdalina* and *V. auriculifera* (ASTERACEAE), two fast-growing species providing small poles and mulch, were omnipresent throughout all agro-ecological zones. Nevertheless, the former is preferred because of its association with soil enrichment.

In some cases, punctual knowledge of the species behavior is not enough. Knowledge about the performance of a particular species under various environments, defined by such factors as topography or slope or precipitation, is required. *Erythrina abyssinica* trees make a good case. These trees are known to perform well in all agro-ecological zones. Still, they are found, only in flatlands and on valley bottoms. Indeed, because of their soft wood, the trees do not withstand heavy winds or rain if they are planted on steep slopes.

By virtue of its architecture, *ensete* (Holttum's model according to Hallé & al., 1978, with its leaves disposed in a funnel-like manner and its interlocking leaf sheaths like the tanks of the BROMELIACEAE (fig. 5.1, ch. 5) is put to multiple use. It captures and stores rainwater, because of it fibrous roots that hold the soil together, it is used in all places. *Ensete* indeed is not affected either by excessive rains or intermittent periods of drought. It is therefore capable to convert rainfall, which is otherwise a would-be curse, on steep slopes, into a blessing. Indeed, its choice by farmers as a pacemaker and placemaker rests on its proven performance.

Firewood to the Gedeo is as essential as *ensete* food. This also explains why plants like *ensete* are chosen as pacemakers and placemakers. Thus, plants with a temperament and properties like *ensete* are everywhere. In the cold highlands where trees cannot be fully integrated with the annual crops, they are still planted at farm edges, e.g. rows of eucalyptus trees making farm boundaries and/or along roadsides. With their fast growth and good form, foreign eucalyptus still did win the respect of the farmers, who cannot be convinced to drop it. Like *ensete*, dicotyledonous trees are multi-product components. Thus, besides wood, such trees provide shade and act as a buffer against hailstorms or harmful insolation. They also assist in soil maintenance by accumulation and humification of their litter, phyllosphere (Ruinen, 1974) and/or rhizosphere (Jenik, 1978) production, such as -fixation of atmospheric N by epiphyllic bacteria (Young, 1983) or of phosphorus by fungi in symbiosis with tree roots (mycorrhizae) (Munyanziza, 1994; White, 1997). Like *ensete*, trees provide biotopes for other lifeforms like nesting birds, which are in turn useful as pollinators or seed dispersers boosting the biological diversity of the agro-ecosystems, or by controlling insect populations. The niche provided by the trees for beehives is a good example of their placemaker role (plate 6.7, ch. 6).

The supportive or complementary role of the subsidiary components stressed in the previous pages, is both ecological as well as economical. Thus, in the midlands, coffee is very important as source of cash income, just like maize, mango or avocado in the lowlands (table 4.5c). The same is true for barley or wheat in the highland zone (table 4.5a). Livestock are also in this category.

Because of the multiplicity and variety of primary and secondary biotopes, Gedeo "agroforests" are as good as a natural home for the wild fauna and flora. Thus, biodiversity is a natural property of Gedeo "agroforests". As in natural forests, animals are transporters of matter and energy within and between agro-ecosystems. Farmers judiciously utilize this agro-ecosystem property, by conserving the "agroforest" floor below larger trees as a propagule bank (Oldeman, 1990). Animals taking refuge in the tree tops or on the "agroforest" soil, deposit plant seeds. One of the best 'Arabica' coffee trees are propagated in this way (ch. 6). Likewise, birds and insects pollinate flowers. This is facilitated by the emergent trees such as *Podocarpus gracilor* (PODOCARPACEAE), *Aningera adolfifriederici*, Rob. (SAPOTACEAE) reaching up to 30 to 50m high and by the trees of species like *Erythrina abyssinica* (PAPILIONOIDEAE), *Cordia africana*, (BORAGINACEAE) *Milletia ferruginea*, (PAPILIONOIDEAE) *Croton macrostachys (*EUPHORBIACEAE*)* and *Albizizia gummifera* Gmel, (MIMOSACEAE) occupying the medium canopy. Certain animals, e.g., birds of song, make sounds, interpreted and used by the farmers to judge the state of their agro-ecosystems as well as their own social state.

4.3.3.2. Crops used mainly for maintenance

The "weedy" herbaceous vegetation is the case in point here. Although these plants are useful in herbal medicine, as a source of leafy vegetables and/or for diverse ritual practices, their use as a means of ecological maintenance outweighs all (table 4.6).

Table 4.6. Use value (summary) of the "weedy" herbaceous vegetation. In total, 122 types of the "weedy" plants were named, appendix) in five major use categories (i.e., leafy vegetables, livestock fodder, soil enrichment, medicine and others). For details, see appendix 4.2.

Use category		no. "species"	%
1	One of the five uses only	31	16.4
2	Two of the five uses only	41	33.6
3	Three of the uses only	26	21.3
4	Four of the uses only	4	3.3
5	Other	18	16.4
Total		122	100.0

Source: this study

4.4. Discussion

For a better understanding of Gedeo land use, the concept of the ecosystem canopy as a green *folded blanket,* developed by Oldeman (1990; 2001) is important. This, as in forests, increases resource use efficiency, particularly the use of the incoming radiation and the interception of rainfall and with it, nutrient-laden throughfall (Sanchez, 1976; White, 1997). A canopy with multiple folds, each fold being folded again, also transpires much more than a flat surface. Finally, this is also related to the root (rhizosphere) production by the perennial components (Oldeman, 1992a; 2001). This is the background of the farmers having a proven, sustainable flow of products and services. This helps the farmers in obtaining from the "agroforests" a sustainable flow of products and services. They put to profit any or all metabolic surface, leaves above the ground and root hairs below, to obtain much higher photosynthetic production rates than any system with a simpler production geometry (Oldeman, 1992b).

Since their maintenance largely depends on the crop vegetation, *ensete*-based Gedeo land use can be related to systems of shifting cultivation where soil maintenance also rests on the vegetation (Sanchez, 1976; Ramakrishnanan, 1992; Vester, 1997; Van der Wal, 1998). In shifting cultivation, the cropland is reverted to bush fallowing for maintenance, whereas under Gedeo land use the two functions are inseparably integrated. The key to this strategy is selection of pacemaker and placemaker crops (Neugebauer & al. 1996).

Trees and *ensete* are such species, fulfilling all attributes of production and maintenance. If dry leaves of *ensete* used as fuel are considered, *ensete* has great similarity to a tree. In view of its food supply, relatively large *ensete* biomass is kept in the agro-ecosystems, over fixed rotation spans, showing its pacemaker role. Pacemakers regularize the rhytmic beat of a systems' dynamics. The placemaker role of e*nsete* is also expressed in the living space or niche it provides, like trees, for other organisms such as that used by microorganisms, worms, insects, frogs, snakes, to mammals. Placemakers make places where other organisms can live and grow, frequently enough to maintain a living population of each species concerned. Both roles have strong implications for the enhancement of species diversity by complexity. In this case, farmers manage this complexity. This is different from the "management of biodiversity", as if it were a more or less independent agro-ecosystem property on which direct measures can be brought to bear. Management of complexity is tantamount to installing an on-off mechanism in the agro-ecosystem design, which works automatically, like a kind of biological clock (Schütz & Oldeman, 1996).

The small weight attached by the Gedeo farmers to livestock should be seen as due mainly to shortage of grazing land rather than to dislike for the animals. Their need for livestock could have been greater, given the high carbohydrate but low protein content of the *ensete* diet (Ethiopian Institute for Health and Nutrition Research, 1997). As a matter of fact, the Gedeo are gradually moving away, in response to population pressure, from livestock production to crop production. This is in contrast to conventional view that livestock production is more intensive than plant production (McCabe, 1996). This can be seen from the relatively high importance attached to livestock in the highland and lowland zones, where there is relatively high availability of land as compared to the midland zone.

4.5. Conclusion

Gedeo land use design represents an instance of farmers' attempts in fitting together living parts of a living puzzle (Oneka, 1996). Because designs of living, i.e., growing and developing systems, are never complete, any imperfection in the design facilitates opportunities to follow, to learn, and therefore to improve, a process commonly called "monitoring". The Gedeo in this connection say, "*Reyon calla ko'o birttaan*", literally meaning: "One truly rests from work only when one ceases to live". This also implies that, as the Dutch saying has it, "One is never too old to learn."

Gedeo land use conforms to the criteria of agricultural systems. However, this land use could not be accommodated into the conventional definition of agriculture, i.e., the selection and breeding of a few high-energy yielding plants cultivated to the exclusion of all other "competing" plants. Neither does it fit in definitions of agroforestry systems, i.e., agricultural systems into which woody perennials are incorporated in some temporal or spatial arrangement (see Oldeman, 1983b; Kippie, 1994; Huxley, 1997). Rather, *ensete*-based Gedeo land use represents an example of a pre-existing agricultural system representing a universal, common ancestor, of which modern-day specialized forms of land use, such as forestry, horticulture or agriculture are the descendants.

By choosing *ensete* and trees as pacemakers, i.e., components that set and/or maintain rhythms of growth and development of ecosystems, and as placemakers, i.e., components that establish or maintain places for other beings to live in, farmers have made a crucial step that staves off hunger. With these qualities, *ensete* indeed deserves, to be called a tree against hunger (Brandt & al. 1997).

Chapter 5. The pacemaker role of *ensete* in Gedeo "agroforests"

Abstract

Farming in the Gedeo highlands is constrained by rainwater erosion, which is averted by the use not of physical soil conservation structures such as terracing, but by the use of water-stocking *ensete* plants. Funnel-like *ensete* leaves collect rainwater towards a barrel-like pseudo-stem, where it is stored and slowly distributed, via the roots, following moisture gradient, avoiding erosion due to direct impact of rainwater. Being one of the most ancient *ensete* peoples, the Gedeo manage *ensete* behavior and use it as an internal biotic pacemaker of very complex multiple rotations. The rhythm or pulsation by *ensete* is followed by other accompanying elements. This differs from "modern" agriculture, the buffering mechanisms of which usually rests on abiotic external inputs and single rotations. *Ensete* plant architecture makes it suitable to rainwater harvesting and storage. Moreover, fibrous roots of *ensete* form a matlike structure holding the soil intact and which on decaying also enriches the soil. This water harvesting capacity in *ensete* enables farmers to intercrop it with various crops such as coffee (*Coffea arabica* L. RUBIACEAE). Farmers' reliance on *ensete* is therefore not only for food and feed but also for its maintenance of the production base. *Ensete* in the expert hands of the Gedeo is indeed the key to sustainable land use.

Key words: Gedeo, Ethiopia, agroforestry, *Ensete edulis*, biotic pacemaker, multiple rotations, biodiversity, and sustainability.

* This is an expanded version of an oral presentation by the author in September 2001 at the 8th International Symposium on Remote Sensing of SPIE, Toulouse, France.

5.1. Background

The high potential of *ensete* for food production is well-appreciated (Bezuneh, 1986; Sam-Aggrey, 1987; Kippie, 1994; Pijls & al., 1995; Diriba, 1996; Abate & al., 1996; Brandt & al., 1997; Asnaketch, 1997; Tabojie, 1997; Tsegaye & Struijk, 2000; 2001). Though some authors (Amare, 1984; Wolde-Aregay & Holdinge , 1996; Neugebauer & al., 1996) have noted the regulatory role of *ensete,* this aspect remains largely neglected in deeper research. On the other hand, many authors (Smeds, 1955; Lange, 1982; Pankhurst, 1996; McCabe, 1996) ascribe this capacity of *ensete* to farmyard manure which is often associated with its cultivation. *Ensete* is analysed as if it were some cereal crop. Smeds (1955), for instance, remarked that cultivation of a plant of such a heavy bulk as *ensete* must very soon involve soil exhaustion, to be avoided only by manuring.

There is a considerable lack and/or misunderstanding of the intrinsic characteristic of the *ensete* plant, to wit its maintenance role. The Gedeo, are able to grow e*nsete* without depending on manure (Westphal, 1974; Kippie, 1994) by using the intrinsic characteristics of *ensete* (Kippie, 1994). Most important, they have managed to protect and conserve their soil from erosion by rainwater using *ensete* instead of terracing.

This regulatory aspect of *ensete* is essential for a better understanding of the dynamics of Gedeo "agroforests". It is also of fundamental relevance for designing more sustainable land use systems (Kippie, 1994; Neugebauer & al., 1996).

The Gedeo use *ensete* as a biotic pacemaker (Neugebauer & al., 1996), i.e., it sets the pulse in the system of multiple rotations of a mixed and uneven-aged plantation of diverse species. The traditional Gedeo system sustains non-maximal, non-declining biomass production in multiple rotations and maintains and/or enhances the quality of the resource base (also cf. Swift & Woomer, 1993). This contrasts with modern ways of land use in which external and abiotic means are applied to buffer forces that may destabilize single crops. For the Gedeo *ensete* is an instrument of sustainability. Sustainability is seen from three angles, an ecological, a social and an economical one (e.g., Oldeman, 1986; Swift & al., 1993; Otto, 1987; Kuper and Maessen, 1997; Eppel, 1999). Though the Gedeo do not separate the three aspects, the present text emphasizes ecological sustainability.

Therefore, the present investigation defines the combined maintenance roles of *ensete* in both ecology and economy. How does *ensete* help the Gedeo conserve moisture and soil in the mountainous terrain (range 1200m to 3000m asl), without terracing? The clue rests in *ensete* architecture. The Gedeo saying that "*ensete* with its limbs widely stretched out begs God for rain" should be seen as a poetic expression of awareness of this principle. For the Gedeo, a pacemaker is one who leads the march in an unknown country. How could *ensete* serve as such? On the other hand, a pacemaker in medical science is a technical device that sets and/or maintains rhythms (Neugebauer & al., 1996). An electronic pacemaker is implanted in the human body by cardiologists to maintain the rhythm of the heartbeat (Neugebauer & al., 1996). In a like manner trees in natural forest ecosystems, set the rhythm (Oldeman, 2001).

With both food production and environmental protection, *ensete* indeed is unique among crop plants. It very well would be a fitting sixth plant to be added to Hobhouse's (1992) list of five plants said to have changed the world. This chapter reports the essential roles of *ensete* making it the key to sustainable land use.

5.2. Materials and methods

Two main sets of observations, i.e., aspects of *ensete* architecture responsible for rainwater capture and storage in the steep slopes and aspects related to the pacemaker role of *ensete*, were made. Both are based on the architecture of the *ensete* plant. The method of architectural analysis used is described by Hallé & Oldeman (1975; Oldeman (1974); Oldeman & Hallé (1978); Oldeman (1980, 1990, 2001).

The architecture of *ensete* is largely unknown. Therefore, literature on the architecture of MUSACEAE and PALMAE, to which *ensete* is closely related, was reviewed (Oldeman, 1990; Kahn & Granville, 1992).

The first set of observations was concerned with rainwater harvesting and storage in the aboveground parts and soil conservation by the roots of the *ensete* plants. This served as a basis for the second set of observations, dealing with the role of *ensete* in the multiple rotations of the mixed species uneven-aged “agroforests”. A protracted observation of *ensete* plants during the rains and afterwards was also carried out. *Ensete* plants at different stages of development were uprooted and their structures (i.e., used for rainwater capturing, storing and distribution as well as those responsible for soil fertility maintenance) were studied. Field observation was complemented with discussion with farmers. By means of a reconnaissance survey carried throughout the Gedeo highlands, the preferred *ensete* cultivar was found to be *gantticho*, and this type was used in the present investigation.

The second set of observations consisted of a census or complete enumeration of mixed species uneven-aged “agroforests” belonging to 9 farm households. The “agroforests” besides *ensete* comprised coffee, various multi-purpose woody perennials and annual herbaceous crops, planted together. *Ensete* was grown in two major settings, pure *ensete* monoculture and mixed uneven-aged populations of various perennial and annual crops. In both cases, *ensete* was the key to sustainable land use.

Since farmers do not keep written records of the *ensete* plants, it was difficult to classify unflowered plants into age-classes, a problem solved by following farmers’ method of using *ensete* morphology. Farmers were able, based on their protracted empirical observation, to distinguish between plants belonging to different age and/or size classes. These farmers’ procedure was used in the present investigation. The resulting data were used to explain the pacemaker role of *ensete* in the multiple rotations.

5.3. Results

5.3.1. Biological architecture of *Ensete ventricosum* (Welw.) Cheesman MUSACEAE

Ensete, being a monocot, follows the same general development outlined for monocots (Corner, 1964, 1966; Hallé & Oldeman, 1978; Castro-Dos Santos, 1977; 1981; Oldeman (1990, page 130-138). *Ensete* conforms to Holttum’s model (Hallé & Oldeman, 1975). Though *ensete* shares certain characteristics, it is quite different from the bananas (*Musa paradisiaca* L MUSACEAE) of Tomlinson’s model. Like other monocots, *ensete* does not have a cambium. The whole aboveground part, i.e., the pseudo-stem and the leaves in *ensete*, constitutes a shoot system (see fig.5.1). Unlike most dicots, which have a primary root system, *ensete* has a monocotyledonary root system. The true stem of *ensete* is the underground corm. The aboveground parts, the pseudo-stem and the leaves carried by it, constitute a pseudo-shoot.

Unlike the banana (*Musa paradisiaca* L. MUSACEAE), *ensete* does not sucker, unless induced by eliminating the apical meristem (Oldeman, 1990) also see ch. 6. The corm (the true stem) of *ensete* plants remain underground till late in the life of the *ensete* plant (i.e., maturity), when the extremely enlarged corm gradually emerges to the surface. Mature *ensete* plants (*daggicho*) had about half of their corm above the ground. On the other hand, in the mature *ensete* plants, the size of the basal part of the pseudo-stem shrinks. The parts used from both crop species are different. Unlike bananas, which are mainly grown for their fruits, *ensete* is cultivated for its vegetative body which on fermentation (ch. 8) yields edible products. Unlike the bananas, *ensete* produces viable seeds (ch. 6).

An ensete pseudo-stem (plate 5.1) is quite different from that of a banana. The banana plant develops a pseudo-stem that is slender throughout. But in *ensete*, the pseudo-stem is dilated at the base, from which its Latin name *ventricosum*, i.e., "with a belly" (Oldeman, pers. com.. 2001) is derived. It functions in a similar way as the leaf base "basin" in epiphytic BROMELIACEAE), growing in very dry environments in neotropical tree canopies, or on rocks, and preserving their water in that basin.

Farmers gauge the potential of *ensete* plants to further growth from the bulging part. The larger the bulging part, the higher potential the plant has. However, as *ensete* plants come to maturity, the bulging part decreases and the pseudo-stem becomes slender, as the plant invests in the inner fibrous inflorescence stalk. The corm also keeps emerging, as the plant matures. This is also used by the farmers, as a criterion of the potential for growth. Plants with prematurely emerging corms have less potential for growth and are harvested, prematurely. This is also related to the growth condition of the plant. *Ensete* plants in a favourable condition keep their corm underground and their basal pseudo-stem dilates. Therefore, the potential in *ensete* plants for rainwater capture and conservation is highest in plants with highly dilating basal pseudo-stem.

The water tank of *ensete* is also related to the micro-organisms such as bacteria as has been found by Ruinen (1978) in the sheaths of grass leaves, and also to organisms visible to the naked eye like insects, spiders, earthworms, frogs, snakes or rats. The pseudo-stem compartments, due to the dried *ensete* leaves (*hashupha*) and midribs (*oofee*) covering them from the outside, therefore acts as a biotope rich in life. The scale of the present study did not allow the analysis of the diversity of life-forms in these *ensete* compartments.

The pseudo-stem in a not flowering *ensete* plant consists of a collection of interlocking leaf-sheaths. At a later stage in its development, the apical meristem (Halle & Oldeman, 1975) differentiates and starts flowering. An inflorescence stalk called *aalaa** is a preferred source for *ensete* fibre (ch.8). As the plant grows older, dead leaf-sheaths are shed and inner and larger leaf-sheaths replace them around the bulging body. The height of the base of the leaf bunch of a young *ensete* plant depends on its immediate light environment. If there is heavy shading as is often the case, the plant invests into height growth and carries the leaf bunch higher up. Otherwise, the plant keeps investing in diameter growth of the basal pseudo-stem. Only after attaining sufficient basal diameter (up to half a meter), it starts investing in the corm. When the basal diameter and corm are sufficiently enlarged, in the development of the plant, the corm begins to emerge from the below ground, a situation similar in palms (Hallé & al. 1978).

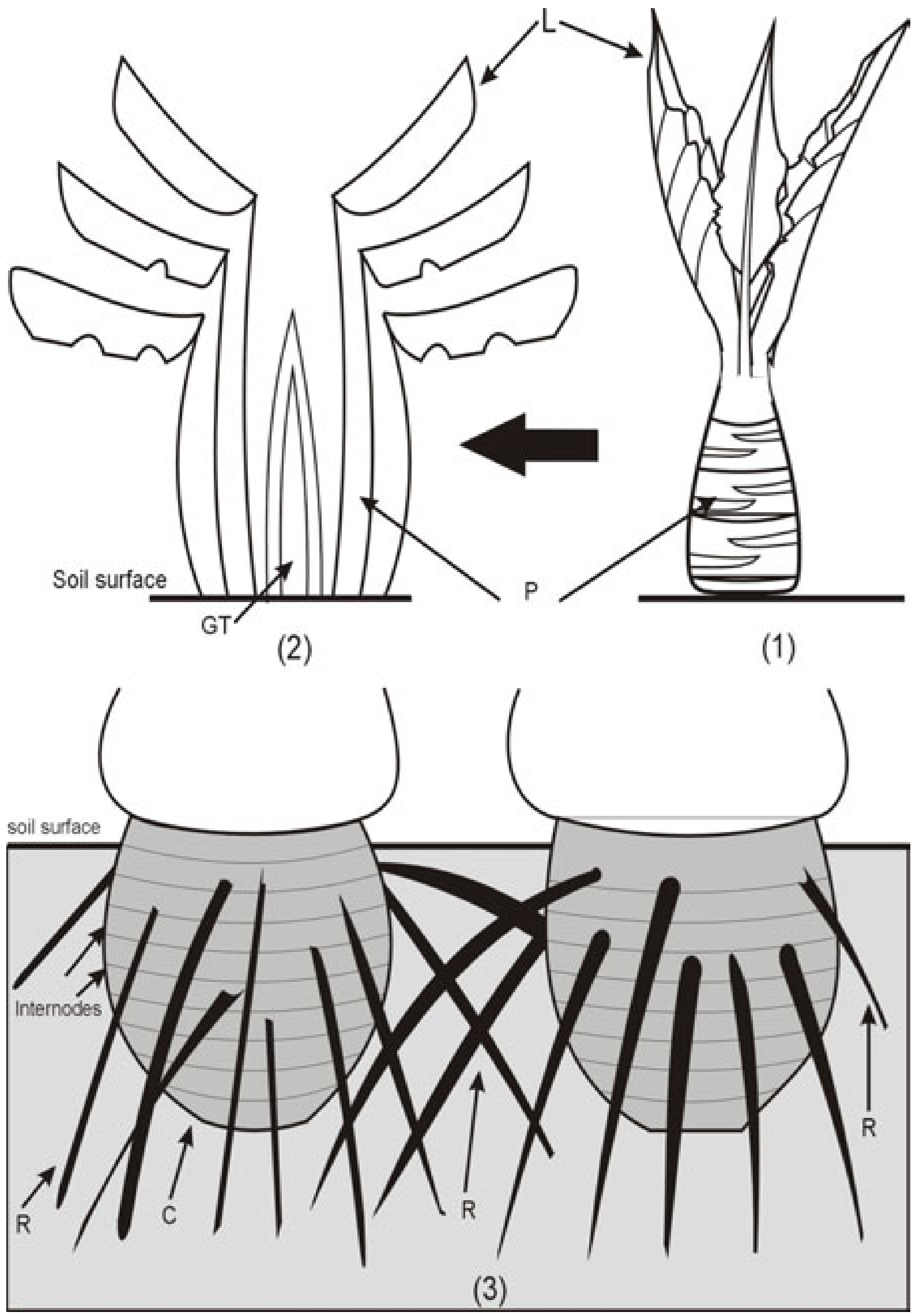
Water inhabited by diverse micro-organisms seeps gradually between the leaf sheaths to the exterior and into the soil, particularly in the dry season or during the driest time of the day, when evaporation pulls it in that direction. Senescence of the tissues holding the water also causes its outward flow. This ecological mechanism functions according to the same principles as the ascent of sap in trees (Zimmerman, 1978), but ecologically without a vascular system. By these outputs from *ensete*, the soil is enriched not only by water, but also by the numerous micro-organisms growing in the tanks.

Therefore, the regulation of soil water, fertility and structure by the water storage and associated micro-organisms in *ensete* and its input-output balance appear to form an inseparable complex of functions, which are put to maximal benefit in Gedeo land use. It is an important element explaining the use of this particular plant species as a soil and water regulator.

5.3.2. *Ensete* architecture, ecological functions and usefulness

Both under- and aboveground *ensete* parts play an important role in moisture and soil conservation. *Ensete* arranges its bunched leaves in a funnel-like manner (plate 5.1; plate 5.2), which the Gedeo say, "*izigoo mageno*", literally meaning "begging God for rainwater" (see also fig. 5.1). A single *ensete,* with up to twenty leaves, all arranged in a whorl at the tip of the pseudo-stem, form a funnel-like structure responsible for capturing and directing any drop of water that falls on them towards the pseudo-stem. The latter is made up of spirally inserted leaf-sheaths. The Gedeo liken this to a water drum (see fig. 5.1; plate 5.1). Leaf funnel in palms were described by Kahn & De Granville (1992).

Figure 5.1. Above- and below-ground *ensete (Ensete ventricosum* (Welw.) Cheesman MUSACEAE) architecture. Above-ground parts, i.e., funnel leaves (L, 1 and 2), and interlocking leaf-sheaths of the pseudo-stem (P in 1 and 2) are responsible for rainwater capture and storage. The pseudo-stem bulges at the base and tapers towards the top. The base forms a drum-like structure (P). Leaf-sheaths are serially inserted on the corm (P in 2), forming compartments (*oo'yo*) in which the trapped rainwater is stored. The compartments also trap leaf-litter and other through-fall (substances dissolved in the raindrops). Thus, the compartments also are a site for various animals such as insects and other arthropods, earthworms, frogs, rats snakes and/or micro-organisms (bacteria and fungi). Roots of *ensete* (R in 3) are responsible for holding the soil intact, and improving the physical soil condition, e.g., due to the tubular epidermis that remains intact after decomposition of the other parts, and chemical soil conditions, due to organic matter added to the soil on the decomposition of the roots. The corm remains subterranean until late in the life of the *ensete* plant , when about half of it will rise above the ground (plate 5.3), in the mature plant. The emergence of the corm in a not flowering *ensete* plant is used by farmers as a good vegetative indicator of food storage in the plant. Roots from several *ensete* plants form a mat-like structure (R, in 3) holding the soil intact against rainwater erosion. See text for explanation (figure based on plate 5.1).


L
Soil surface
GT
P
(2)
(1)
soil surface
Internodes
R
C
R
R
(3)

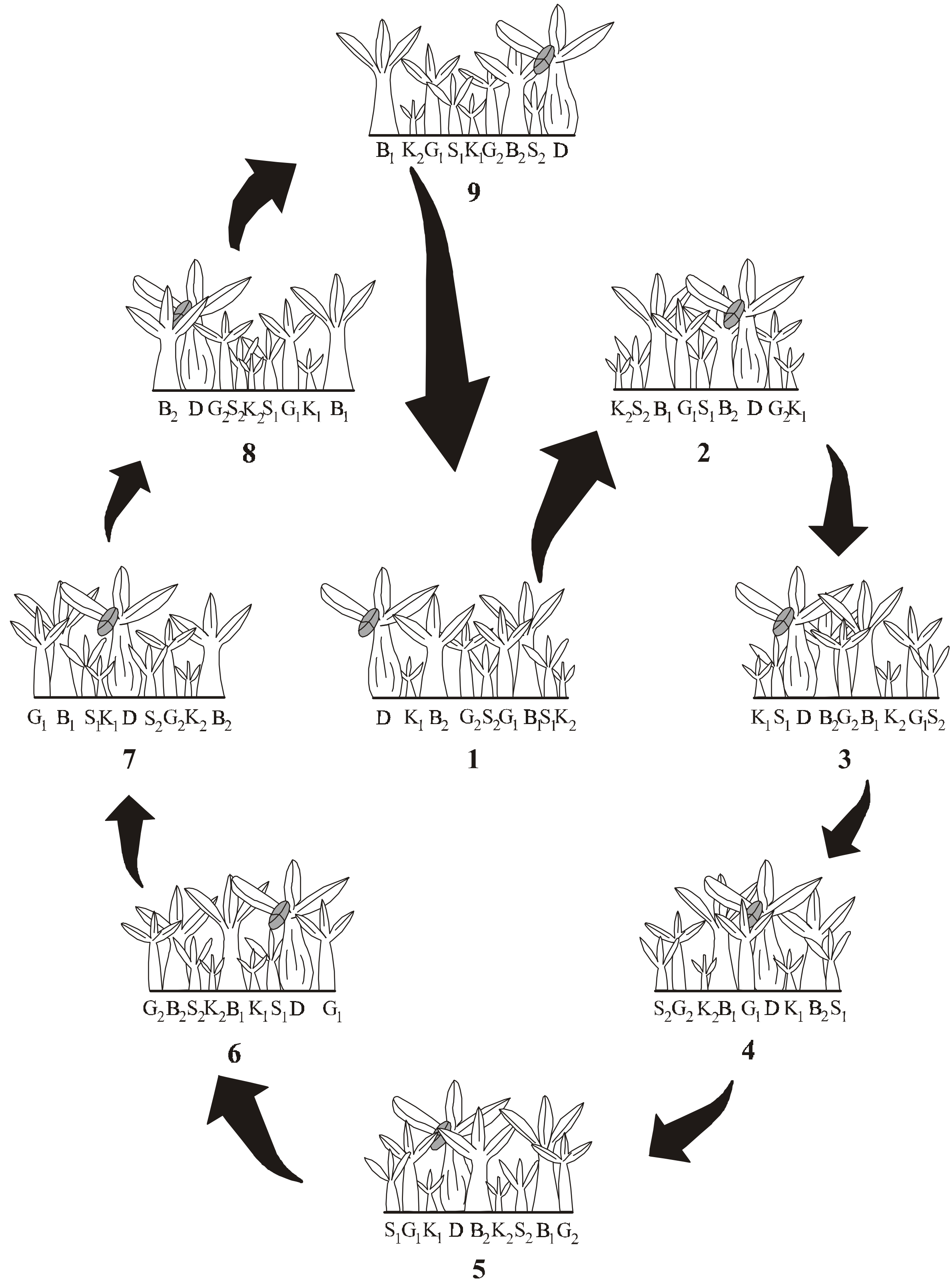
This adaptation of *ensete* to moisture conservation, as its largely hydrophilous body needs enormous amounts of water, is put to good use, on the steep slopes of Gedeo highlands. Any drop of rainwater that falls on an *ensete* leaf is directly led by gravity to the basal part of the pseudo-stem. Since the erosive capacity of the raindrops is considerably reduced, there is less erosion. This architecture suits *ensete* to the rugged terrain of the Gedeo country, which nevertheless gets nine months' rainfall (see ch. 1; ch. 4). Dead leaves of the plants, locally known as *hashuphaa* and dead parts of the pseudo-stem called, *oofee* (plate 5.1), shield transpiring and evaporating surfaces, and so reduce loss of water collected. The most important role of the *ensete* plants in erosion control is not, however, the amount of the water stored as much as the reduction of its erosive potential.

A considerable amount of rainwater is captured and stored in the compartments. Attempts to open the compartments (*oo'yoo*; plate 5.1) causes the water held by them to escape. This makes field measurement of the water held by the *ensete* plants extremely difficult.

Roots radiate from all points on the corm (see fig.5.1; plate 5.3). Roots extend up to half the height of the pseudo-stem, horizontally (see table 1). Roots from several *ensete* plants form a mat-like structure, which binds the soil together (ch. 7). Roots of *ensete* barely penetrate below 50 cm in the soil, and when they die, organic matter is released. Besides, the tubular epidermis of dead roots remaining intact, like earthworm tunnels, is important for soil aeration (Lavelle & al. 1989; White, 1997). An estimate of the root mass of a mature *ensete* plant at *daggicho* or *idago* stage is given in chapter 8.

Regarding the role they play in soil maintenance, farmers differentiate between two types of *ensete*, i.e., soft (*shaqqaxa weesee*) such as *qarasse*, *danbballee* and *toorame,* and hardy (*jabaxxa weesee*) such as *ganttoolee*, *niffee* and *haaramee*. "Soft" *ensete* types are planted out in exhausted soils on hope of rehabilitating it.

Figure. 5.2. *Ensete* (*Ensete ventricosum* (Wele.) Cheesman Musaceae) in the system of multiple rotations. Nine years (omitting the one in the nursery in the homestead, see table 5.1) are shown. In step 5.2.1, an *ensete* plant (K2) is shown, which can be followed through (clock-wise) up to step 5.2.9, when it has grown into D (*daggicho*) at the right. Coming back to fig. 5.2.1 (in an iterative way), we see the plant being replaced by another K_2 in the next rotation. This step can be followed with any of the *ensete* plants shown, starting from anywhere. *Ensete* here is depicted alone for the sake of simplicity. In an actual situation, various components follow the same pattern (see table 5.2).


B_1 K_2 G_1 S_1 K_1 G_2 B_2 S_2 D
9
B_2 D G_2 S_2 K_2 S_1 G_1 K_1 B_1
8
K_2 S_2 B_1 G_1 S_1 B_2 D G_2 K_1
2
G_1 B_1 S_1 K_1 D S_2 G_2 K_2 B_2
7
D K_1 B_2 G_2 S_2 G_1 B_1 S_1 K_2
1
K_1 S_1 D B_2 G_2 B_1 K_2 G_1 S_2
3
G_2 B_2 S_2 K_2 B_1 K_1 S_1 D G_1
6
S_2 G_2 K_2 B_1 G_1 D K_1 B_2 S_1
4
S_1 G_1 K_1 D B_2 K_2 S_2 B_1 G_2
5

5.3.3. The pacemaker role of *ensete* in multiple rotations

The foregoing architectural attributes of *ensete* are used in connection with their economic and environmental benefits. With a rotation of about ten years, *ensete* in the system of multiple rotations maintains a periodicity which is followed by other accompanying elements, i.e., the coffee with a medium rotation of about 30 years and multi-purpose trees with a rotation extending to a century (see plate 5.2).

Ensete plants are established either in even-aged blocks or are dispersed among the uneven-aged-mixed plantations of diverse perennial and annual crops (see chap.6). From these plantations, *ensete* normally are harvested and replaced at the very start of their sexual maturity (flower initiation), the time the best biomass investment made in them is obtained (ch. 8). Plants from one to ten year of age are therefore maintained in the field, in both schemes of establishment. It is common silvicultural knowledge that in dicotyledonous timber trees size and tree age are not well correlated, if at all. However, *ensete* is a monocotyledon and its development classes correspond to its age-classes as discerned empirically by Gedeo farmers under Gedeo names. Farmers could easily tell the age of *ensete* plants, with fairly good precision, by looking at their basal part (see fig. 5.1, section 5.3.1, above), and table 5.1). Thus the larger the aboveground portion of the corm, the more biomass it contains (see 5.3.1, above).

The Gedeo distinguish five size-classes of *ensete* (s*imaa*, *kaassa*, *saxaa*, *guumee*, *beyaa* and *idago/daggicho*), each covering the equivalent of two years at least. The stage *simaa* contains plants from one to two years old ready for planting in the field and these are kept in the homestead (chap.6). The size-class encompassing the smallest *ensete* plants in the field is *kaassa*. The next larger size-class, *saxaa*, includes plants having passed up to four years in the field. *Guumee* consists of plants that have been growing up to six years since being planted out and may be harvested in an emergency. The *ensete* plants in the next two size-classes, *beyaa* and *daggicho* are of a size good for harvest and give the highest return for the investment made in planting them (Kippie, 1994; Taboje, 1997; Tsegaye & Struijk, 2000, 2001). The latter class, *daggicho*, includes flowering *enset* plants in optimal shape for harvest, if not harvested, the plants wither away in accordance with the hapaxanthy ("once flowering") in Holttum's model (Hallé & Oldeman, 1978) that characterizes the genus.

Data (leaf number, leaf length, leaf width (at the middle and widest part of the leaf), pseudo-stem diameter (at the widest part above the ground) are given in table 5.1. Number of leaves can be higher, as the leaves (more than half) are lowered to avoid overshading of the smaller plants by the larger ones (chap.6). Lowering the leaves is carried out in such a way that the photosynthetic capability of the leaves is not impaired

From the uneven-aged *ensete* plantation, plants in the last size-class, *daggicho*, are harvested, and replaced by plants of the first size-class (*kaassa*) fig. 5.2)). Thus, $\mathbf{K_2}$ **(**step 5.2.1), to the far right, can be followed through nine steps of about one year (step 5.2.9). In year two (step 5.2.2), the plant has become $\mathbf{K_1}$, in year three (step 5.2.3) $\mathbf{S_2}$, in year four (step 5.2.4) **S_1**, in year five (step 5.2.5) **G2**, etc. In year nine (step 5.2.9), the *ensete* plant becomes **D** (*daggicho*), which is harvested and replaced (step 5.2.1), completing the rotation, in an iterative sequence (van der Wal, 1999).

Ensete plants are maintained in these size-classes in proportions determining a specific rotation and ecosystem architecture by applying well-designed spacing patterns of

Table 5.1. Census of *ensete* (*Ensete ventricosum* (Welw.) Chessman MUSACEAE) population over 4.5 ha of farmland feeding nine farm households or 63 people. Gedeo size-classes: subscript **1** represents the oldest phase; **K** = *Kaassa*; **S** = *Saxaa*; **G** = *Guumee*; **B** = *Beyaa*; **D** = *Daggicho* (for meaning see text). Symbols: **Pd** = pseudo-stem diameter (at the widest part just above ground); **Ph** = height of pseudo-stem (from ground level to the whorl of leaves); **LN** = leaf number; **LL** = leaf length; **LW** = leaf width at the widest middle part.

Size class	Pd cm	Ph (m)	LN	LL (m)	LW (m)	NP	%Total
*Simaa**	nil	nil	nil	nil	nil	892	14.8
K_2	12.5	0.8	3	1.8	0.2	811	13.5
K_1	17.0	1.5	5	2.3	0.4	737	12.5
S_2	20.5	1.9	7	2.8	0.7	670	11.1
S_1	30.5	2.0	9	3.3	0.9	609	10.1
G_2	40.0	2.4	10	3.6	1.0	554	9.2
G_1	52.0	2.6	11	4.7	1.0	504	8.4
B_2	64.0	3.1	14	5.0	0.8	458	7.6
B_1	82.5	3.5	14	4.0	0.8	416	6.9
D*	75.0	4.1	17	2.5	0.4	378	6.3
Mean	43.8	2.4	10	3.3	0.7	6029	100.0

Simaa (suckers in the nursery) comprises the smallest size class of *ensete* plants. On field transplanting, these become K_2. As *ensete* plants come to maturity, a drastic reduction in leaf length as well as leaf width occurs.

uneven-aged plants. In figure 5.2 the size-classes are each subdivided into two classes of one year approximately. *Simaa*, another size-class (not shown) with plants up to two years of age, are kept in the nursery in the homestead (see ch. 6). Taking this into account, there are ten-year classes, calibrating a time scale with one-year units. To come to maturity, *ensete* plants therefore need some seven to twelve years (ch. 4).

This temporal backbone of multiple rotations allows fitting in shorter or longer rotation crops, mixed with *ensete* plants in the same field (table 5.2). The table shows longer-lived coffee (*Coffea arabica*) trees, mixed in certain proportions and in certain spots through the *ensete* pattern. The shorter rotation (*ensete*) and the longer one (coffee) are intertwined in the mixed population of multi-purpose trees with very long natural rotations, the latter timing the average ecological turnover (see table 5.2). Odum (1975, p.28) defined turnover time as the ratio of the standing state (that is, amount present) of biotic and abiotic components to the rate of replacement of the standing state".

Table 5.2. The place of *ensete* (*Ensete ventricosum* (Welw.) Cheesman MUSACEAE) in the multiple rotations with other "agroforest" components.

Rotation time	Species								
	Ensete	*Milletia*	*Coffea*	*Pygeum*	*Albizzia*	*Celtis*	*Aningeria*	*Cordia*	*Podo**
0-10	x								
10-20	x	x							
20-30	x	x	x						
30-40	x	x	x	x					
40-50	x	x	x	x	x				
50-60	x	x	x	x	x	x			
60-70	x	x	x	x	x	x	x		
70-80	x	x	x	x	x	x	x	x	
80-100	x	x	x	x	x	x	x	x	x

* *Podocarpus gracilior*- PODOCARPACEAE

On the other hand, long-lived perennial components such as timber trees require a rotation time of well over a century. These are therefore harvested after a time period in which *ensete* will have rotated ten times. Medium rotation crops such as coffee are replaced about every fifty years. So *ensete* rotation times the dynamics of the agro-ecosystem.

5.4. Discussion

Ecological functions of *ensete* such as rainwater harvesting and storage represent aspects in traditional land use, which though neglected by conventional wisdom, are at the very root of the sustainable functioning of these systems (Ramakrishnan, 1992; Van der Wal, 1999). Without organising *ensete* and other crops in the way they do, it is questionable whether the Gedeo could have lived in their rugged and undulating terrain, mainly due to the danger of erosion by rainwater (Amare, 1984; Wolde-Aregay & Holdinge, 1996).

The soil and water maintenance role of the crop vegetation is clearly obvious from the rich water resources of the Gedeo highlands where one cannot traverse a kilometre without crossing a stream or river. The fact that these are not dirt-laden like most streams and rivers from the rest of most Ethiopian highlands during rainy seasons (Kippie, 1994) is also a clear symptom of the low level of erosion in Gedeo highlands. The present finding are also in line with an observation reported Kippie (1994) that in emergency cases, farmers obtained water for washing and /or drinking from live *ensete* tissues.

The foregoing environmental benefits from crop vegetation presuppose a specific organization of crops, so that optimization between protection and production functions is achieved. The key to such a scheme is provided by the use of *ensete* as a pacemaker. This allows regular inclusion of diverse crops including the weedy flora with diverse roles.

Optimization between the protection and production functions is achieved using cyclic change of agro-ecosystems (Oldeman, 1983). Here the concept of eco-unit (one ecosystem developing on one surface, cleared by one impact, from one specific moment on, and following one development process (see Rossignol & al., 1998, p152), is very important. Eco-units created by *ensete* harvests are equivalent to those due to dispersed tree mortality in a pristine forest (Oldeman, 1990).

The smaller this area, the better. Farmers therefore strive to minimize this area, thus imitating nature. Their choice of *ensete* as a pacemaker rests on this principle. Other components accompanying *ensete* are made to conform to the pattern or pace set by *ensete*. Annual crops can be intercropped with *ensete*, provided the latter are established in even-aged blocks (as is the case in the extreme high- and lowlands), as will be described in ch. 6. In uneven-aged mixed plantations, annual crops can be grown in sequence. Annual crops therefore shift places, leaving behind closed canopies and occupying newly released open spaces. The situation in the mixed uneven-aged plantation is quite different. As in forests, the area released is either replaced with the same or another crop or it can be left to be occupied by the surrounding expanding vegetation (see block transects, ch. 4). Management practices in the uneven-aged mixed populations are complicated, as will be analyzed below (ch. 6).

The sustainable turnover of biomass in the “agroforests” is shown by *ensete* harvests. For instance, harvesting 378 mature *ensete* plants by the nine farm households per year (table 5.1) causes 378 canopy openings and 378 impacts on the existing green canopy. In mono cropping, such impacts wreak havoc with management plans. However, "disturbance" or “catastrophe" is an integrated part of Gedeo “agroforest” cycles. Words with this meaning and with such depreciatory connotations do not exist in Gedeo language. No environmental hazard, not even drought, can disturb the sustained flow of biomass, for flexible cohorts of water-stocking *enset* plants intervene every year as planned (see fig. 5.2, steps 1 to 9).

A well-balanced uneven-aged *ensete* population is therefore a pacemaker of the "heartbeat" of these very complex “agroforests”. *Ensete* is very well chosen, its moderate rotation of some 9 to 12 years (see table 5.2) makes it a flexible tool to weave together into longer tree rotations and shorter rotations of annual crops. As a main food source, *ensete* strongly incites farmers to manage it with care, their very livelihood depending upon it.

Assuming an average spacing of 1.5 m by 3 m, an area of about 0.2 ha is required for the *ensete* needs of a farm household of seven. The number of *ensete* plants that are harvested from the stock, i.e., the size classes D (*daggicho*) are replaced by new suckers (K_2) from the stock in the homestead. A farm household maintains about 540 *ensete* plants of which 54 should come to maturity every year including contingencies (field mortality, reserve for special occasions and for multiplication). The area needed to grow these plants, about one fifth of a hectare, is obtained by multiplying 540 by $4.5m^2$, average spacing required for growing *ensete*. Replanting the whole area released by the harvest of 54 *ensete* plants takes only about 10% of the total *ensete* area. That means, 90% of the area remains intact. In other words, the turn-over time of the *ensete* area will be ten years which can be compared to the situation in annual cropping where the whole area is turned over every year, exposing the soil to destabilizing forces. The maximum traditional farm size of about 2 ha follows from these facts.

The Gedeo, precisely obeying their knowledge of biotic complexity, hence achieve sustained biomass production through the multiple rotations. This contrasts with industrial agriculture, which reduces agricultural, floristic and faunistic complexity of agro-ecosystems and downgrades multiple rotations to simple, all-but abiotic single crop rotations. Such mass production is sustained at the price of massive, abiotic external inputs. The Gedeo on the other hand, work without inputs, each and every “agroforest” component contributing towards the up keep and/or improvement of the production base.

5.5. Conclusion

Ensete plants with their built-in mechanisms for water and soil conservation fit in the group of those few vegetable organisms that, besides feeding people, conserve the production space. Therefore, Gedeo use of *ensete* for rainwater harvesting is an instance of age-old objective of many human societies, i.e. to capture and conserve as much rain water as possible. However, while most human societies have opted for abiotic means like terraces or reservoirs, the Gedeo are distinct in choosing the least costly biotic alternative, live vegetation.

Principles underlying the use of complexity instead of simplicity in agro-ecosystem design do exist and are applied by experts like the Gedeo (Kippie, 1994; Neugebauer & al., 1996), or the Mexican Chinantla (Van der Wal, 1999). The Gedeo obeying this knowledge reached agricultural sustainability during millennia. The core secret is the choice of the crop species to be the pacemaker of multiple rotations in the system, to wit *ensete* (Kippie, 1994). Like medical pacemakers are in control of the human heart, so agricultural pacemaker plants regulate the beat of a complex agro-ecosystem (Oldeman, 1995; Neugebauer & al., 1996). This is genuine biological automation (Schütz and Oldeman, 1996). Indeed, *ensete*-based farming reflects the whole agricultural concept and its expression in a certain climate, on a certain soil and under pressure of a given human population density.

Chapter 6. Gedeo land use: towards understanding farmers' natural resources management

Abstract

Principles and practices of farmers' natural resources management are described. Farmers' effort is directed at reciprocal optimization of the interrelationships among diverse agro-ecosystem components. In doing so, farmers employ single or multiple rotations, both rotations involving mixed cropping. Single rotations combine annual and perennial crops separately, i.e., group-wise, one part of the farm being devoted to annuals and another part to perennials. Examples include grain crop fields with diverse land races, or even-aged *ensete* plantations with diverse clones or tree lines with diverse species. In a system with single rotation emphasized in the highlands and to a limited extent in the lowlands, harvest is total and occurs at the same moment. Multiple crop rotations, emphasized in the midlands, consist of mixed, uneven-aged plantations of mainly perennials, harvested selectively when mature. In both single and multiple rotations, management is geared towards a harvest of only consumable biomass, the rest being left in the field. This leads to a live storage of biomass, a stratagem that safeguards the sustained flow of useful products and services in an unpredictable biophysical and social environment.

6.1. Background

Discussion of the nature of farm components (ch. 4) and their organization (ch. 5) logically leads to their management, the subject of this chapter. Most of the available data on *ensete* are either crop-specific, or poorly related to farmers' natural resources management. This is, however, non-conforming to the actual practice of *ensete* agriculture which rarely, if ever, is based on *ensete* alone. Cultural practices of *ensete* agriculture are also interconnected with the larger biophysical environment (Bezuneh & Feleke, 1967; Godfrey-Sam-Aggrey & Tuku, 1987; Sandford, 1991; Kippie, 1994; Diriba, 1995; Fekadu, 1996; Woody Biomass Inventory, 1996; Abate & al., 1996; Asnaketch, 1997). Isolation of *ensete* agriculture from these aspects therefore makes our understanding of *ensete*-based land use incomplete.

Though intercropping *ensete* with various crops is a common management practice among various *ensete* peoples (Bezuneh & Feleke, 1967; Makiso, 1980; Godfrey-Sam-Aggrey & Tuku, 1987, Sandford, 1991; Brandt, 1996; Brandt & al., 1997), the Gedeo are unique in combining *ensete* with diverse multi-purpose trees and shrubs including coffee, various annual crops and animals (Kippie, 1994; The Woody Biomass Inventory, 1996). The inclusion of trees in particular distinguishes Gedeo *ensete*-based land use from others (Kippie, 1994). Therefore, unlike in most *ensete* peoples, the basis of management among the Gedeo is the whole agro-ecosystem (chs.4 and 5) of which very little is known in literature.

Because of misunderstanding this fact, some development efforts among the Gedeo went astray (Agricultural Bureau for the Gedeo Zone, unpublished), as attempts to replace Gedeo systems with simpler cropping systems (annual grains or mono-crops of coffee) evoked resistance from farmers (ch. 1). Such misunderstandings can only be remedied by research (Kippie, 1994). It is therefore important to know why farmers, instead of subscribing to alternatives presented to them, stick to their own traditions. Knowledge of farmers' problems and how they try to solve these is therefore important.

Also, *ensete* land use is commonly regarded as a development in response to higher population densities (Kippie, 1994; Abate & al., 1996; Brandt & al., 1997; Asnaketch, 1997). This is easily proven by the higher carrying capacity of land planted to *ensete* (ch. 8). For instance, the carrying capacity of Gedeo "agroforests" is about 500 persons per square kilometer square (Central Statistical Authority, 1996). However, management practices behind this are not well known (Kippie, 1994). It is therefore important to see the higher population density in relation to farmers' natural resources management.

Higher diversity of crops is often related to subsistence and self-sufficiency (Kippie, 1994; Diriba, 1995; Rhamato, 1996; Almaz, 2001). Nevertheless, the inclusion of such cash crops as coffee in Gedeo land use links them not only to the national economy but also to the global one. Therefore, the problem of valuation and exchange becomes important. Moreover, how the management fosters development of the indigenous knowledge is essential for a better understanding of the "agroforests".

It has recently been discovered that the system of valuation used by traditional societies is quite different from those used in conventional agriculture (see Gatzweiler, 2001 for a case studies with the *Dayak* of Indonesia). Given their agro-ecosystem level management, it is important to see the valuation system used by the Gedeo. In chapter 5, it has been shown how *ensete* plays a regulatory role in the system of multiple rotations. It is important to see how this is expressed in practice. How, for instance, is this expressed in planting and harvesting so that a sustained flow of useful products is ensured from year to year? Results may be of high relevance for highly populated mountainous areas. Therefore, a survey and a case study aiming at understanding Gedeo farmers' management practices was initiated. This chapter reports.

6.2. Materials and methods

This chapter is based on data collected from a comprehensive survey and case studies (ch. 3) covering the three agro-ecological zones of the Gedeo zone. In the reconnaissance phase, seventy farm households in seven agro-ecological zones were approached with a questionnaire. Data related to principles and practices of farmers' management in general were collected.

Based on the forthcoming data, case studies were carried out over 27 farms in the three agro-ecological zones, highland, midland and lowland (ch. 3). Data from the reconnaissance phase were organized into a checklist of questions (appendix 3.1). To facilitate the participatory observation, discussions were held in farmers' fields while the farmers carried out farm activities. Both sexes were consulted, as both have their own respective shares of the farm work. Besides these selected farmers, data were collected from elders, teachers of rural schools, health workers in local clinics, rural shopkeepers, merchants, administrators and religious leaders, as these had a great deal of knowledge about the area in which they work.

The author's experience of more than twenty years living and working among the Gedeo was also very helpful. He had unusually free access to the Gedeo society.

6.3. Results

The principles and practices applied by the Gedeo in managing their "agroforests" are adapted to the constraints they face. The basic constraints of course are those related to land, i.e., land shrinkage and fragmentation of landed property (Table 4.4, ch. 4, fig. 6.1). Other problems such as population growth and unbalanced interaction with the external world exacerbate this basic one. The state and the market, both impinging upon the land resource exerted challenges that remained fairly constant throughout Gedeo history (ch. 1, ch. 9). Hence, the farmers' strategy could only aim at sustaining their self-sufficiency. All their principles and practices are directed towards this objective.

6.3.1. The resource base: land and labor

6.3.1.1. Gedeo attitude towards land

Land is the most precious item to the Gedeo. It can neither be sold nor bought but it can be leased out. Land is so important among the Gedeo that it functions as a membership card. This goes so far, that a man without land among the Gedeo is not considered a fully developed human being. In the past, migration to natural forest areas to the further south, e.g., Hageremariam, was a means of increasing one's land property, but not any more. Nor are there alternatives in towns, as until very recently (1991), the Gedeo were legally barred from working and living in towns. Only one in five town dwellers in Gedeo country is a Gedeo today (CSA, 1996). Discrimination against the Gedeo in the towns was so severe that even those Gedeo with some formal education returned to the farm. Because of this marginalization, if the Gedeo ever entered the towns, it was either to sell or to buy something after which they returned to their seclusion.

This made the Gedeo look "inwards." To withstand the challenges and hardships they incessantly experimented with their plots of land, their only resort. Today still, every farm household experiments with better ways of intensifying the multiple use of its land, of course within the limits defined by basic principles which prescribe not to breach sustainability (see ch. 9). Exchange of information among the farmers is facilitated by the variety of social networks such as *goottalee**. This is pooling village labor to mutual benefit as in coffee harvesting, building houses or felling larger trees. The host afterwards provides the feast. Another means was the institution of in-laws, tribal relations and/or religious affiliations. These principles prevent the repetition of mistakes made by somebody else somewhere else.

6.3.1.2.Gedeo laws and rules related to land

No matter the strength of the farmers' struggle, almost no farm household can be fully self-sufficient, mainly due to inheritance of already scarce land. Therefore, farm households with insufficient land often cannot but engage in off-farm activities, mostly in petty trading. This provides them with the means to lease some land. Every male Gedeo considers a share of family land as a birthright, because land ownership defines his very humanity and status in Gedeo society. Land ownership is also sought for status and dignity of land owners, heightened by the culture. Until very recently the Gedeo buried their dead, particularly those having died at an advanced age in the farmland so as to make the land sacred. Since the ancestral bones lying in the land represent their efforts and labor, those inheriting the land have no absolute right over the land but they are obliged to maintain it.

Women are excluded from inheriting family land. This is directly linked to the vital priority of protecting the life support structure of tribal lands. Since daughters are married off outside their own tribe (i.e., marriage within the tribe is prohibited), loss of tribal land through inheritance is avoided, as the tribe follows male lines. The tribe of her husband would then acquire the land, not the wife. The husband and his tribe would become the owners of the land according to the Gedeo traditional law. This would strongly enhance the risk of accumulation of land in few hands and a concomitant increase of the risk of damage to the agro-ecological life support infrastructure. Daughters in Gedeo society are known as "*manna*," i.e., foreigners. That means they are only born to be given away to another tribe. A young woman's membership to her tribe lasts only until her marriage, when she loses her old citizenship and becomes a citizen of her husband's tribe. That is why the Gedeo consider it a curse to have a married woman give birth in her mother's house. In case a married woman dies in her parents' house, the latter are prohibited from performing burial ceremony, and they have to take the body to the tribe of her husband.

In the present study, an average Gedeo farm household consisted of seven.The husband or an adult male is the head of the household. On his death, the husband, the head of the family among the Gedeo, is succeeded by his elder son or his brother. Like in ancient Egyptian tradition (Murray, 1964), women become the heirs through their sons and themselves never may be heads of households. The decision of the head binds all household members. There is gender-based division of labor. Men and able-bodied boys work in the fields. Women and able-bodied girls work in the house. Women are also responsible for harvesting, processing and marketing *ensete* and its products, and for fetching firewood, water and consumable items from the market. Interference is forbidden. If a man interferes in his wife's duties, she has the right to present her case to the community elders or her family of birth. The latter are entitled by the culture to preside over such matters and to levy a fine off the party found guilty. On the other hand, if the husband is found guilty, he will be forced to pay the fine to his wife, as compensation. Men on the other hand have a monopoly over cash crops such as coffee and over farm animals except poultry where women and young boys have also a stronghold. Men are required to build houses, to harvest trees and tree products including honey, to fight in wars and build roads, bridges. Men are also expected to speak in public while women are discouraged to do so.

Men and women within the household help each other. For instance, women and girls assist men in transporting household refuse or farmyard manure and *ensete* suckers to the field while men and boys also assist women and girls in uprooting *ensete* plants particularly the larger heavy plants initiating their inflorescence (see ch. 8). Heavy tasks sometimes beyond the forces of the women and girls can also include transportation of *ensete* biomass to the processing site. They receive assistance from their sons or husbands. The *dogodo**, a shelter over the *ensete*-processing site is also constructed by men.

The need for comprehensive training is obvious. This is the foremost responsibility of the family, of course supported by the society at large. In view of their education, boys therefore spend most of their time with men while girls do so with women. Initiation to adulthood in the Gedeo society requires learning of all duties that are considered basic, particularly farming. Therefore, every household works hard to equip its young members with necessary skills and knowledge. Successful parenthood is judged by the behavior of their children.

Marriage marks the culmination of formal Gedeo training. However, newly married couples pass through another period of intensive training not less than a year. The bridegroom is trained by the father and the bride by her mother-in-law. The father pushes his son to the minimum required capability to use his power, deciding on matters of family land. To ensure obedience, the father gives land to his sons piece-meal. The mother also trains her daughter-in-law severely, in all duties regarding *ensete* and other farm resources. Graduation into adulthood among the Gedeo is not easy.

Daughters being married away cannot inherit family land, but their family makes sure that they are married to well-to-do families. This can mean a compromise in a young woman's choice. Gedeo women at first are little more than daily laborers, relying on their skills and knowledge in matters regarding the house as well as *ensete* harvesting and processing. With children, particularly sons, this position of Gedeo women improves considerably, as through their children they become one in-blood with the tribe of their husbands. This is very important, as Gedeo women until very recently had no right to share in the property even if acquired in marriage.

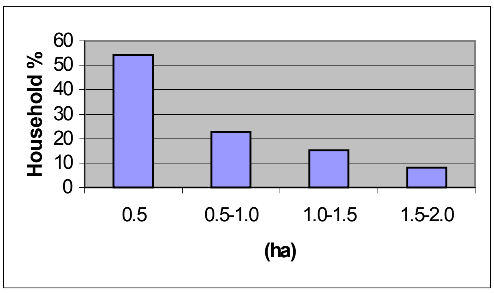


Fig. 6.1. Land holding: distribution among farm households. More than 50% of the households operate on holdings less than 0.5 ha and the maximum land holding per household is 2 ha (cf. table 4.4).
Source: **Agricultural Bureau for the Gedeo Zone**

Marriage gives entry to farming, so early marriages are stimulated. This is against the immemorial Gedeo tradition, according to which marriage follows physical, emotional and mental maturity of the parties and not vice versa. Gedeo tradition in former times required of young men to show their strength by hunting large dangerous animals such as rhinos or leopards. They also should demonstrate their skill in climbing large trees as in hanging beehives in trees (6.3.3.4) and in honey harvesting and finally in economy (by petty trade or herding animals in the lowlands). Today, the weight given to marriage has considerably decreased failure rate of marriage has increased. This is a development seen as detrimental by the elders. The self-contained nature of Gedeo farming system makes modern education of little importance.

6.3.2. Constraints under which farmers operate

6. 3.2.1. Constraints connected to land

The mismatch between the limited land resource and the increasing Gedeo population (see fig. 6.1) growing annually on average at more than 3% (CSA, 1997) and the external forces adding to the pressure on the land have been analyzed above. Problems have further been exacerbated by inappropriate interventions, often by ambitious development people, lacking basic understanding of Gedeo land use.

The full impact on the Gedeo society of the policies of the previous governments (see ch. 1) is just becoming manifest. As stated above, surpluses of the Gedeo have been seized and used by the states and their associates. That means that, for more than a century, Gedeo highlands were just mining grounds. The fact that Gedeo highlands are coffee belts (fig. 4.4, ch. 4; transects, appendix 4.1 and appendix 4.1c) worsened the situation. Tolo (1989) notes that no people in Ethiopia were so economically exploited as the Sidamo and Gedeo, the main reason being their coffee.

Therefore, it was no coincidence that the Coffee Improvement Project (CIP) was initiated with such feverish ambitions and focused on a single component of a multi-component agro-ecosystem. The plan turned a blind eye upon *ensete*, multi-purpose trees and other useful plants that normally accompany the coffee. CIP is the only development intervention that has produced so massive an impact on the Gedeo highlands.

The Gedeo are not new to the cash economy (table 1.5, ch. 1; table 8.4, ch. 8). Coffee as a cash crop has been with them since times immemorial. Although the influence of the cash economy has been increasing from Menelik's time to Emperor Haile Sellassie's, it was in the communist era of the Dergue that extra emphasis began to be given towards cash cropping. This is also related to the global market. Producing for cash is not a problem as long as the staple crop production is not compromised by it. The Gedeo zone was among the potential production areas to maximize coffee production selected by the Dergue. Although best quality coffee grows under *ensete* shade, the latter was excluded from the coffee extension program. As though they themselves did nothing about trees grown with coffee, farmers were supplied alongside improved coffee seedlings and farm inputs like fertilizers and pesticides, with exotic shade trees like *Sesbania sesban*, *Grevillea robusta*, *Leucaena leucocephala*. On the other hand, they were advised or rather ordered to remove *ensete* and indigenous multi-purpose trees like *Melletia ferruginea* (PAPILIONOIDAE), *Erythrina abyssinica* (PAPILIONOIDAE), *Cordia africana* (BORAGINACEAE) and *Albizia gummifera* (MIMOSOIDAE), which are renowned shade trees for coffee.

Table 6.1. List of farmers' major constraints. These constraints were rated by seventy farmers consulted in the course of the present study.

Constraint in order of importance		Rating by farmers (%)	Remark
1	Land shortage	100	All agro-ecological zones
2	*Ensete* root diseases and pests	100	Midland and lowland zones
3	Coffee berry disease	100	Midland zone
4	*Ensete* pests (field mice)	100	Highland and midland zones

Source*: this study*

The whole medium altitude zone, known as the coffee belt (fig.4.4) is affected including lower altitudes that are not too hot for coffee. Thus, the CIP project sought to strategically replace *ensete*. They were very careful not to even mention this to the farmers when supplying them with free seedlings of coffee and the input that goes with it (fertilizers, farm tools and equipment and farm chemicals). Farmers were also tempted by the rocketing coffee prices of the 1980's, when a kilo of sun-dried coffee was sold for up to 10 Ethiopian Birr (about US $2, at the price that prevailed). Participating farmers persuaded themselves that with increasing coffee income they would be able to purchase from the market whatever they wanted, including *ensete* food. However, as coffee prices began to fall it did not take long for the farmers to see that they were wrong in their reasoning. They saw that they had invited hunger into their country that was once of plenty. There were no more rising coffee prices to benefit from. Without the necessary skill or knowledge to administer cash, most coffee farmers proved to be "unprepared prey" to the "shark" merchants who knew how to attract or rather to seduce them.

Farmers in the lower and higher altitudinal agro-ecological zones are equally affected by the development policies emphasizing cash crops. Farmers in these zones were encouraged to focus on annual crops as a source of cash, i.e., maize, *teff* or wheat in the lowlands or garlic, leaf cabbage (*Brassica* sp.), barley, horse bean, chickpea and/or vegetables like onion in the extreme highlands. *Ensete*, the livelihood of the farmers', as in the midland zone, was neglected.

The above does not imply that farmers did not need cash income. However, introducing a destabilizing factor into their subsistence economy is harmful, as shown. Increased cash-flows as a result of either higher coffee prices or increased coffee production only motivated farmers, but with less know-how as to its handling, it seduced them to spending in times and in ways disastrous to their own well-being. Almost no thought was given to this aspect by the project (Agricultural Bureau for the Gedeo Zone, unpublished reports). This then unwittingly turned a blessing into a curse.

Another intervention to increase farmers' cash income was based on fattening cattle for beef. The "weedy "herbaceous vegetation and *ensete* by-product were to be used as fodder. However, the project failed to understand that most farmers are not self-sufficient in these resources. The result was the breaching of the egalitarian principle allowing access to private land for the cut-and-carry grazing for one or two milk cows. This principle then was abused for profit.

Multi-purpose trees and shrubs of the Gedeo "agroforests" are also affected by greed for more cash. The rising demand for fuel-wood and timber attracted the attention of merchants to the multi-purpose trees of the Gedeo highlands (Romeijn, 1999). There also occurred an unusual demand for sawnwood by the woodworking shops in six towns of the Gedeo Zone, Dilla, Wonaago, Chaffee, Kochchorre (formerly Fisagenet) and Chelelettu. The merchants sent middlemen with saws to the countryside to buy trees, using the infrastructure of roadside settlements. Trees up to a hundred years old were bought for only a tenth of their final value. After felling and sawing by the local labor, the wood is transported on human shoulders to the nearest trade posts. Here, it is loaded on lorries by night, avoiding daytime transport so as to hide the illegal business. This generated a class of farmer "entrepreneurs" who buy trees from other farmers at a very low price and resell them with a profit. This practice decimated the older trees, the capital created by generations of farmers. The soil is denied its leaf litter and is exposed to the direct impact of the sun and to torrential rains. The severity of the unbalance in the biomass and nutrient budgets is so increased, but the long-term impact of removing trees still needs further assessment.

As a supplement to *ensete*, farmers in the lowland (below 1750 masl) and highland (above 2500 masl) zones grow grains and vegetable crops. However, in pursuing high cash income, crops such as maize were advocated to slopes up to 50%. Here, perennial cropping only, without terracing. is practiced. This was misunderstood by the development people who advocated the cultivation of annual crops like maize without soil protection measures. This proved a grievous mistake as the soils were exposed to erosion by rainwater. Since this was at the expense of *ensete*, which is already a cash crop, the economic virtues of this intervention seem dubious and need at least to be checked.

Disregard for the subsistence economy automatically resulted in disregard for resource economy, because these are inseparable in the Gedeo way of life. Soon after the "modern" interventions, the notorious Coffee Berry Disease hitherto unknown in the Gedeo country struck (6.3.3.7). According to farmers, attempts to control it with fungicides caused more harm than the disease itself. Blanket spraying at least seven times in a single season was carried out. Farmers prepared or calibrated the spray in the streams from which they drink. All this rises the probability of excess chemicals entering the agro-ecosystem. Moreover, some farmers believing that anything good for coffee is good for man, too, took a cup or two of the fungicide and collapsed. Other farmers applied the fungicides to their eyes, thereby losing their sight. Moreover, the "weedy" herbaceous vegetation under the coffee trees was also affected. The sheep that grazed there were poisoned, with dire consequences for shepherding. This in turn affected the supply of sheep's manure (*cege'o*) highly valued by farmers as soil input (see ch. 7). Moreover, the chemicals are known to affect the honeybees. They became rare and honey production fell (Agricultural Bureau for the Gedeo Zone, unpublished archives and pers. observation). The effect on the honeybees is not understood. Perhaps, they are affected by the coffee flowers, which form the larger portion of bee fodder (6.3.3.4).

The current Ethiopian Government promotes production of organic coffee and is unwilling to subsidize the price of the fungicides. As a result, farmers have resorted to the use of resistant coffee lines, which are strongly promoted by the Agricultural Bureau for Gedeo zone.

6.3.2.2. Exchange and associated problems

The higher human population density of the Gedeo also causes a higher demand for goods and services (Ellis, 1988). Farmers feel that their "agroforests" provide both sufficient food and cash crops such as coffee and also *ensete* so that they can potentially meet this demand. The Gedeo produce about 20 thousand metric tons of clean coffee every year (table 1.5 (ch. 1) and table 8.4 (ch. 8)) and are consumers of many industrial goods (Department of Commerce, Industry and Transport for the Gedeo Zone, unpublished archives). If demand and exchange capacity are there, there are also complaints, showing the need for markets to be organized otherwise. The complaint of the Gedeo farmers, that they are 'sowers but not reapers' shows, that a genuine market is indeed lacking.

The Gedeo see markets as centers for the exchange both of commodities and information. It is in the markets that prospective husband and wife see each other. A market is also a place where relatives from far-away places meet and exchange greetings. In the absence of services like post and telephone taken for-granted in the modern world, the role of the markets in bringing rural people together can not be over-emphasized. The high number of market days speaks a clear language. Thus, the Gedeo people do not go to markets just to eat and drink, as a biased note of Woldemariam (1972) implies. Eating outside the home goes against the Gedeo tradition. Whenever they are out, they carry their own food, *oxa*, with them.

Markets in the Gedeo Zone are local and regional and at times global. Local markets are daily markets meeting in the afternoons and serving farm households in a few villages. They are like small multi-purpose-supply shops in city corners. Most often women and children buy supplies for everyday needs, such as fresh milk, butter, meat, fresh vegetables, kerosene, salt or soap, at these markets.

Sale of sun-dried coffee in local markets is common in the season of *Adooleessa* (fig. 4.1). *Ensete* food, vegetables, chicken or eggs are also sold in local markets in the season between April and November. Grown-up men rarely attend these markets. They have a special meeting place called s*onggo*, a hut with furniture and a yard, where daily information is exchanged. *Songgo* primarily is a ceremonial place where the elders occasionally present prayers. Adult men here play local sports and games such as *saddeeqa*, a game of stones and wooden or stone plate with holes, the stones in most cases being the gleaming, black seeds of *ensete*. Here the elderly overlooking the younger men play engage in intellectual discourse from which younger men benefit.

Regional markets are larger markets uniting several villages from different agro-ecological zones. People bring their wares, *ensete* food, grains, honey, coffee, or handicrafts either on their shoulders or on pack animals. Vendors with merchandise from towns also visit these markets. Animals for sale arrive from faraway places, after a drive of two to three days, and are kept in large barns. There is a barn or a designated place in the market for every kind of farm animal, e.g., cattle, sheep and goats, mules, horses and donkeys as well as chicken. In dry seasons, lorries also arrive from towns to transport local wares such as coffee, *ensete* food, wood, cereal grains, beef cattle and/or sheep to Addis Ababa, the capital.

Three main groups (the Guji, the Sidamo and the Guraghe, the latter making the bulk of town merchants, have important trade links with the Gedeo. In former times, groups beyond Abaya Lake (the Wolaita, the Gamo and the Dorze) and the islanders called Gidicho used to supply the Gedeo with cotton and cotton garments. This trade has now considerably declined as a result of industrially manufactured garments.

It is important to note in passing the role played by farmers' cooperatives on which the socialist economy of the Dergue operated. Cooperatives were particularly important in the marketing of coffee and supplying consumer goods to the farmers. The cooperatives protected the masses from the unreasonable pricing of the town merchants. The cooperatives also provided employment opportunities for several members of the local youth with some education, who served as accountants or secretaries.

Two or more farmers' associations (fig.3.2a, ch. 3) came together to establish a cooperative. Then, all members of the farmers' associations were automatically enrolled as members of the cooperative. The cooperatives were led by a committee elected among the farmers by a majority vote.

The cooperatives were offered bank loans with which they established coffee processing factories and some of them purchased heavy duty pick-up vehicles and still others lorries and also buses for public transport. The cooperatives collected fresh coffee from the farmers, washed it and delivered it to the central market in Addis Ababa. The cooperatives also established supply shops in the rural areas.

Other than electing the committee members once in two or more years, and supplying or selling coffee to the cooperatives on cash or on credit, no sound structures were put in place, for the members of the cooperatives to exert any influence in the running of the cooperatives. This gap left the cooperative at the mercy of the cooperative leaders and other interest groups. They soon became under the control of the communist Dergue, at the same time losing their mass support. As a result, most cooperatives went bankrupt. Some farmers' have come to dislike cooperatives and call these "*durriisinxxe dikko*", literally satanic markets.

There is a widespread belief among the farmers that the officials enriched themselves and did little to improve the lot of the masses. Even after the fall of the Dergue, the situation of the cooperatives has not changed much and so there remains the bad picture of the cooperatives in the farmers' minds.

However, farmers feel that the fate of their coffee is doomed without the involvement of their cooperatives as a regulatory organ, even more so in today's market economy. The present Ethiopian government realizes the importance of cooperatives in economic development in general and that of the farmers' cooperatives in fostering rural development in particular. Thus, a separate department has been established to assist in the organization and development of cooperatives. Much is expected from the department to change the bad image of the cooperatives in the eyes of most farmers.

6.3.3. Production of major crops: principles and practices

6.3.3.1. *Ensete* (*Ensete ventricosum* (Welw.) Cheesman MUSACEAE)

(a) Initiation of suckering in *ensete*

The level of farmers' experiential knowledge is nowhere as well expressed as in *ensete* multiplication. However, they do not use seeds (plate 6.3c). This is due to difficulties involved. The time between sowing and planting *ensete* is long. The seedlings are few and little vigorous. Finally, the fermented product from plants raised from seed has a bitter taste.

Vegetative reproduction of *ensete* depends on the elimination of the unique apical growing tip of the underground stem (*ha'micho*). This provokes neoformation of meristems in the stump causing the development of several suckers by prolific reiteration (Hallé & al., 1978). Because *ensete* does not form wood, the general term sucker is used here instead of "coppice" which refers to woody plants (cf. rhizome, rootstock in the glossary).

For sucker production, the Gedeo cut *ensete* in the season of *Bonoo* (fig.4.1), a period marking the end of the wet season and the onset of the dry one. The choice of time is connected to the physiological state of the plants, the symptom of which is when the plants become 'fatty'. This symptom is the visual parameter of the condition of the carbohydrate reserve in the plants. The procedure starts by the removal of the whole foliage from selected plants, i.e., two to three years old medium-sized plants in the field (see fig.6.3). This is done a month or two in advance of the removal of the apical meristem, with a specially prepared and disinfected knife (see fig. 6.2.).

Well before severing the plant, the dried outer leaf sheaths and outer compartments of the pseudo-stem are removed, working from the outside to the inside of the plant. Then, the plant is severed from its subterranean parts at about 10 cm above the ground. If no sufficient corm is exposed, which is particularly the case in vigorously growing plants, some of the surrounding soil is dug away (fig.6.3). The, *illicho*, literally "eye", is eliminated. This is the apical meristem of the plant. The meristem disappears when the top of the axis is hollowed out by means of a sharp knife, which must first be disinfected by heating. Then the corm, while still intact in the ground, is split into two or to four equal parts, depending on its size. It is left open for two to three hours, after which it is covered with dried *ensete* leaf sheaths and soil, to protect it from animals and to provide a favorable condition for the 'healing' process to take place (fig. 6.3). The ecological factors involved in this conditioning of the environment of the reiteration process (see Hallé & al., 1978) have not been studied in detail.

From the surface cut oozes *gororaa*, a fluid. This is a disconnected sap stream. According to farmers' knowledge, this fluid plays a role in the initiation of the reiteration process and the differentiation of the reiterated shoots into young *ensete* plants or suckers. For good results, moderate moisture is essential and extreme moisture is avoided to avoid decay of the mother corm. After cutting the plant, it takes 4 or 5 months, for 50 to100 suckers per plant to appear.

Then the intact stumps with the suckers are uprooted and transferred to an already prepared nursery in the homestead (fig. 4.2; fig.3) where they are tended for a year or two. After one year, provided the suckers are large and vigorous enough, they are separated from the mother corm and transferred to the second nursery. If not, they are allowed to remain on the intact mother corm for one more year. Suckers are sorted out according to size. Assorted suckers are transferred to the second nursery. Larger suckers are directly planted out in the field whereas smaller and weaker ones are planted in a line in the second nursery to be tended for a third year (see fig. 6.3).

(b) Nursery and field management of *ensete* suckers

A household needs two nurseries for *ensete* suckers, one for newly emerging suckers still intact on the mother corm, called *simaa*, and the other for the suckers separated from the mother corm and now planted in a line, called *huuffee* (see fig.6.3). Both nurseries are carefully prepared by intensively manuring with farmyard manure or household refuse, beforehand.

Ensete suckers need intensive care. The area is fenced in to keep out domestic and wild animals. Even human beings, except the farmer who works in the nursery, are not allowed to enter an *ensete* nursery. *Ensete* suckers in the nursery are compared to a bride who in Gedeo culture is not to be seen until her honeymoon is over. *Ensete* suckers, if approached unduly, are reputed to "see" and "shy away" from growing.

Once the suckers are established, frequent cultivation is unnecessary and better avoided. "Weedy" herbaceous growth is allowed to grow profusely with the suckers. The weeds are slashed in the dry period between May and June when the suckers, due to the microclimate in the herbaceous vegetation, have grown too high for their girth. But until this stage, weeds are allowed intentionally. This is done to avoid the rosette habit that *ensete* plants develop if allowed to grow in too wide a space. Soon after slashing the "weedy" growth, the suckers put on girth and attain good, lean shape for field planting.

At intervals, preferably after slashing the “weedy” herbaceous vegetation, application of manure and/or household refuse and/or humus from the field is required as this helps towards “hardening” the suckers for field planting.

Fig. 6.2. Set of tools mostly used by men. Slashing knives (*labba habille,* (1a)) and *salaxo* (1b)) are used for slashing the herbaceous vegetation. African hoes (*qotto,* 2a and 2b) are used for planting and uprooting, axes (*meessano* (3a), *maxaraba* (2c) and *qocee*, (3b) are used for wood working. *Meessano* (3a) is mainly used for cutting large boles and to split them and *qoce* (3b) and *maxaraba* (2c) are also used for pruning branches or for pollarding trees. All of these are pieces of shaped metal inserted in wooden handles. The preferred wood, which first is weathered to avoid splitting, comes from the stems of young trees or from the lower well hardened branches mature trees of *garbbe* (*Pygeum africanum* ROSACEAE). *Hookko* (3c) is a wooden hook used in reaching for distant coffee branches during harvest or for leaves of larger *ensete* plants. A grinding stone (*daamma* and *qarsso*, 4a) is used for grinding grain and to sharpen the metal part of the tools. A thick and up to 50 m long cable (*gishsha*, 5) is used in climbing trees, as well as in suspending and lowering beehives in honey production (6.3.3.4) or in tree harvests, i.e., in directing felling trees.

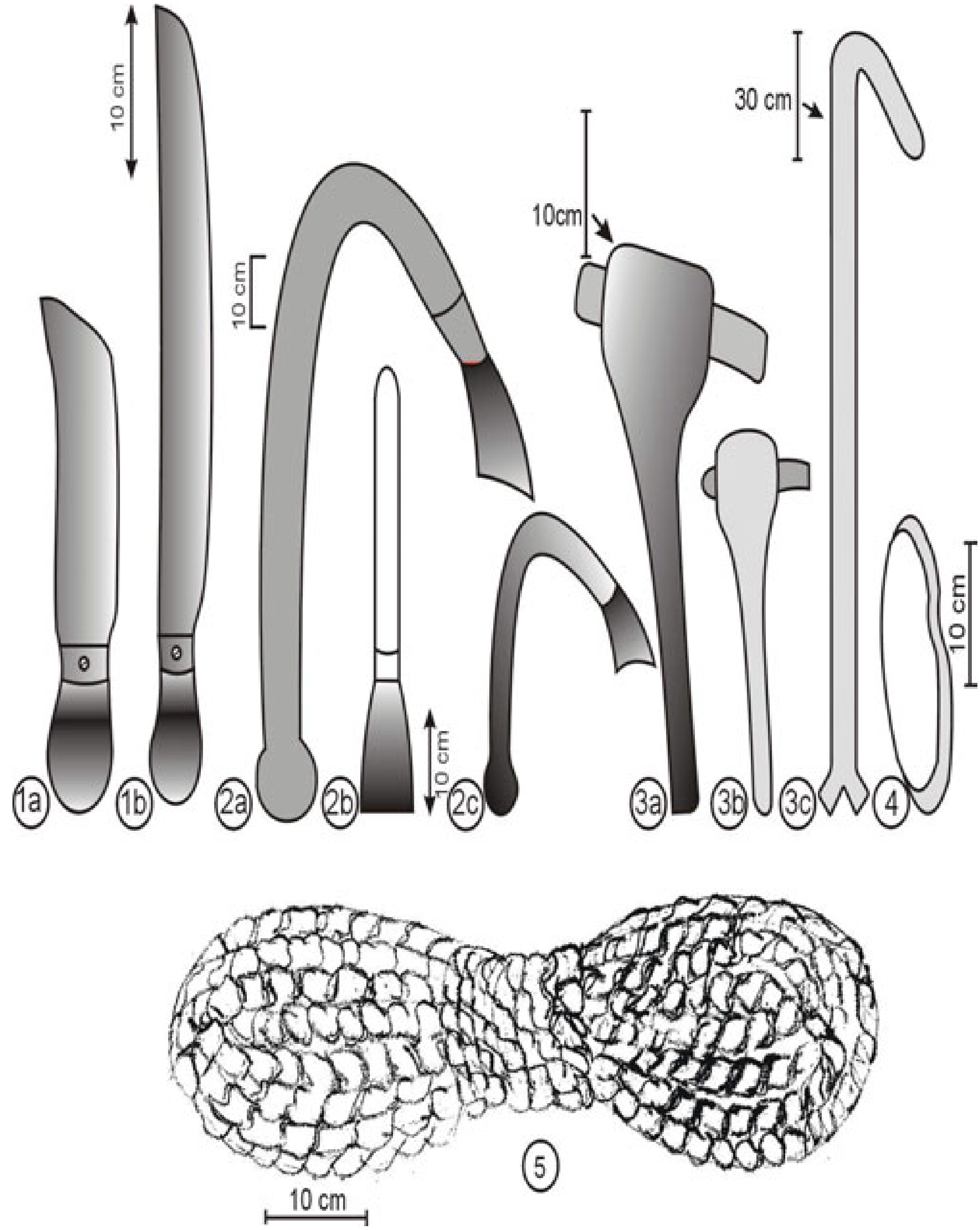


Figure. 6.2

In the highland (above 2500 masl) and lowland (below 1750 masl) zones, *ensete* planting is usually confined to the homesteads and their surroundings (fig. 4.2), as this shortens the transport route of farmyard manure and/or household refuse. Here, planting is mainly to establish a new block of even-aged *ensete* plants (fig.6.4; plate 4.4, plate 6.2). But in the midland zone (1750 to 2500 masl), *ensete* is planted in fields far from the homestead. Unlike in the preceding zones, here planting is to enrich the field by replacement of harvested plants in a mixed uneven-aged plantation (fig.6.5; plate 4.1; plate 4.3, plate 4.6, plate 6.3a, plate 6.3b, plate 6.4a, plate 6.5). Nevertheless, the two types of plantation are established in quite similar ways, so that the sustained flow of biomass is not violated. This shows that the Gedeo living in different agro-ecological zones are united in sharing this principle.

How a sustainable flow of food is ensured following either management of uneven-aged blocks of *ensete* or through management of a mixed species uneven-aged plantation of diverse crops is discussed in ch. 5 (cf. fig. 6.4 and fig 6.5 with fig. 5.2).
In both cases, a long period, up to ten years, is required for the establishment of the commonly grown *ensete* type, *gantticho*. This is not due to shortage of planting material, as might be suspected, but mainly to the priority requirement of "caring for the standing biomass", a principle in Ethiopia only observed among the Gedeo. The Gedeo do not have any definite harvest date or season for *ensete* plants. *Harvest is continuous throughout the year.* It is noted here already that this principle has been defined and applied more recently to forest trees from the 19th century on, by the mountain foresters of Central Europe *(" Vorratspflege'* or 'care of the living (standing) stock"; e.g., Leibundgut, (1985), Mayer (1980), Schütz & Oldeman, 1996).

Therefore, both types of *ensete* plantation are established in a step-wise enrichment process. In the first year, only plants enough for one year's consumption plus up to 10%

Figure 6.3. Inducing reiteration (suckering) in *ensete* (*Ensete ventricosum* (Welw.) Cheesman (MUSACEAE). (A) Parts of a young *ensete* plant to be severed (1, 2, 3), so as to induce reiteration. (B) After the foliage leaf and the upper pseudo-stem are removed, the underground corm is exposed, by digging out the soil surrounding it. Then, the bases of the leaf-sheaths are scraped off with a disinfected, sharp knife. Finally, the central meristem which farmers call *illicho* is also scraped off. The meristem is not destroyed, as is erroneously depicted in the literature. The "blind" corm, i.e., without a control center or *illicho* is now split into either two or four equal parts, depending on its size. Then, it is left to dry in the open air, for 2 to 3 hours. It is then covered with clean *hashupha* (dry leaves form young *ensete* plants). Then, without adding anything else, the soil is heaped upon it. To prevent damage by animals, a kind of fence is provided. This consists of four small poles half a meter high, erected surrounding the corm and strengthened by *xushsho* (dried petioles of *ensete* leaves, used as fiber). After four to five months, new sprouts appear, from the callus (Cl). The corm with the suckers (*simaa*) intact (C), is then uprooted and transferred to a pre-prepared nursery in the homestead. Here, it feeds the suckers for a year, after which they are separated from the mother corm and either planted out in the field, if large and vigorous enough or they are planted in a line in the homestead. Plants in the line are known as *huffee* (D), and are cared for a year when they will be ready to be transplanted in the field.

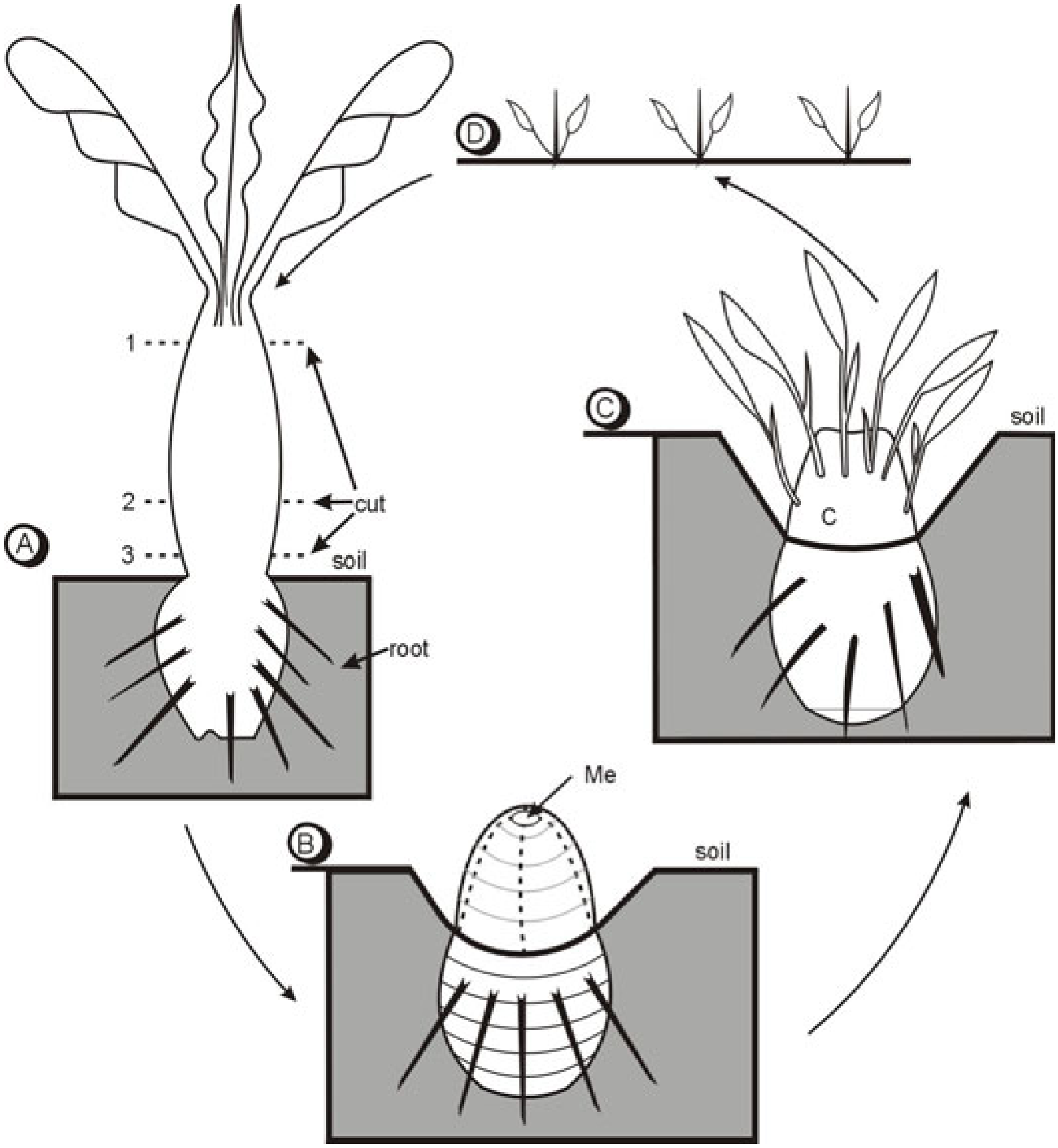


Figure 6.3.

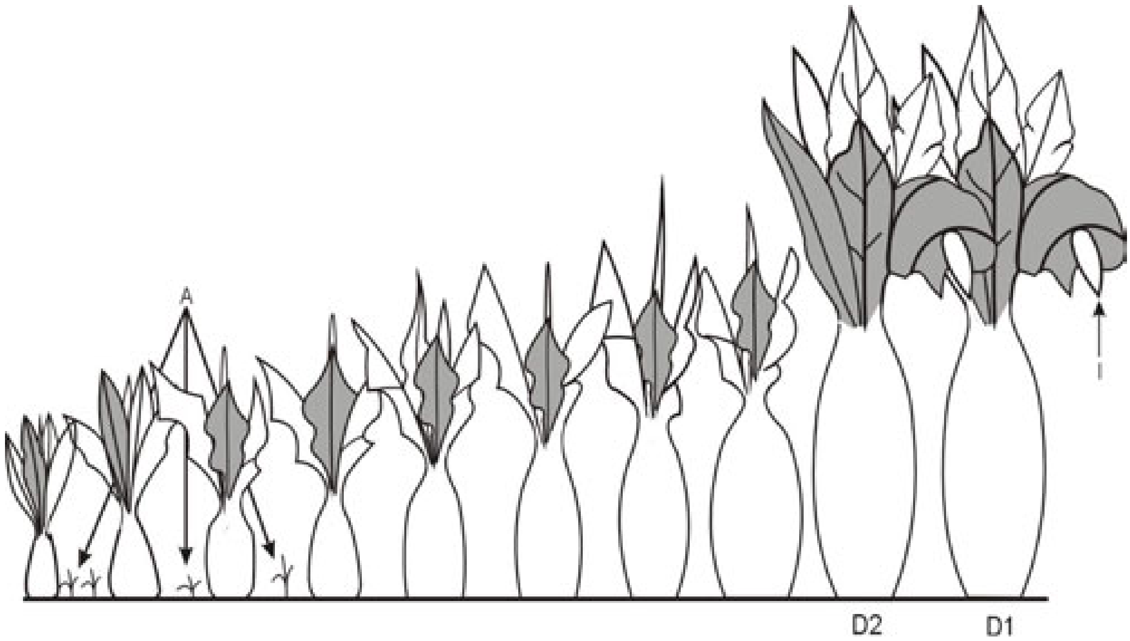


Figure 6.4. Simplified profile diagram through even-aged blocks of *ensete* (*Ensete ventricosum* (Welw.) Chessman (MUSACEAE)) plantation. Block-wise crop establishment and management is shown. In the far right a block with two *ensete* plants with their inflorescence (I) initiated (*daggicho,* D1 and D2) are shown. These plants must be harvested and replaced. It is also essential that each year a block with mature (flower-initiated) plants is available, so as to provide an uninterrupted supply of food. On the other hand, blocks to the far left contain the smallest plants, e.g., K (*Kaassa*), just planted out in the field. It is also essential that such smaller plants, representing future food, are present, in almost the same proportion, of course with some extras in case of contingencies, as the mature ones. Due to the wider spacing maintained in the initial phases of *ensete* development, annual crops (A) are intercropped. Here, the basis of management is a block, unlike uneven-aged mixed plantations (fig. 6.5), where the basis of management is formed by single plants, dispersed throughout the "agroforest". Figure based on block transect 1 (appendix 4.1a).

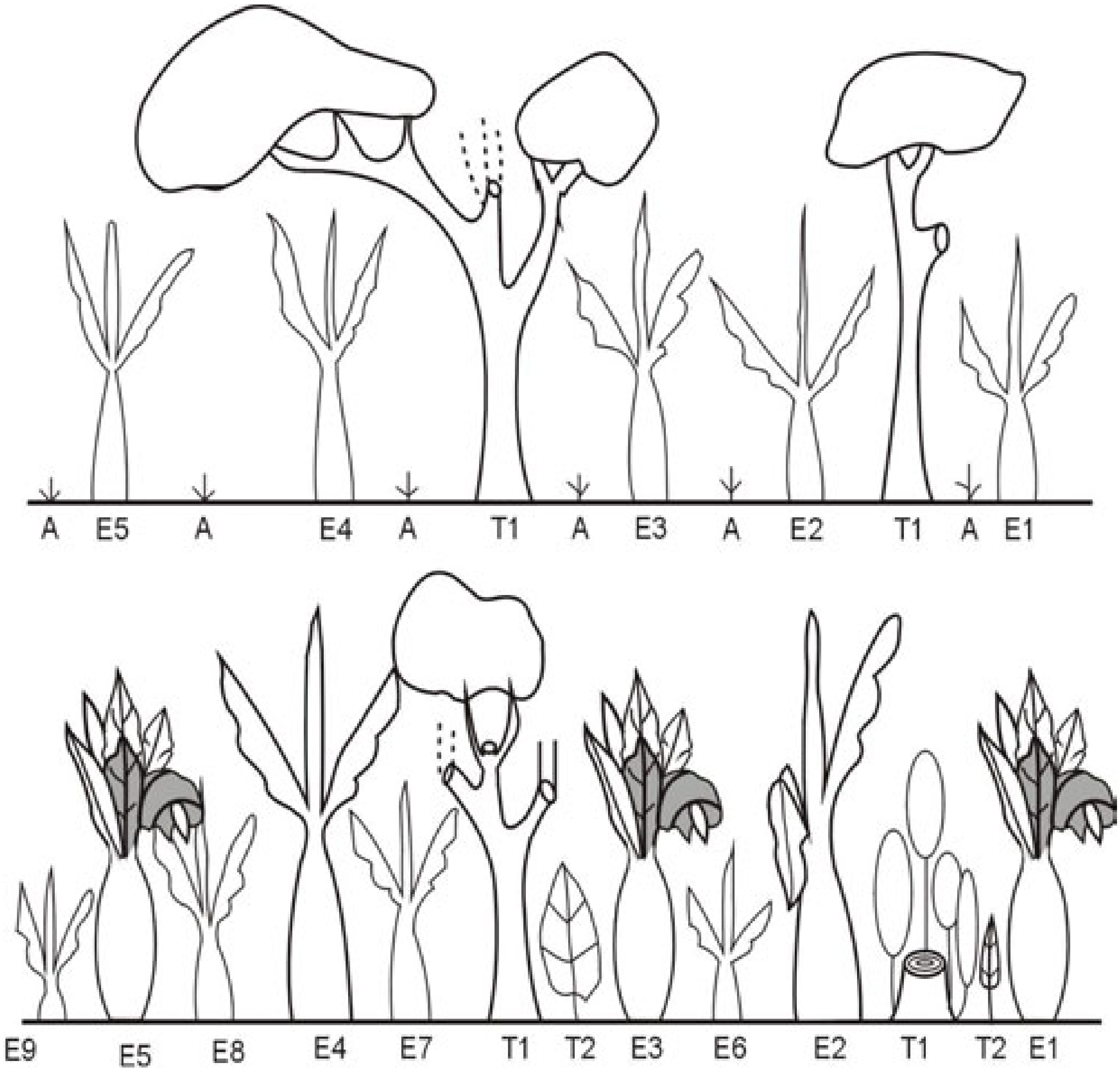


Figure 6.5. Simplified profile diagram through a mixed species, uneven-aged plantation. Two phases, initial phase, (upper diagram), and later phase (lower diagram), are shown. The lower diagram shows how the block is enriched by step-wise planting of *ensete* (E6, E7, E8, E9) and coffee (T2), replacing the annual crops (A), which in the initial phases were favored by the wider spacing. The *ensete* plants, E1, E3 and E5, with their inflorescence (I) initiated, show, unlike in block management (fig. 6.4) harvest is dispersed throughout the "agroforest". Also note management practices applied on the trees (T_1). Here, management is replacement planting, typical of one-plant *eco-units*. A = annual crops, E1 – E9 = *ensete* (*Ensete ventricosum* (Welw.) Chessman MUSACEAE), T1 = *Milletia ferruginea* tree, T2 = coffee (*Coffea arabica* L. RUBICAEAE). Figure based on block transects (appendix 4.1b and appendix 4.1c)

contingencies are planted, not more. In the initial stages, growing of annuals like vegetables or grains (fig. 6.4' fig.6.5) in between the perennial components is possible, due to the wide spacing of the latter. In the highland and lowland zones, *ensete* plants are planted in one block (fig. 6.4), whereas they are dispersed throughout the whole farm or field in the midland zone (fig.6.5). The same procedure is repeated until the tenth year, when the planting is completed, and when the *ensete* planted in the first year are ready for harvest (D1, D2, fig. 6.4 and E1,E2,E3, fig. 6.5). From this stage onwards, only replacement planting takes place in the highland and lowland zones or enrichment planting in the midland zone. The same procedure is applied to other perennial components accompanying *ensete*.

Why do mono-cultures exist in even-aged *ensete* blocks in the highland and lowland zones? The main reason is the nature of the soils in these zones, which require frequent care by applying farmyard manure and/or household refuse. Moreover farmers complain that the soil "evicts" the *ensete* plants after one generation, requiring rotating it with other crops. The situation is forced upon the farmers, who have to maintain a sustained biomass flow anyway.

In other words, *ensete* in these bioclimates is a true pioneer plant, disappearing in later successional stages. The distribution of the species follows Budowski's rule (as amended by Oldeman, 1990 p331): "any plant, which plays a pioneering role in a hospitable environment, shows a geographical distribution, which includes more inhospitable environments". In the midlands, *ensete* is a pioneer, colonizing medium-sized openings in a multi-species forest canopy, whereas the more inhospitable zones in the highlands and lowlands show *ensete* in mono-specific stands. Such distributions are often linked to the hydrothermic characteristics of neighboring bioclimates. For the Gedeo zone, no hydrothermic diagrams (Gaussen, ex Oldeman 1990) are known as yet.

Once *ensete* plants are established in the field, the farmer must slash back the "weedy" herbaceous growth once or twice a year, usually in the dry seasons. He also must bend down some of leaves from the older plants to minimize over-shading (fig. 6.8). Need for organic manuring varies along the agro-ecological zones (ch. 7).

Maintenance of an optimum balance among the diverse components of a mixed uneven-aged plantation where *ensete* is only one component among the many is of crucial importance in the midlands. Here pollarding trees, pruning tree branches besides lowering *ensete* leaves of emergent *ensete* plants is essential to provide sufficient light for newly planted and younger *ensete* plants, including other crops in the understorey (see fig.6.8).

Repeated or serial transplanting of *ensete* suckers as widely reported for other *ensete* peoples (see Asnaketch, 1997; Tsegaye & Struijk, 2000) does not exist among the Gedeo. *Ensete* plants are planted in the field only once and no more transplanting is needed afterwards (plate 4.6, ch. 4). This makes Gedeo *ensete* culture less labor demanding. Gedeo management of *ensete* in mixed uneven-aged plantations is also unique.

Two persons are needed for planting in the field, one for making the planting holes and planting, using a *qotto* (African hoe, see fig. 6.2) and the other person for transport (i.e., carrying plants around). This is particularly important in enrichment planting in mixed uneven-aged plantation (fig. 6.5). Preparation of planting holes constitutes the larger portion of fieldwork on *ensete*. Indeed planting holes strongly influence the later development of plants (Oldeman, 1990, p. 215) and a great deal of energy is invested in the careful preparation of these holes. Tree stumps and/or roots when encountered are removed, when preparing the holes. Farmers are judged by the condition of their planting holes, which can be observed by the growth performance of the *ensete* plants. Plants in well-prepared holes invest in diameter growth sending their corms deep into the soil. The corm then emerges later, in its flowering stage, whereas plants in improper holes rather invest in height growth and bring their corms upwards prematurely (see ch. 5; plate 6.1).

(c) *Ensete* harvest, storage and marketing

The details of *ensete* harvesting and processing are discussed in chapter 8. Only a few points are raised here.

Maturity in *ensete* plants is gauged by their content of carbohydrate. This stage varies among *ensete* types grown. In *gantticho*, this time is reached when the plants initiate inflorescences, on average within six to seven years after field planting. However, plants take longer in the highland zone (up to 12 years) and shorter in the lowland zone (6 years) to come to maturity (table 4.3 (ch4)).

The most important point at this stage is the concern not to over-harvest. The uninterrupted harvest is possible because planting and harvest are synchronized so that the approximate number of harvested plants corresponds to the number to be planted as mentioned before. This is similar to selective cutting in sustained yield forestry (Ciancio, 1997).

Ensete plants like forest trees pass through three development phases, ending as plants of the *past*, after having been plants of the *present* and having started as plants of the *future*. Plants of the *past* are called *cimaaleeyye* represented by flowered *ensete* plant, *daggicho,* or flower initiating *ensete* plant, *idago*. Since these have finished their potential of expansion and are vegetatively declining, they should be harvested immediately. There is nothing to be gained by keeping them in the field. Plants of the *present* are called *ka'uma,* and these are represented by *beyaa*. These are in the pre-production phase, their architecture being mature but their biomass still filling up. They are not to be harvested unless there is a serious need to do so. Plants of the future are called *oosee,* represented by *saxa* or *kaassa*. These are still incomplete architecturally. Their limited biomass is not yet fit for fermentation. In case of dire need, *saxa* and *kaassa* may be used as root vegetables.

Components in the “future “ and “present” classes normally are not to be harvested. Their harvest invites destabilization of the system, as they have not yet expressed their potential. On the other hand, components in the “past” category must be harvested and not doing so is a waste of resource, as their maintenance incurs cost.

Households are always careful to maintain these classes in the right balance for continuous harvesting. This is essential. Once the balance is lost, due to skipping a planting season, and/or over-harvesting, it is difficult to readjust because of the perennial nature of the crops. Farm households who have achieved the optimum balance between the mature and immature plants can live on the “ interest”, maintaining the capital. Because of the intensive management and /or input, no two gardens are the same. Each garden carries the fingerprints of its owner (Michon, 1983). Careful and diligent farmers are able to keep a finer balance among the age classes of the components, thus having

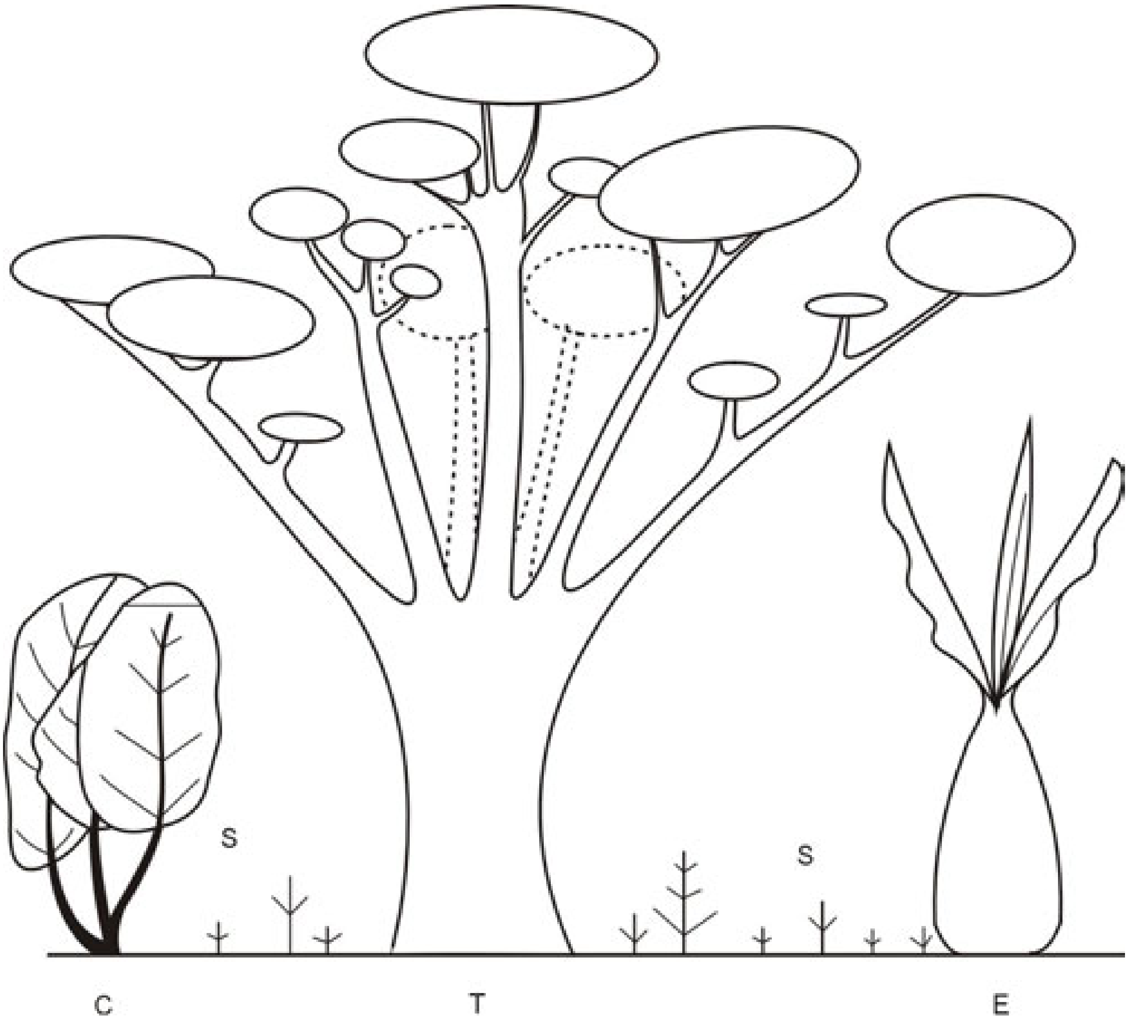


Figure 6.6. A nursery under *Ficus* sp. (MORACEAE) tree (T) (*xillo qilxxa*). Because of the availability of food and space, diverse frugivore animals arrive from faraway places, bringing with them seeds of diverse species. Wild fauna, through transport of biomass (seeds and other propagules), therefore serve as a bridge between Gedeo "agroforests" and other ecosystems. Seedlings of various tree and shrub species including those of coffee are raised here. This natural nursery provides planting material for all plant components except for *ensete* and few cultivated herbaceous crops. Yirga-Chaffee*,* one of the world's best quality *arabica* coffees, is raised in this way. From right to left, E = *Ensete* ventricosum (Welw.) Cheesman MUSACEAE)), S = seedlings of diverse species, T = Ficus sp., C = *Coffea arabica* L. RUBIACEAE. Figure based on plate 6.4, block transect 2 (midland zone, annexed) and block transect 3 (lowland zone, annexed).

Table 6.2. Growth/ development/ stages/classes/ in the perennial crop components

	Future	Present	Past
Ensete	*simaa,saxaa,mu'lo*	*beyaa*	*idago/daggichcho*
Woody perennials	*golqqo, hiilo,galo*	*nophpha*	*cimaaleessa*

Source: this study

achieved sturdy sustainability of supply, a characteristic lacking in gardens of careless farmers where it is much less stable.

In striving towards this model, farmers follow different approaches. One is keeping a ready supply of seedlings for replacement (*wobbisa)*. Impatient farmers who do not want to wait till the next planting season plant throughout the year. However, replacements of *ensete* out of the season require careful follow-up.

Table 6. 3. Labor needed for major farm activities. The table is based on an average farm of 0.5 ha feeding seven people.

	Farm activity	Man/woman days*
I. For men		
1	Cutting *ensete* for sucker production	1.0 – 2.0
2	Transferring suckers to nursery	1.0 – 2.0
3	Tending the suckers	2.0 – 5.0
4	Slashing back the herbaceous vegetation (twice a year)	5.0 – 10.0
5	Pruning/pollarding and/or felling trees	5.0 – 10.0
6	Coffee harvest	15 – 20.0
7	Planting *ensete* out in the field	10 – 15.0
8	Planting coffee out in the field	0.5 – 1.0
10	Preparation and hanging beehives in the trees	5.0 – 10
12	Harvesting honey	3.0- 5.0
Total		55.0 – 80.0
II. For women		
1	*Ensete* harvest	50 – 70
2	Fetching wood	10 – 30
Total		60.0 – 100.0

N.B. Time spent on minor farm visits (*towachcho*, for both sexes) is not included. This part of the farm activity is more important among the Gedeo farmers. One man-day = 4 to 6 hours per day One woman-day = 5 to 8 hours.

Source: this study

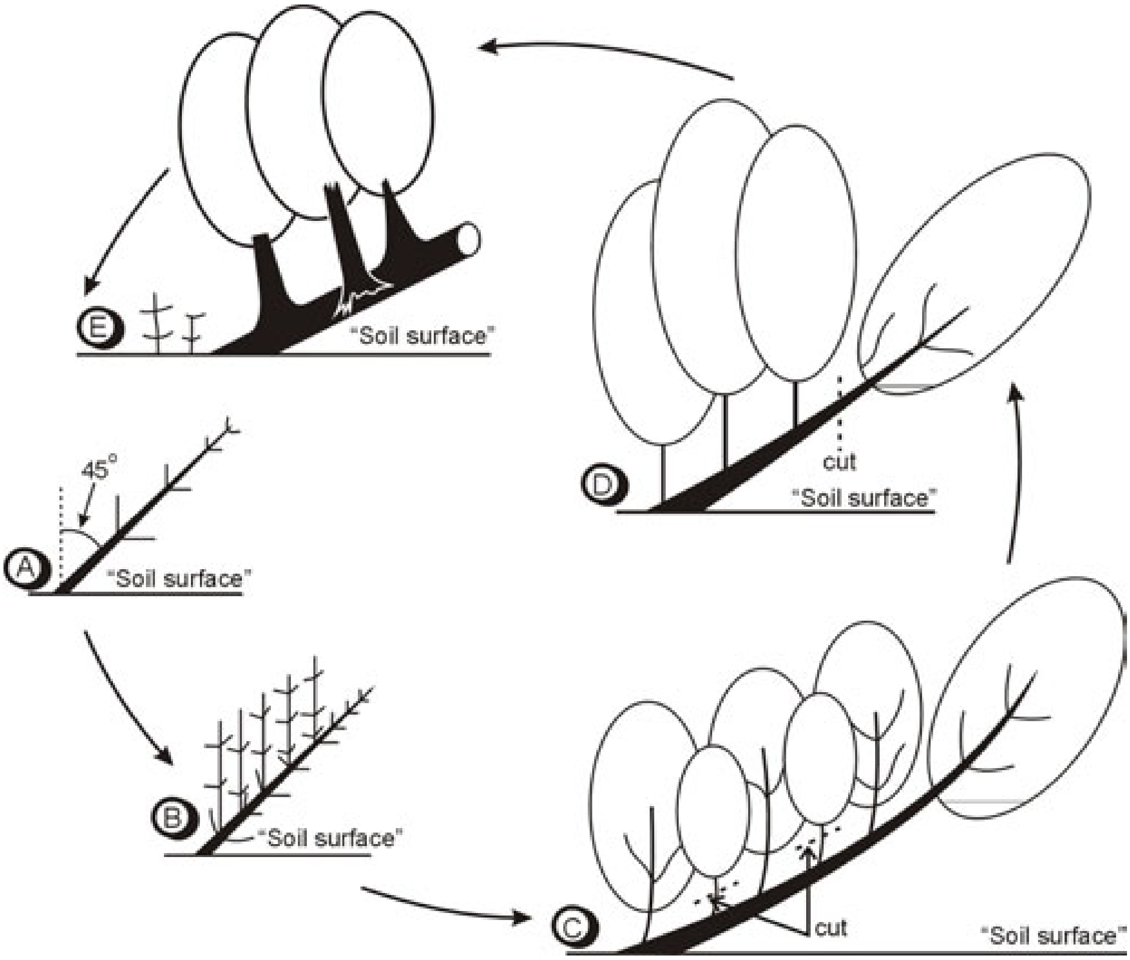


Figure 6.7. Inducing reiteration (suckering) in coffee (*Coffea arabica* L. - RUBIACEAE). A seedling is planted tilted (A), at about 45° with the soil surface. Holding grip of the soil, the seedling produces several suckers (B), only three of which are retained (C). These develop into main, producing branches (D) and (E). Note coffee seedlings, to the left of (E) under a producing coffee tree. The reiterative cycle is completed, when this seedling reaches a size appropriate to be planted out in the field. (Figure based on block transect 2 (appendix 4.1b; plate 6.4a) and block transect 3(appendix 4.1c; Plate 6.4a).

6.3.3.2. Coffee (*Coffea arabica* L.- RUBIACEAE)

(a) Planting material

Farmers depend on natural regeneration (see fig. 6.6), so they rarely raise coffee seedlings in beds. Usually, they tend seedlings that germinate under mature coffee trees (fig. 6.7). Sometimes, the soil under the older trees is worked over, after harvest to help spared beans to germinate. Because of the hospitable biotope, diverse frugivore animals arrive in the big tree crowns carrying seeds of diverse species (fig. 6.6). These boitopes hence are consciously used to enhance the variation of genotypes and species in Gedeo lands. Scientifically, these ecological compartments of Gedeo vegetations might be called "biodiversity bumps". It is easy to see that they have natural counterparts in natural forests.

As a result, the Gedeo highlands have become the breeding grounds for a rich array of genotypes of *arabica* coffee. Genetic conservation and enrichment of coffee has been extremely successful by using this method. This attracted coffee breeders from the Jimma Coffee Research Center (Agricultural Bureau for the Gedeo Zone, unpublished). The farmers recognize about five varieties of *arabica* coffee, i.e., *wolisho*, *kudhumee*, *deegaa*, and *baddeessa*. One of the best known highland coffee in Ethiopia (Yirga-Chaffee) is named after one of the Gedeo districts and is grown in this way.

(b) Planting coffee out in the field

Unless they are sure that rains are imminent, farmers do not uproot seedlings to plant out in the field. Notwithstanding the utmost care, an appreciable part of the feeder roots and sometimes even the taproot are damaged. However, farmers do not worry about it, as the longest living coffee trees (up to 70 years old) are raised in this way indicating the high rate of success.

Most often, seedlings are planted under older coffee trees or *ensete*. Intercropping coffee with *ensete* is common in the Gedeo highlands. The reason for doing so is that both crops yield well and coffee trees live longer. Both effects are related to the moisture supply by the *ensete* plants (see ch. 5). It has not been studied whether or not a sound soil micro-life contributes to this result, e.g., by a balanced effect of mycorrhizae and bacteria (e.g., Smits & al., 1987). Coffee seedlings are planted in a tilted sense (under an angle of up to 45 degrees with the ground. This promotes reiteration resulting in vigorous suckers on the upper side of the stem. Coffee so gets a bushy architecture, with a wide, low crown and no primary trunk (fig. 6.7; plate 6.4a). This facilitates harvesting. All suckers are not retained. Farmers select potential suckers assumed to become the best producers and prune others. "Weedy" herbaceous vegetation is used as shade for the newly planted coffee seedlings. The herbs are not slashed until the newly planted coffee seedlings are solidly rooted.

Seedlings supplied by the Coffee Improvement Project (6.3.2.1.) raised in the conventional nursery beds were extended to some farmers. Most of them, however, held on to their traditional method, because it is less costly (in labor and materials) and performes well. Contrarily to the recommendations by the extension service, farmers do not prepare planting holes prior to the planting season. Uprooting and planting are simultaneously carried out.

(c) Harvest, Storage and Marketing

The herbaceous vegetation beneath the coffee tress is slashed in the beginning of the dry season. When most of the beans are fully ripe, they are stripped off, taking care neither to remove leaves nor to break branches or twigs. To reach out for distant branches, farmers therefore use specially prepared ladders and a fork (*hookko*, fig.6.2.).

Coffee harvest has two phases. In the first phase, called *tisha*, only ripened (deep red) berries are selectively picked, leaving the greenish ones behind. This requires concentration and time and it is left to children and women who are adept in this. The household head designates the trees to be harvested. Less value is attached to this harvest since its proceeds are spent on immediately consumable items. This coffee is directly sold to washing factories that now number over a hundred in Gedeo country. The government sets the bottom price for a kilogram of fresh coffee. However, farm gate price of a kilogram of fresh coffee has not ever fetched Ethiopian Birr five (about fifty US cents, at current price). The norm is between two and three Ethiopian Birr. The Agricultural Bureau and the Department of Commerce, Industry and Transport for the Gedeo zone make sure that the coffee merchants abide by this law.

The second phase of harvest called *bunin qocca*. It needs more organization of household labor, and also the pooling of labor of neighbors or and/or relatives (*goottalee*). Recently, employing off-farm labor, particularly women and children has become a normal procedure. Since the second coffee harvest phase is squeezed into a short period between mid-December and mid-January, this is important. Loss of yield may easily result, as coffee berries dry on the trees if left too long. As soon as the berries are dried on the tree, the coffee tree initiates flower primordia and picking coffee berries once this has happened means aborting the flower primordia, as these and the dried berries are very close to each other on the coffee twigs.

Working in the coffee canopy after harvest determines future coffee yield. After harvest, farmers therefore return each and every branch to its former position, using *hookko* (fig.6.2). Branches must be returned exactly to their previous position, since displaced branches need one or two years to become settled in the new position and initiate flower primordia. Excess suckers and older and exhausted branches are also removed. Thick mulches are placed at the foot of every coffee tree, as moisture and a sound organic soil layer are the two most important factors required by coffee trees for the initiation of flower primordia and thus for the next crop. As an example of the biological processes involved, see Smits & al. (1987) for the link between mycorrhizal periodicity, the rainy season and flowering in Indonesian dipterocarp trees.

Like in the case of cut-and-carry foraging, Gedeo tradition allows access to private property, the coffee farm, after its owners of the coffee farm have finished harvesting it. Therefore, small farmers, women and children can enter and glean the remaining coffee berries, a practice called *sheffile** in Gedeo language. Farmers in serious shortage of land for planting coffee can plant a few trees (*rubbana**) in some one else's field, and these remain the planter's property.

Coffee beans thus collected are dried in the sun on a bed at 0.5 m – to 1 m high from the ground covered by bamboo mats called *qarxxa*. Dried coffee beans are stored in large bamboo baskets called *doonee*, which are placed on a rack at 30 to 50cm above the floor, to allow good ventilation. The coffee so keeps its good quality until it is sold. Sun-dried coffee can be stored, without spoilage, for more than a year, allowing farmers to react to changing coffee prices. Coffee can be sold to vendors who come to the farmers' or it can be taken to towns on pack animals. Fearful of towns, perceived as treacherous and deceitful, most farmers sell their coffee to vendors. Just like in fresh coffee, the government fixes the bottom price of a kilogram of sun-dried coffee, which has not fetched more, till now, than ten Ethiopian Birr (about US$2.0, at current price). The norm is between three and five Ethiopian Birr.

Although fresh coffee fetches relatively better prices than sun-dried coffee, farmers prefer to sell their coffee sun-dried. Farmers so save value in the coffee till late in the *Adooleessa* (late September). This is a way of saving. Money in cash obtained by selling fresh coffee would not have lasted this long. This strategy of farmers is also applied when marketing other crops, for instance, barley. Some farmers stock the harvest of two or three years, if prices fall drastically. But most farmers must sell whatever they have produced within the same year. Those farmers who can defer sale of their harvest to late in the coming season have a lot of respect in Gedeo society. *Ensete* makes farmers so self-reliant that unless they spend extravagantly, most farmers can skip one or two marketing seasons.

6.3.3.3. Trees

(a) Introduction

Farmers' experiential knowledge in working with trees is reflected by the trees they selected for various purposes such as soil enrichment or for fuelwood. *Albizia gummifera* (MIMOSOIDAE), *Milletia ferruginea* (PAPILIONOIDAE) and *Erythrina abyssinica* (PAPILIONOIDAE); (see table 6.4) are used for their soil maintenance and restoration. Most of the trees are fast growers, easily propagated and tolerant of regular pruning. Farmers of course selected the trees for these characteristics. Trees such as *Peygeum africanum* (ROSACEAE) are still popular among the farmers for their high energy fuelwood and also fast growth, though this tree species is regarded as not suitable for intercropping.

Table 6.4. Multi-purpose tree and shrub species commonly used by Gedeo farmers.

Scientific Name	Major mode of Reproduction	Suckering capacity	Suitability for beehives	Use by bees as fodder	Resistance to pruning	Quality for timber	Use as fodder	Use as fuelwood
Albizia gummifera	seed	high	high	high	high	low	low	low
Aningeria adolfi-friederecii (SAPOTACEAE)	seed	high	high	high	medium	high	-	low
Celtis sp. (*deegaa*)	seed	high	-	high	high	high	high	high
Celtis sp. (*saarajje*)	seed,cutting	high	low	high	high	high	high	high
Cordia africana	seed	high	high	high	high	high	low	low
Croton macrostachys	seed	high	high	high	high	low	-	high
Erythrina abyssinica	seed	high	low	high	high	low	high	low
Euphorbia abyssinica	cutting	high	low	low	high	low	-	low
Fagaropsis sp. (*sisa*)	seed	low	low	high	high	low	-	high
Ficus sp. (*ode'e*)	fig,cutting	high	high	high	high	low	high	high
Ficus sp. (*golalo qilxxa*)	fig, cutting	high	high	high	high	low	high	high
Ficus sp. (*xillo qilxxa*)	fig, cutting	high	high	high	high	high	high	high
Hagenia sp. (*heexoo*)	seed	high	high	high	high	high	-	low
Hagenia sp. (*Hanqqo*)	seed	high	high	high	high	high	-	low
Juniperus procera	cone	high	-	high	high	high	-	low
Milletia ferruginea	seed	high	high	high	high	low	high	high
Podocarpus gracilior	cone	-	-	high	high	high	-	low
Polyscias ferruginea	seed	-	high	high	low	low	-	low
Pygeum africanum	seed	high	low	high	high	low	high	high
Vernonia amygdalina	seed	high	-	high	high	-	high	low
V. auriculifera	seed,cutting	high	-	high	high	-	-	low
Syzygium guineense	seed	low	high	high	high	high	-	low
Trichilia sp.	seed	high	high	high	high	high	-	high

Source: This study

Farmers valued these trees for their energy-rich wood, but today, these single-purpose tree species have become rarer because of the farmer's preference of multi-purpose ones. The farmers do believe that every member species of their system must be conserved, as there is no substitute for it. *Pygeum africanum* (ROSACEAE) for instance is a source of medicine which farmers cannot afford to lose. Therefore, farmers relocate these trees instead of letting them become extinct. The method adopted is to grow such trees mixed with eucalyptus in farm boundaries and along roadsides. Eucalyptus are praised for their fast growth and good stem form, but disliked for their soil desiccating property.

(b) Planting and field management

As in coffee (6.3.3.2), natural regeneration by frugivorous mammals and birds plays a large role in the multiplication of multi-purpose woody perennials. However, farmers are involved in improving conditions for this to happen. As in *ensete* (see 6.3.3.1), they prefer vegetative reproduction. The main reason is economic, as plants raised from suckers or coppices grow faster than those raised from seed. However, species multiplied in this way are used for fuelwood, shade and soil enrichment (see table 6.4). Timber trees are usually raised either from seeds or from stem suckers. Exotics such as *Eucalyptus* species (MYRTACEAE) are reproduced by seed. To facilitate germination of seeds, farmers as in coffee work over the ground under the trees before the rainy season.

From emerging reiterates (suckers, coppices) and/or seedlings, farmers select plants of high growth potential. Farmers do this using easily identifiable parameters, such as leaf characteristics, length of internodes or branching habit. Farmers distinguish between "female" trees, i.e., fast-growing and "male" trees, i.e., slowly growing. Once the new trees have established themselves, the next management measure is shaping the crowns, i.e., pruning or pollarding branches for an optimum balance of light and shade (fig.6.8). Utmost care is taken to minimize damage to understorey crops by reducing the tree crowns before felling and/or by girdling the tree several months prior to cutting.

Sometimes, farmers are helped by the litter fall of deciduous trees such as *Albizia gummifera* MIMOSOIDAE, *Milletia ferruginea* (PAPILONOIDAE) and *Erythrina abyssinica* (PAPILIONIODAE); (table 6.4). These lose their foliage seasonally in response to moisture stress (personal observation). The proper time for litter management, as in all Gedeo farm practices is the season of *Ba'leessa* (fig. 4.1). This follows the working principle that forbids breaching the balance between biomass exported and that left on the site. The dry season provides the conditions to distribute fallen foliage as mulch. To facilitate this, the herbaceous vegetation is slashed and leaves of *ensete* plants are lowered in a way that does not hamper their photosynthetic activity (fig.6.8). Pollarding is preferred to pruning, particularly in the rainy season, so as to minimize damage that results from falling branches. By pollarding, tree leaves and foliage dry and fall leaving the trunk and main branches behind. Moreover, gravity or wind assists in the distribution of the leaves and twigs throughout the farm.

(c) Harvest and storage

Trees are felled rarely and only if they have completed their growth potential. Moreover, the presence of a younger tree, preferably of the same kind, is checked. If selection involves a choice between or among trees of similar size, the one with least development potential is felled. As in *ensete*, a knowledgeable household member or relative checks this. Farmers can differentiate between promising and declining trees by carefully examining the growth of leaves and the branching behavior of the trees in question. Farmers act as if they have maps in their mind more or less congruent to what Halle & Oldeman (1970), followed by Hallé & al. (1978) called architectural tree models.

Farmers take care not to fell lonely trees as doing so will be against their sustained yield principle, endangering not only sustained wood supply but also introducing disturbance by opening overly extended soil surfaces. However, trees growing in the open can be felled without need of pruning or girdling, showing once more that the latter are practices employed because of the protection of understorey crops.

There are three ways of harvesting wood from trees: a) harvesting the branches only (by pruning or pollarding); b) felling the tree after pruning back the branches; c) felling a tree after first girdling it and d) directional felling. The last method is preferred for free standing, isolated trees. In harvesting trees farmers employ a local axe (*meessano*, fig. 6.2) and a cable (*gishsha,* fig. 6.2) for pulling trees in the desired felling direction.

It is a normal procedure for housewives to harvest wood in the dry season and store it in the *dagama*, a loft, just above the fireplace, for storage of wood. This facilitates drying.

Wood is also stored in the verandah (*soro)*. Here too, an egalitarian principle, equivalent to *sheffile* or *rubbana* in coffee, is in operation. Families not self-sufficient in firewood glean (*haasume*) in some one else's private property.

Farmers are not familiar with modern saws, recently brought to the Gedeo zone by woodworking shops most of which are illegal (Agricultural Bureau for the Gedeo Zone, unpublished). In recent times the demand for wood has increased tremendously, turning trees into cash crops. The price of fuelwood has tripled. One load to be carried on one's back, which five years ago barely fetched five Ethiopian Birr (about US fifty cents), now costs fifteen Birr (about US$2.0, at current rate). Farmers fell trees, split the boles and stack the splints at the roadside for sale.

Farmers benefit very little from these developments. Those living further away from the roads are most affected. These have to sell their wood to middlemen who are often perceived as treacherous and deceitful (see 6.3.2.2). The demand for timber has rocketed with the coming in to Gedeo zone of the wood working shops. Most of these are illegal, and have established illegal networks of middlemen.

6.3.3.4. Utilization of the root floor and Canopy of perennial vegetation species

(a) Root floor utilization

Because of the preponderance of arborescent components, the Gedeo also recognize root (*tutume*) harvests. Tree roots interfering with working the soil are pruned back. Moreover, roots of trees dying of old age are uprooted and make a larger portion of the fuelwood harvest in the dry season.

The Gedeo also practice a simple form of canopy farming, without a permanent infrastructure of walkways and/or ladders being built in the tree crowns. They suspend beehives in trees (block transect, appendix 4.1b; plate 6.7). They also plant climbing pulses *qoqee* (*Phaseolus lunatus* L.) and *hamara* (*P. vulgaris* L., climbing type) underneath trees so that these can climb and occupy the upper canopy (block transect 3, appendix 4.1c). *Boyina* (*Dioscorea abyssinica* - DIOSCOREACE) and pumpkin (*Cucurbita* sp.- CUCURBITACEAE) are also planted beneath trees with the same aim. Farmers use cables (*gishsa* (fig. 6.2)) to climb the trees. Proper use of the *gishsha* requires prior training.

Figure. 6.8. Reiterative cycle of steering in the canopy of perennial species. Vigorously growing *Milletia ferruginea* tree (1) has some of its branches severed (2) but left intact, hanging, so as to facilitate distribution of leaf litter by gravity (3). The branches devoid of leaf litter are then dropped carefully, so as to avoid damage to the understorey crops. The branch wood is used as firewood. The tree reiterates again (4) and the remaining old branches are then severed, in the next cycle. *Ensete* (*Ensete ventricosum* (Welw.) Cheesman, (MUSACEAE)) leaves are also lowered, to reduce shading, in such a way that their photosynthetic capability is not seriously impaired. T = tree (*Milletia ferruginea* (PAPILIONOIDAE), E = *ensete*, C = coffee (*Coffea arabica* L, RUBIACEAE).

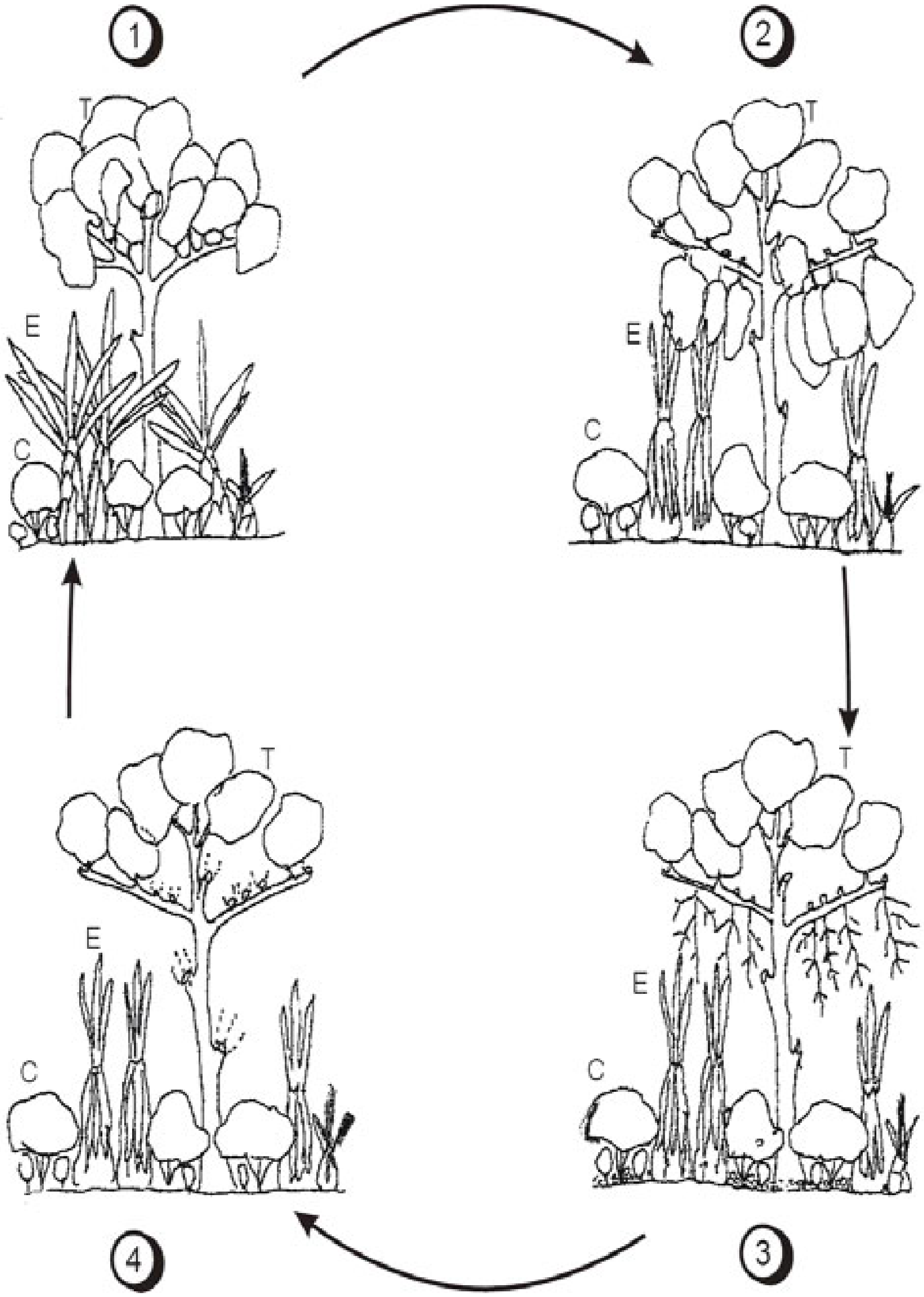


Figure 6.8.

In some fast-growing tree species such as *Milletia ferruginea*, farmers have observed that they could obtain more wood per year from the branches than from the trunk, so they harvest branches rather than the stem. This is one version of coppice production. The existence of this way of using trees in other regions of the world is attested by historical paintings on which they figure, and by the existence of a German word for this practice (*Kropfausschlag*). Harvesting the twigs and branches of trees (fig. 6.8) can also be considered as "canopy farming".

Table 6.5. Tree species preferred for making beehives

Cordia africana	*weddeessa*
Croton macrostachys	*mokkeenssa*
E rythrina abyssinica	*weleenna*
Euphorbia abyssinica	*adaamma*
Ficus sp.	*ode'e*
Ficus sp.	*xilo qilxxa*
Ficus sp.	*golalo qilxxa*
Polyscias ferruginea	*tala'a*
Schefflera adolfi-friedericii	*gudubo*
Syzygium guineense	*baddeessa*
Trichilia sp.	*onoonoo*

source: this study

(b) Production in the tree crowns

Honeybees are part of the Gedeo "agroforests" (ch. 8) and many of the multi-purpose trees serve as beefodder (table 6.5). Honeybees, utilized by the Gedeo farmers, are not fully domesticated. Thus, these migrate between the lowlands and highlands, following availability of nectar and other environmental conditions (dry season with high temperature); (see table 6.5). Bees come to the Gedeo highlands in the season of *Bonoo*. This time corresponds with the flowering of most perennial components of the Gedeo "agroforests". Farmers exploit such behavior patterns in the life cycle of the bee colonies.

Farmers prepare beehives in a shape of a drum from wood preferred by the bees (see plate 6.7; appendix 4.1b). A bole, about 1.30 m long and about 30cm diameter, is cut from seasoned wood and split. The inner part of the two halves is hollowed out with a *maxaraba* (fig.6.2). Then the pieces are stacked in a rack (*dagama*) just over the fireplace, so as to season them. At the time of the arrival of the bees from the lowlands, the pieces are taken and rubbed with leaves of *Fagaropsis* sp. (*sisa*). According to farmers, bees like the smell of these trees. Then the parts are fitted together into a drum and tied together using *xishsho*, an *ensete* fiber, after clothing it with bamboo scales (*oncce*) or dried *ensete* leaves (*oofe*). Sometimes, dried grass thatch or barley stalk is used. The aim is to provide the bees with a correct ambient temperature. Then, the beehives are hung up in trees that are known to be preferred by bees (see table 6.5; plate 6.7).

In the tree thus selected, farmers look for the right space (*ma'ne*) for the beehive. This is usually provided by three or four interconnected branches. A bee farmer is free to select any unoccupied tree, whoever it belongs to. Then it becomes his *ma'ne,* a communal principle related to *oki'a* or *sheffile* (6.3.3.4). Trees thus selected are not cut, unless they die of old age.

Once he has his beehives hung in a tree, the bee farmer waits for the arrival of the bees. According to the farmers, the bees do not directly occupy a beehive. First, the bees send their inspectors (*sone*), who check whether or not the beehive and its surrounding are fit for habitation. The farmer estimates the amount of honey he should expect from the type as well as the population of the bees. There are bee types disliked by the farmers as "dry", giving none or only little honey, as there are others, which are liked by the farmers for their high honey production. But farmers have no means to prevent the bad bees from occupying their beehive or to attract only highly productive ones.

Neither there are means with which farmers influence the productivity of the bees, once these have occupied a beehive.

Farmers check whether there is enough honey for harvest or not, after the environmental conditions and after the behavior of the bees. Abundance of flowers and the weather are important environmental factors (Goewie, 1978). The drier the season and the more abundant the flowers, the more the amount of honey expected by the farmers. If the bees have accumulated more wealth in the form of honey, they become very aggressive, say farmers. To be more sure, farmers also climb the trees and knock at the beehive and carefully listen to the sound made. Beehives with sufficient honey, according to farmers, give out a bass sound while those with less or no honey give out a treble sound. Knowledge to do so is important, a mistake means loss of honey yield, as the bees either consume what is there and migrate to the lowlands, or are still in the process of production. Therefore, it is not easy to distinguish between these situations and knowledgeable farmers are consulted.

If there is sufficient honey, the beehive is lowered using the cable (*gisha*). Bees fiercely defend their home by stinging, and farmers have nothing to do but to risk this. Since male farmers are well trained in this (6.3.1.2), bee bites are not more than a simple nuisance for well experienced farmers. Moreover, this is one task to the Gedeo to show their masculinity. It is often said, "bearing the difficulties of childbirth is to the strength of a woman as bearing that of climbing trees and harvesting honey is to the strength of a man".

An average beehive can yield from 5 to 10 kg clean honey, depending on the type of bee and the environmental conditions. Farmers speak of bee swarms that can give up to 50 kg clean honey. Yield from beehives also includes the honey, the larvae and the beeswax. The latter and part of the honey are sold while larvae are eaten. After honey harvest, most of the swarms migrate back to the lowlands. But if the bees sense the presence of nectar, some can reoccupy new hives that are put up by the farmers. Honey from these is harvested in the *Adooleessa* season (i.e., between May and June).

6.3.3.5. Herbaceous annual crops

(a) Seed procurement and planting

The status of annual crops among the Gedeo is that of vegetables mostly grown for home consumption. Only farmers in the highland and lowland zones grow these for sale. In the latter case, annual crops have a role similar to that of coffee (i.e., serving as a source of cash income) in the midland zone (ch. 4).

Herbaceous annual crops fall into three major classes, grains (barley (*Hordeum vulgare* L. - GRAMINEAE), maize (*Zea mays* L. - GRAMINEAE), and papilionaceous pulses (haricot bean *Phaseoulus vulgaris* L), peas (*Pisum sativum* L), horse bean (*Vicia faba* L), various kinds of leafy vegetables (long season, short season, diverse colors, diverse sizes, even some perennial ones such as *gumari* (*Brassica* sp.) or *deello(Brassica* sp.), root/tuberous vegetables such as sweet potato, yam (*Dioscorea abyssinica*-DIOSCOREACEAE) or rhizomatous vegetables such as *Colocasia esculenta* Schott. (ARACEAE), bulbous vegetables of the LILIACEAE, such as garlic (*Allium sativum*) and onion (*Allium cepa*).

Methods used by the Gedeo in the seed production, field management and harvesting of cereal crops (e.g., maize, barley) and leafy vegetables (e.g., *Brassica* spp.), onion and garlic or pulses (haricot bean, peas), in most respects, are similar to those used in other subsistence systems. However, the attitude of the Gedeo to weeds, pests or diseases makes their management quite different from the others. So are the principles of harvest, the Gedeo focusing on agro-ecosystem management and not on the individual crops (ch. 4).

From the harvest of the previous crop, the best performing plants are selected to provide seeds for the next season. In selecting these seed plants, farmers rely on such parameters as growth habit, e.g., in maize, short height so as to avoid lodging, but high yielding potential, i.e., one or two large ears each with a greater number of seeds. In leafy vegetables, plants that sucker profusely and tolerate continuous harvests, in bulbous vegetables, those that produce large bulbs are selected. In tuberous vegetables such as *boyina* (*Dioscorea abyssinica*), plants that produce larger and more than one tubers are selected. The list of herbaceous crops cultivated is given in ch. 8.

Seed selection is enhanced by the exchange of information and/or planting material among farmers. For instance, information exchange on seeds is usual between relatives and neighbors and so is seed sharing. Seeds are also available in markets. But farmers are careful in purchasing those seeds, as their sources can rarely be checked. Therefore, if farmers have to buy seeds in the market, they use their networks of relatives and acquaintances, in order to obtain detailed information on the seed source. However, every farm household is expected to be self-sufficient in seed supply and those who fulfil this condition are highly appreciated.

In this way, crop diversity is enhanced too. Genotypes of the same crop with slight differences are grown together. For instance, barley (*Hordeum vulgare* L.) of different seed sizes, seed color and two-rowed, four-rowed or six-rowed, are grown together.

The seed is stored in a safe place, in the *dagama*, until next sowing season.

The seed bed is carefully prepared, with minimum tillage. Farmers have no need for working the soil thoroughly, as they consider the latter harmful to the final yield. In the highland zone, it is a common practice to have the soil put under maintenance, i.e., passing it through a *moonaa* (ch. 7), before sowing. Also, there is no need for weeding, as the weedy flora is used as grazing for livestock.

(b) Harvest, storage and marketing

Grains like barley or horse bean (highland zone) and to some extent maize and haricot bean (*Phaseolus vulgaris* L.) (lowland zone) are harvested when dry. Farmers check dryness of the grains by chewing. If it is as dry as desired, the grain breaks instantly with a dry sound in the mouth. If not, it remains entire between the teeth. This method is also used in checking the dryness of coffee beans. Vegetables for the market are harvested piecemeal, so as to avoid spoilage and adjust the quantity harvested to the prices of the day.

Grains like barley or horse bean are dried and stored in stacks before threshing. The latter is deferred until the onset of the rainy season. Once the grains are threshed, farmers usually have to sell them, because either another crop is due or there are problems of storage.

6.3.3.6. Faunal "agroforest" components

(a) Livestock production

Livestock is an integral component of *ensete*-based Gedeo "agroforests" (table 6.6). However, the Gedeo have less livestock today, in response to scarcity of grazing land. In former times, most farmers owned land in two zones, one piece in the highland or lowland zone where livestock is kept and another piece in the midland zone where *ensete* and associated crops are grown. However, animals are secondary producers. In case of shortage of land, farmers revert to primary production by crops. The position of livestock so is progressively curtailed due to the increasing scarcity of grazing land, mainly due to increasing human and animal population densities.

Livestock, i.e., cattle, goats and horses, are relatively more important in the highland and lowland zones, sheep being predominant in the midland zone. Scarcity of grazing land rather than farmer's preference dictates the choice of species. Sheep can subsist in the midlands, by grazing on the undergrowth components.

Besides supplying manure, livestock is an important life insurance. Keeping livestock, particularly by small farmers, is seen as a means of extending one's hand to the scarce resource of land, through *ok'a* (cut-and-carry-grazing), or grazing the livestock in the foreground of the *songgo*, a meeting place, or in the roadside. Beef cattle and/or draught animals (horse, mule or a donkey) are preferred for this purpose. Use of animal power in working the soil is limited in the Gedeo highlands, primarily because of the topography and the perennial cropping. However, livestock is intensively used for transport. Horses (highland zone), mules (midland zone) and donkeys (lowland zones) are used for transporting goods. Horses and mules are also used for transporting people.

Table 6.6. Farm households (%) with livestock in the three agro-ecological zones (highlands, midlands and lowlands).

Zone	Cattle	Sheep	Goats	Chicken	Horse	Mule	Donkey	Honey bees
Highland	100.0	100.0	33.3	77.8	90.0	33.3	Nil	33.3
Midland	22.0	65.0	Nil	90.0	11.1	11.1	11.1	65.0
Lowland	100.0	33.3	65.0	100.0	11.1	33.3	33.3	33.3
Mean	74.0	66.1	32.8	89.3	37.4	25.9	14.8	43.9

Source: this study

In the midland zone, the Gedeo keep sheep and chicken. In the highland and lowland zones, cattle, goats, equines and poultry are kept. Poultry are more important in the lowland than in other zones. Overall, the Gedeo are not self-sufficient in livestock and its products, for which they depend on commerce with their neighbors (see 6.3.3).

(b) Wild fauna

These, unlike in most domesticated ecosystems, have a well recognized role in the functioning of the "agroforests". The very design of the "agroforests" makes this obligatory. Farmers therefore have to manage these animals through their management of agro-ecosystem complexity (ch. 4). The role of this component in the functioning of the "agroforests" is discussed in chapter 8.

6.3.3.7. Aspects of Crop Protection

The attitude of Gedeo farmers to weeds, pests or disease organisms is quite different from the conventional agriculture or forestry. These are not externalized by the farmers. This is consistent with the their agro-ecosystems design, i.e., combining in space and time various plant and animal species. It is therefore difficult for farmers to discriminate against some. In other words, farmers therefore rely on the self-regulation of their agro-ecosystems.

Farmers follow various management approaches in crop protection. However, it is difficult to isolate those activities from others, since their management is based on the whole agro-ecosystem. Therefore, most of the farm activities discussed in the preceding pages in one way or another are also related to crop protection. It is only when a particular organism poses a threat to the system that activities aimed at controlling it are manifested. Farmers' success is indicated by the few crop protection problems they have.

Three diseases were mentioned by the farmers. These are *koleera or* Coffee Berry Disease (CBD), caused by a fungus *Collettotrichum coffeanum* (Wrigley, 1988), *we'lo*, *ensete* wilt (*Xanthomonas musacearum* (Abate & al. 1996)) and *xete,* the causal agent of which is not identified. Coffee Berry Disease appeared in the Gedeo country in 1978 (Wrigley, 1988). As the name indicates, the fungus attacks coffee berries and the whole coffee farm may be emptied of any berries. As indicated earlier (6.3.2.2), damage caused by this disease was so high at one moment in time that a comprehensive control program using fungicides, including the development of resistant coffee varieties, was attempted. However, none of them is viable and farmers have resorted to their own environmental modification. This mainly involves steering in the canopy of the shade trees and *ensete*. In some instances, shade is reduced while in others it is enhanced. According to farmers, coffee intercropped with *ensete* is less affected. It is the monoculture of coffee that is most affected.

Unlike CBD, *ensete* wilt (w*e'lo*) is believed to be as old as *ensete* cultivation itself. The disease also attacks bananas. The mechanism by which the disease organism causes damage is not well known (Bezuneh, 1996). However, from the symptoms observed on affected plants, i.e., "yellowing" of one or few leaves at first and the crumbling of the whole plant to decay afterwards, the point of attack seems to be the apical meristem. The transfer of the disease by contact, i.e., through contaminated farm implements and/or animal teeth also favors this explanation. *We'lo* is mainly a disease of *ensete* monoculture, for which there are no known control measures, other than a quarantine measure traditionally applied by the farmers. Affected plants are easily recognized by the typical wilting and discoloration (yellowing) of their innermost leaves. Thus, once such plants are identified, farmers uproot and bury them immediately beyond the reach of grazing animals.

Farmers regard *xete* as one of the oldest diseases which unlike *ensete* wilt *(we'lo)* does not kill *ensete* plants but reduces their vigor considerably and also their final yield (both quantity and quality). But *xete* does kill coffee trees. The incidence of this disease is related to the alteration of the environment. *Xete* attacks the corm of *ensete* plants and the roots of coffee trees. Thus, in *ensete*, the bottom part of the corm is attacked. As soon as these plants are identified, they are either harvested or transplanted to another site, if unfit for harvest. Affected coffee trees shed their leaves and gradually weaken, finally succumbing to death. According to farmers, there is some chance of elongating the life of affected coffee trees for one or two years, by providing "aeration" to the roots. To that effect, farmers dig below affected trees. For better results, the treatment must be applied in the earliest stage of the disease. Farmers see the disease as the major cause of coffee death, which has increased following the coffee population increase in the farms.

Xete, is by far of a more wider occurrence than *we'lo* in the Gedeo highlands. However, because of the higher crop mixture maintained by the farmers, the effect from these diseases is localized. The quarantine measures with which farmers are familiar are helpful.

Gedeo farmers believe that *ensete* wilt (*we'lo*) can be controlled by planting *Euphorbia abyssinica* trees (*adaamma)* among *ensete* plants. This is reinforced by the observation of higher densities of these trees in *ensete* monocultures, particularly in the highland zone. However, the actual mechanism involved in this empirical solution is not studied.

In the course of this study, an unidentified disease similar to *xete* was reported by farmers (table 6.1) from the lowland zone where coffee monoculture is practiced. A young farmer by the name of Taaddasaa Waataa claiming that he has been searching for a control measure for the last seven years was approached by Daawit Moges (Kiphee), the leader of the field group working in the area (in Bilooyaa Peasant Association). The farmer was so delighted by the work being done on *ensete* that he came to the present author's place and shared his experiences. The present author on visiting the farmers' field observed how the farmer barred the unidentified organism causing the damage to the *ensete* corm from reaching the corm using discarded plastic bags from the nearby coffee nursery. Treated *ensete* plants were performing well. The claim of the farmer is being verified by the experts of the Agricultural Bureau for the Gedeo Zone.

Among pests, field mice (*tuqa* or *kurre),* wild pigs and porcupine were mentioned as attacking *ensete* and other root crops. All these being burrowing animals, they are controlled by locally made traps and making the environment less attractive to them by pouring hot water into their burrow. Sometimes, farmers in a village organize themselves into a group and dig out and destroy the burrows.

6.4. Discussion

There is a good case to compare Gedeo farmers' understanding of sustainability with the sustained yield forestry, i.e., normalcy, of earlier period in Europe (Ciancio, 1997). It is evident from the preceding pages that, the Gedeo focus not only on wood, as was the case for the early foresters of Europe. While the foresters worked on the higher level, i.e., supplying market demand for wood, Gedeo farmers operate on the level of farm household. However, as far as the objectives of sustained yield are concerned, these two are similar. Like the foresters, Gedeo farmers maintain a balance between planting and harvest. Though not as sophisticated as that used by European foresters' (e.g., yield tables), the Gedeo have comparable yield accounting procedures, as will be shown later (ch. 8).

It is also important to compare the Gedeo concept of sustained land use with other conventional land use systems. The common definition of sustainable land use requires a production pattern harmonizing the needs of present populations and those of the future populations, by conserving and/or enhancing the resources on which the production depends (Agenda 21, 1992; Huxley & Van Houten, 1997). The Gedeo concept conforms to this definition, but it also introduces an element of self-limitation or self-control on the part of the human component. Human desires have no known limits and without self-discipline, sustainability is impossible. Any human activity, even those of the hunting-gathering societies, is potentially capable to undermine the integrity of the production base (Leaky & Lewin, 1987; Van Helden, 2000; Demme, 2001). It is the degree of self-discipline that determines the impact of some specific human activities on the immediate environment.

Disregard by development workers for the Gedeo concern for the production base in the past led to a repetition of what Chase (1987) has observed of the conservationists playing God in the Yellowstone Park.

Based on the degree of self discipline, agricultural land use systems can be put on a continuum (ch. 9) starting with the least impact (food gathering) to the highest destabilizing impact (today-conventional maximum yield agriculture). The place of Gedeo land use in the continuum, with its low ecological impact, lies close to the early agricultural societies, between subsistence and market-oriented systems, with a “first things first” attitude towards harmonization between local human aspirations and the perduring carrying capacity level of the local lands. This harmonization has been brought by the Gedeo to a high level of intensity of land use by the strict application of the principles of whole ecosystem management. This millenary perseverance of the peasants was essential for the systems to survive to the present day.

However, this should not be understood as implying Gedeo systems to be primitive. They are conventional land use systems, in so far as they operate within the market economy (Kippie, 1994). However, the Gedeo system is different from the majority of contemporary land use systems, which have a laissez-faire attitude towards the environment. Gedeo land use incorporates mechanisms, which, as we saw, have indeed enabled them to sustain an average 500 persons.km^{-2} during 5000 years (ch. 9). The basic feature of the Gedeo design is, that yield is maintained at a constant, millenary level, below the maximum yield that could be artificially achieved.

Still many development people in the Gedeo zone do not like to admit the relevance of farmers’ ways over alternatives that have been on the agenda for the last thirty years. Those who admit the success would nonetheless like to wrongly ascribe farmers’ achievements to some supposed richer natural resource endowments such as soil fertility or favorable climate. However, Gedeo highlands, as an ecological resource base, are not inherently different from other parts of the Ethiopian highlands now largely denuded due to mismanagement (Amare, 1984; Wolde-Aregay & Holdinge, 1996).

Notwithstanding their top performance, Gedeo systems are under serious challenges, even threats, from internal as well as external destabilizing forces.As mentioned, the main challenge to these systems is pressure on the land. There is also a threat from the market forces. The ever-increasing population coupled with problems of exchange has stretched their possibilities to the extreme. For instance, the Gedeo system is under the pressure of external pricing, either because of falling prices for farm outputs, or by prices of industrial goods being raised above the market value, via usury. One means used is, for instance, the advancing of loans to farmers at levels of interest, which exceed current market rates. Coffee, the export crop, then acts as a lever. Swinging prices of coffee hit

Gedeo farmers hard. Due to an indirect tax imposed on the merchants, coffee is sold for a price little related to world market prices. It is feared that these problems may sooner or later lead to the economical disintegration of the farmers. This is related to the problem of subsistence farmers in general.

There are two schools of thought about the fate of present-day subsistence farmers (peasant economies) in general. One school which still draws its now obsolete vocabulary from the Marxist past, maintains a pessimistic view. Its proponents claim pressure from the capitalist relations of production causes social differentiation within the peasant communities, disintegrating them into a class of capitalist farmers and a class of rural wage labor. According to this school (Ellis, 1988, p44-58), the disappearance of the peasant form of production within the dominant capitalist mode of production is inevitable. This would be due to the pressure from the capitalist production system, i.e., private property in land, differential adoption among peasant farmers of improved cultivation practices, enforced abandonment of farms by indebted farmers and increasing employment of the latter by capitalist farmers.

In the Gedeo case, land is not fully a private property. Moreover, the Ethiopian Constitution, both federal and regional, considers land as a state and public property that cannot be sold or bought. This has some points in common with the Gedeo notion of land (6.3.1). Therefore, the neo-Marxist scenario is improbable, given the situation of Gedeo highlands. Moreover, *ensete*-based Gedeo systems are based on a purely traditional ecosystem approach to farming in a fragile environment on fragile soils and steep slopes vulnerable to erosion (see ch. 7). The production components of *ensete*-based agro-ecosystems such as *ensete*, multi-purpose trees, except coffee in the midlands are not suited to market-driven manipulation. Its sustenance owes much to the sheer enterpreneurship of the farmers, a situation in which farmers 'exploit themselves' in order to survive (Ellis, 1988). The culture of the Gedeo (their traditions, beliefs, and world-outlook) also has an integral relationship and is even indissolubly interwoven with the performance of the *ensete*-based systems

This latter position is supported by a second school of reasoning which is more optimistic about the persistence of peasant economies within the dominant- "capitalistic" mode of production Ellis(1988). According to this model, family farm production possesses an internal logic which permits it to resist the pressure of capitalist production relations and thus to reproduce itself indefinitely. This reasoning is based on peasants' control over the means of production, especially land, and on the social norms of the peasant communities which are directed towards reciprocity rather than individual profit maximization. It further would rest upon the subdivision of land by inheritance, the capacity of farmers to overcome market pressures by intensifying the amount of labor committed to production, i.e., farmers' capacity for 'self-exploitation', natural or technical factors specific to farming. The latter make agriculture unattractive to capital and to functional advantages for capitalism (e, g., cheap food, less risk for the capitalists) by leaving agriculture in the hands of the peasants.

Ellis (1988) supporting this position writes that various opposing forces exist that influence the long-term viability of peasant household production. According to this author, it is the interplay between these rather than the complete dominance of one or another, which determines the fate of peasant societies. In certain conditions, the forces of disintegration are observed to dominate while in others the forces of stability or persistence seem to prevail. In contemporary agrarian societies, the relative strength of these opposing forces is influenced by two factors. One is the intensifying pressure imposed on the peasants to yield a surplus which is captured by other social groups and the second is the role of the state in regulating the stability and instability of rural production.

The above destabilizing factors must be addressed as a matter of, literally, life and death. Farmers' resistance to various destabilizing (ch. 1) forces reinforces this. It must be recalled that *ensete* systems have escaped the hunger in large parts of Ethiopia. Relief from some of the pressures can be achieved by promoting all-round rural development and research and both in the long and the short term, more intensive production is needed. Intensification is a progressive development for *ensete*-based Gedeo systems. On the other hand, extensivation by focusing on monoculture would lead backwards, as their development history indicates (ch. 9). One potential to focus upon will therefore be promotion of *ensete* cultivation to increase food security outside Gedeo country, and at the same time earn supplementary cash income, by selling *ensete* food in the increasingly viable markets. This will take away some of the pressure put on land in pursuing cash crops such as coffee in the midland zone and maize in the highland and lowland zones. This effort could be enhanced by more efficient use of organic wastes, involving modern composting technologies (FAO, 1975; Sanchez, 1976; Oelhaf, 1978; Lockeretz (ed.), 1983; Brady, 1984; White, 1997; Compara International, 1999). These composting techniques have already been started among some *ensete* peoples, e.g., the Guraghe of southern Ethiopia (Bierwirth, 2000). Composting is even more suited to the situation in Gedeo zone, due to the high amount of biomass for decomposition such as leaf litter and/or crop by-products.

Another option may be increasing the use of the canopy space, particularly in the midland and lowland zones. Examples are the judicious use of tree canopies for beefarming, intensifying use of climbers like yam (*Discorea abyssinica* - DIOSCOREACEAE) in the root floor or increased use of the climbing pulses such as *qoqee (Phaseolus lunatus* L.) and *hamara* (*P. vulgaris* L.) in the canopy. The same can be done with the various kinds of edible fungi (*shopha*, *ceqe'na*, *qaaqe).* Forest floor farming (Oldeman, 1993) would be another focus, a more efficient utilization of the ground layer, to be achieved in the sorter term by planting shade tolerant herbaceous plants- such as *godarree* (*Colocasia esculenta-* ARACEAE) and/or *kororima* (*Aframomum korarima* - ZINGIBERACEAE while on the long run research and development on the commercial selection of symbionts (mycorrhizal fungi, useful bacteria) would open a way to producing commodities with tiny biomass and large added market value.

6.5. Conclusion

The principles and practices presented in the preceding pages are farmers' responses to the constraints they have met. Unless something is done, sooner or later these constraints would develop beyond the intensity which the farmers' responses were suitable. This would threaten the very integrity of the Gedeo land use system. Almost all these principles and practices point to the main concern of farmers, i.e., sustaining self-reliability in a way consistent with the human dignity. This should be borne foremost in mind when designing interventions. Any program contradicting this core objective of Gedeo farmers openly or indirectly is liable to raise resistance. Such "development programs" may be investing in their own demise. This was observed in previous attempts at intervention (Kippie, 1994; Agricultural Bureau for the Gedeo Zone (unpublished)).

Besides, population increase and the issue of equity at the national, regional and global levels are the main sources of the problems for Gedeo land use. Therefore, if the objective is real help to the Gedeo people, projects should aim at the problem of land, which in itself is a reflection of other problems, notably population pressure and unfair exchange. The problem of equity hence needs to be addressed starting from the household level, step by step through community and national levels to the global levels. Most Gedeo rules, from which most of their principles and practices are derived, aim to maintain equity. Only if sustainability is perceived to be at risk by egalitarian solutions distinctions are made. They are limited to patriarchal heritage lines and gender-based distribution of work. All other social rules are egalitarian, such as the access to private property (cut-and-carry grazing, gleaning firewood and/or coffee beans), the right to land ownership although only along male lines and division of labor within the household, although gender plays a strong role there. A relationship aiming at a more mutual benefit for all the parties involved must be sought in all cases.

Today, however, Gedeo farmers must first of all be taught how to cope with market forces. One way of doing this is giving special emphasis to the education of women and girls, as these cast the economical foundation of the society. Otherwise, they would remain "sowers but not reapers', as one elderly farmer had it. This would mean a strong modification of the division of labor, but without breaking through the traditional principles. In this way, problems are solved by strengthening and improving the existing societal structures, of which the sustainability is proven over five thousand years. This kind of solution is to be preferred over revolutionary change, which nearly always is followed by interruption of sustainability chains. This is proven by the historically frequent occurrence of famines as sequels of revolutions (France 1789, Russia 1917, Cuba 1959, etc.).

The holistic Gedeo concept of land (Dubois, 1997) cannot be underestimated in the development of *ensete*-based Gedeo "agroforests". The private element, in this tenure system fosters long-term investment, while the communal element, mainly aiming at conserving tribal land rights, also maintains the egalitarian principles.

Chapter 7. Principles and practices of organic soil management

Abstract

The nature of the soils under Gedeo "agroforests" and the farmers' soil management principles and practices are dealt with. The soils are clayey loam, with pH (H_2O) ranging between 5 and 6. The limiting factor was found to be available phosphorus (range 1.0 to 4.0 ppm). Organic matter (%) ranged between 4 and 5, total nitrogen (%) between 0.3 and 0.5 and *cation exchange capacity* (meq/100g soil) from 21 to 25.0. Gedeo soil management is organic, using crop by-products, leaf-litter from multi-purpose trees and shrubs and from the weeds, household waste, rotation of dwelling sites and farmyard manure. Most farmers do not know mineral fertilisers. "Weeds" are agents of soil protection from the impacts of rainwater and carriers of soil nutrients for the future. The complex crop mixture would make mineral fertilising unreliable and risky. Besides, the soils are supported by the *phyllosphere* and *rhizosphere* exudates processed by micro-life.

7.1. Background

Little is known about *ensete* soils. It is generally believed that these soils are maintained by constant supply of farmyard manure (Smeds, 1955; Westphal, 1974; Terrence, 1996). For the same reason, *ensete* cultivation is considered to be inseparable from livestock (Pankhurst, 1996; McCabe, 1996).

While this holds for many *ensete* cultures in Ethiopia, it falls short of fully expressing the situation in Gedeo highlands where emphasis is on vegetation rather than on animals. In describing agricultural systems in Ethiopia, Westphal (1974, page 40) mentions that the *Darassa* (Gedeo) unlike other *ensete* peoples depend least on dung. McCabe (1966), supporting this view wrote that all groups but the Gedeo make extensive use of manure, so as to ensure use of the same agricultural plots indefinitely. This is still true at present (Kippie, 1994). Along with crop by-products, biomass from "weedy" herbaceous vegetation and diverse multi-purpose woody perennials plays a larger role as a source of soil input (chs.4, 5 and 6). These are supplemented by farmyard manure where there is livestock. However, use of mineral fertilisers as soil input is not yet included in local habits and is limited to trial plots of agricultural extension.

Apart from systems of shifting cultivation (Sanchez, 1979; Louman, 1986; Ramakrishnan, 1992; Van der Wal, 1998) where soil maintenance also rests on the regenerative capacity of the vegetation, dependence on vegetation for soil maintenance as the Gedeo practice it is uncommon. It is important to see this as a progressive development (Carter, 1974), in response to scarcity of grazing land (ch. 4). That these systems are highly intensive is demonstrated by their high carrying capacity (close to 500 persons per km^2, Central Statistical Authority, 1996).

Gedeo land use, integrating crop production, wood production and animal production and providing habitats for the diverse flora and fauna, is quite different from modern day agroforestry systems (Huxley, 1983; Kippie, 1994; chs. 2, 4 and 5). These are more than agroforestry systems. In this respect, Gedeo land use systems are close to natural forest systems (Kippie, 1994).

This way of land-use enabled the Gedeo not only to avert hunger in the steep sloping highlands without terracing (ch. 5) but also to produce commodities for the market, such as above mentioned *arabica* coffee types (Kippie, 1994).

Since Gedeo land use has never been a subject of scientific inquiry, little is known about its soils. We do not know for instance, the physical and chemical status of the soils. We do not know how farmers' management principles and practices fit in with the physical and chemical properties of the soils and/or with the natural environment. There have been many comments on farmers' practices without adequate knowledge of the situation. For instance, it was known since long that implements used by the farmers (fig.6.2, ch. 6) in working the soil are of antique design. Development people had at times offered alternatives, thinking that the antique ones were inappropriate. But farmers refused, sticking to their old ones. What is wrong here? Is this the usual conservatism on the part of the farmers or is there a valid basis for their refusal? What is the nature of organic soil inputs in Gedeo land, and how are these managed?

To answer these questions, a study of soils and farmers' soil management practices and principles was undertaken. Its results can serve as a basis for development interventions in the Gedeo highlands. They can also be relevant to other farming systems in marginal areas elsewhere in the world.

7.2. Materials and methods

7.2.1. Soil samples

For a description of the geology of the Gedeo highlands, the reader is referred to Wolde-Mariam (1972).

A survey of soils, soil management principles and practices and vegetation used for soil maintenance, over the three major altitudinal agro-ecological zones (see ch. 4 for definition) of the Gedeo highlands was carried out. In selecting the agro-ecological zones and farms for the survey, stratified random probability sampling was used.

Soil samples were taken using a soil sampling auger, borrowed from the Soil research Department of Awassa Agricultural Research Centre, and with a 0 – 30cm and 30 – 60cm graduation. Each of the soil samples was taken from four spots at these depths (0 – 30cm and 30 – 60cm). The samples were later bulked to get a 1kg sample, which was labelled and brought to the central soil research laboratory of the Ethiopian Agricultural Research Organisation where the samples were analysed.

A checklist of questions was set and used as a field guide in gathering verbal information from farmers (ch. 3).

7.2.2. Foliage and crop by-product samples

In order to assess the nutrient status of foliage, samples of seven woody species together with samples of *ensete* by-products each weighing 1kg were taken, oven-dried in the facilities of the Wondo Genet College of Forestry and brought to Wageningen where these were analysed according to the standard procedure described by Walinga & al. (1989).

7.3. Results

7.3.1. Physical and chemical soil properties

The colour of the soils was not determined in the laboratory. Under visual observation, they ranged from dark brown (highland zone, above 2500m asl) to light brown (midland zone, 1750 to 2500m asl) to reddish brown (lowland zone, below 1750m asl). In texture class, the soils ranged from clayey to clayey loam. The soils are slightly to medium acid in reaction (see table 7.1).

Table 7.1a. Some soil physical and soil chemical properties.

Depth	Sand (%)	Silt (%)	Clay (%)	pH (H_2o)	P av (ppm)	T.N (%)	O.M (%)	C:N
0-30, n = 7	26.6	33.0	40.1	5.8	2.4	0.4	5.3	9.9
95% C.I.* ±	7.8	3.2	7.1	0.5	1.6	0.1	1.0	1.6
30-60, n = 7	20.0	27.1	51.6	5.5	1.5	0.2	3.4	9.5
95%C.I±	3.8	3.8	7.9	0.5	1.1	0.1	0.7	1.2

- 95% C.I = Ninety-five per cent confidence interval for the mean, computed using 7 degrees of freedom from the t-distribution.
- Pav stands for available phosphurus.

[1] The value for organic matter is obtained by multiplying organic carbon (%) by a factor of 1.724, per convention followed by Young (1976).

Table 7.1b. Some soil physical and soil chemical properties.

Depth	Meq/100 g soil				PPM					% BS	Sum*
	CEC	K	Na	Ca	Mg	Fe	Mn	Zn	Cu		
30-60, n = 7	**24.9**	**1.4**	**0.3**	**12.6**	**3.0**	**14.5**	**24.5**	**2.8**	**0.8**	**68.3**	**17.1**
95% C.I.* ±	**4.1**	**0.4**	**0.2**	**3.2**	**0.5**	**5.2**	**5.0**	**1.2**	**0.3**	**12.5**	**3.9**
30-60cm, n = 7	**21.1**	**0.8**	**0.4**	**9.2**	**2.7**	**7.5**	**16.6**	**0.9**	**0.4**	**60.5**	**11.9**
95% C.I. ±	**2.3**	**0.4**	**0.1**	**2.8**	**0.6**	**4.4**	**4.1**	**0.6**	**0.2**	**14.2**	**2.6**

- 95% C.I = Ninety-five per cent confidence interval for the mean, computed using 7 degrees of freedom from the t-distribution.
- *sum is of the bases.

7.3.2. Farmers' soil management: principles and practices

Topography is one single factor affecting farmers' soil management strategies. The land slopes from west to east. The altitude rises from ca 1250 (around Lake Abaya) to 2800 m above sea level (around Bule town), within an average distance not exceeding 50km.

Slopes reaching 75% were put to cropping. Gentle slopes suited to annual cropping are available only in few places, either on top of the highlands or down in the lowlands. The situation is exacerbated by the high-risk of rain erosion. Rains are often torrential, though well distributed over nine months (Ethiopian Mapping Authority, 1984). The average annual temperature of 17° to 24° degrees Celsius (Ethiopian Mapping Authority, 1984) provides favorable growing conditions.

Diverse soil maintenance techniques are used, most of which in one way or another are based on vegetation. These are of two major kinds. Mulching is augmenting the organic matter reserve, with crop by-products, leaf litter, and with biomass from the "weedy" herbaceous vegetation. It is practised over 80% of the Gedeo zone. Farmyard manure, for which livestock is mainly kept in the Gedeo highlands, is second in importance. Though more important in small areas in the highland and lowland zones, it is only supplementary in the whole midland zone. However, it is never considered as the unique means of soil maintenance.

Therefore, throughout the Gedeo zone, stall-feeding is a common practice of animal husbandry. Scarcity of grazing land is so reflected by farmers' choice of animals. The only communal grazing area left is made up of roadsides and public meeting places, often overgrazed (ch. 6). While cattle and equines (horses and mules or donkeys) are preferred in the highland and lowland zones, sheep and poultry prevail in the midlands. Here too, well-to-do farm households keep one or two milk cows. The preference for the sheep and poultry in the midland zone is also related to their capacity to feed on the undergrowth of the perennial crops (ch. 6).

The most important crop by-product comes from *ensete,* of which 50% to 70% of the produce is left in the field as a by-product (ch. 8 and table 7.2). Next comes leaf litter from the dry-deciduous multi-purpose trees and shrubs (see tables 7.2 and 7.3). Leaves and branches are harvested from these either for mulch or for fodder (chap.6). "Weedy" herbaceous vegetation provides a much-prized mulch, due to its high decomposition rate.

Mineral fertilisation of the soils is a new technology introduced for coffee and annual grains such as maize. The mixture of crops grown by the Gedeo is not suited to the use of mineral fertilisers because they select crops rather than increase production in such such complex ecosystems.

7.3.3. Gedeo attitude to land and life: the basis for their organic soil management

The Gedeo implicitly apply principles of minimum tillage. They use simple tools (Werth, 1954; fig. 6.2, ch. 6). Frequent and thorough working of the soil is avoided, as they have the thorough and sad experience that this rather decreases soil productivity.

Farmers' practices of working the soil are also related to their concept of land and everything that lives on it. The Gedeo see land as a living being with "feelings". To them working the land is therefore the same as inflicting a wound on a living being and hence there is a need to lessen the resulting pain as much as possible. The Gedeo also see land as the beginning and end of man, i.e., man comes from land and returns to it. Therefore, farmers see mistreating land as mistreating one's final home, only to be paid back later. Among non-Christians, performing rituals (*xeeroo*) before working the land was common.

Also, land needs to be worked only at specific times of the year (see ch. 6, and ch. 4 for the Gedeo farming calendar). Working the land in rainy seasons is prohibited, mainly due to erosion hazard.

In choosing plant or animal species for inclusion in the vegetation, farmers give highest priority to soil protection and/or maintenance (see table 4.2). Of the 150 different kinds of the "weedy" flora encountered in the present study, more than 80% have some soil enriching potential (ch. 4). The foregoing also explains why the Gedeo use simple tools (ch. 6). All tools the Gedeo use are pieces of metal fitted to wooden handles. *Qotto* (the african hoe (fig.6.2)) is used for planting and uprooting while *habille* or *sholee* and *salaxxo* (fig.6.2) are used as slashing knives.

7. 3. 4. Soil management using vegetation biomass

Five different soil management practices common to the three agro-ecological zones were observed. These were, in their order of importance, the use of the "weedy" flora, the use of crop by-products including leaf litter from the multi-purpose woody perennials, the use of farmyard manure, the use of household refuse, and finally rotation of dwellings. Though common to all zones, use of the "weedy " flora and crop by-products were most emphasised in the midland zone. On the other hand, dependence on farmyard manure was much emphasised in the highland zone, followed by the lowland zone. Fallowing part of

Table 7.2. Elemental composition (dry weight, gram.kg^{-1}) of foliage from seven tree species and of *ensete* by-product.

Species	Nt	Ct	C:N	C:P	C:S	P[2]	K	Ca	Mg	S
Ensete ventricosum[1]	27.94	403.80	14.45	183.5	26.83	2.20	30.48	73.36	3. 43	15.05
E. abyssinica	29.84	423.70	14.20	210.80	28.71	2.01	11.05	284.31	4. 37	14.76
M. ferruginea	18.11	467.40	25.81	708.18	29.60	0.66	7.21	399.32	3. 45	15.79
A. gummifera	26.33	464.40	17.64	266.90	21.85	1.74	10.56	271.32	4. 02	21.25
V. amygdalina	7.27	431.30	59.32	371.81	15.89	1.16	31.79	314.97	0. 69	27.15
V. auriculifera	4.30	401.80	93.44	704.91	15.85	0.57	33.34	304.88	2. 92	25.35
Cordia africana	29.15	430.00	14.75	186.15	25.95	2.31	46.30	300.24	2 .34	16.57
Trichilia sp.	31.09	446.50	14.36	253.69	29.01	1.76	15.64	314.53	3.33	15.39
Mean	**21.75**	**433.61**	**31.74**	**360.74**	**24.21**	**1.55**	**23.30**	**282.87**	**3.07**	**18.91**

[1] Includes all by-products (root, dried leaves and leaf sheaths of an *ensete* plant (*ganticho* type) at *beya* stage (see ch. 8).
[2]Macronutrients (C, N, P, K, Ca, S, Mg) generally occur at concentrations >1000 mg kg^{-1}per plant dry matter base), White, 1997)). However, [2] P is given as being in the range of 0.05 – 0.5% of plant weight (Ibid.).

the farmland as a strategy of soil maintenance was rare and was restricted to the highland zone, whereas rotation of dwellings was mainly used in the midland and lowland zones. Settlement rotation is an old and well-known method from shifting cultivation (see ch. 9).

7. 3. 4. 1. Crop by-products in soil maintenance

Most crop vegetation used by the Gedeo performs two basic functions, production and soil maintenance (ch. 4). This is rendered more explicit in the staple crop *ensete* (ch. 5), by the larger area it occupies (ch. 5), making the proportion of its root mass and by-products used for soil maintenance considerably higher (ch. 8). A household of seven harvesting 42 mature (*daggicho, idago or beyaa stage*, *gantticho* type) *ensete* plants per year on average obtains 3.6 ton of by-products (dry weight basis). Each mature *ensete* (*gantticho*)
type, harvested at *daggicho*, *idgao* or *beyaa* stage (see glossary for definitions), gives 84.9 kg of dry biomass of by-products on the average, which is about 73.2% of the total *ensete* production (ch. 8). This by-product yield does not include organic solutions leaking from the fermenting *ensete* biomass, processed by farmers at special *ensete*-processing sites in the field following a specific rotation.

7.3.4.2. The "weedy" herbaceous vegetation in soil maintenance

"Weeds" also provide useful products such as leafy vegetables, medicine, products used in decoration and fodder (ch. 4; plate 5.1, ch. 5). Moreover, the Gedeo see green plants in general as symbols of Life and thus of peace and mercy. If in a quarrel, the offending party offers the other a bunch of green twigs, it will be forgiven.

"Weeds" are also seen as "protecting" farmers from over-harvesting the soil, i.e., "trapping" site resources for the future, including what is scientifically seen as soil nutrients. Thus, "weeds" are seen as storehouses, taking care of the future production capacity of the land. The importance of the weedy flora in protecting the soil from torrential rains and from intruding heat of the sun and contributing to the humus layer of the soil when slashed and mulched over the surface, is summed up in this conception of the "weedy" flora.

Farmers are well aware that this function of the "weeds" leads to the reduction of today's yields. But being subsistence farmers in the best sense of the word, they are also interested in tomorrow's yielding capability of their land. Farmers reach a practical compromise between present and future yields and this constitutes the essential strategic principle of organic soil management.

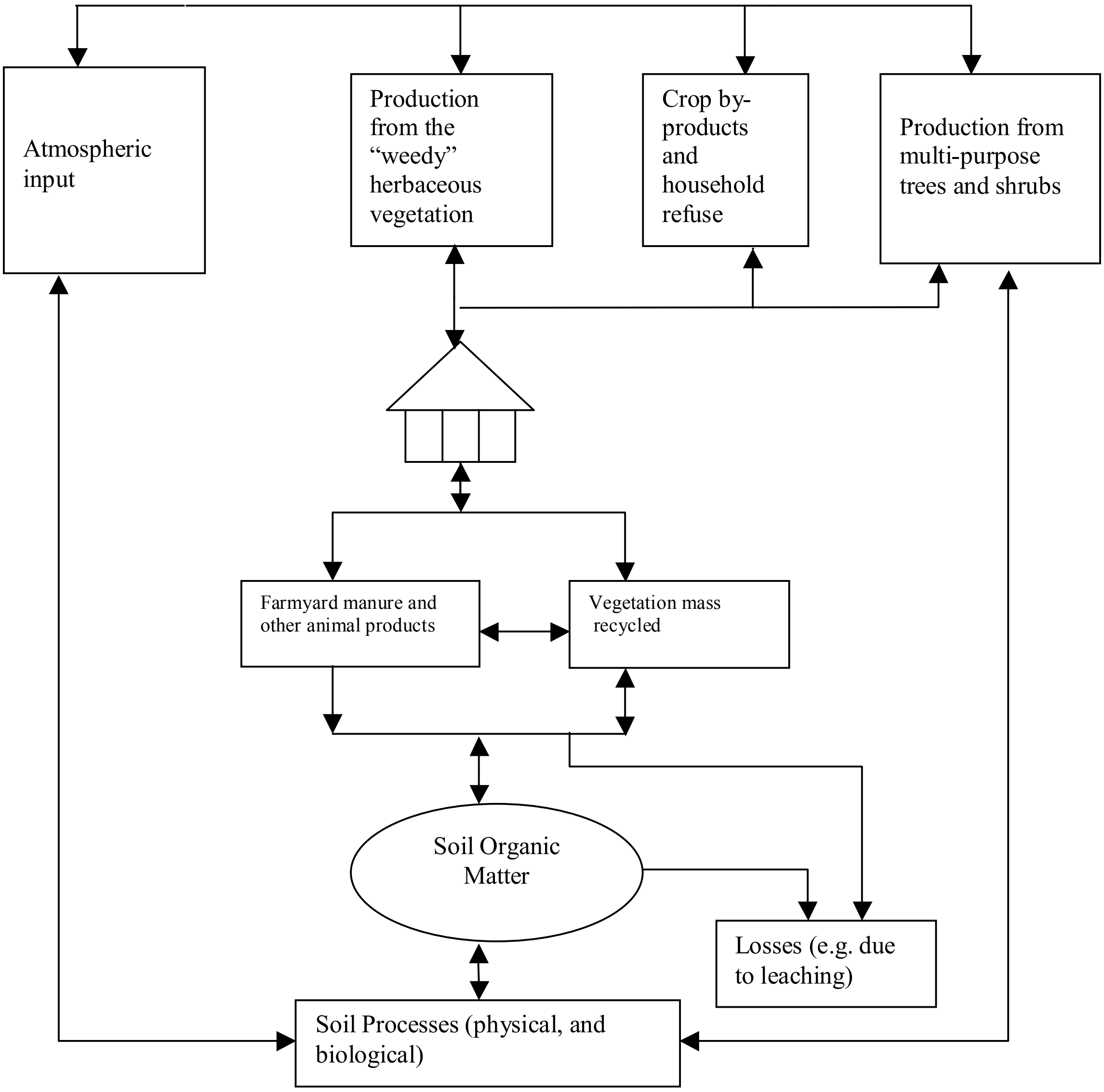


Figure 7.1. Organic matter input-output dynamics. Organic matter enters the soil either directly or through the agency of human beings and livestock. Gedeo land use favours high dynamics in the flow of organic matter. Soil processes in the rooting zone (rhizosphere) still are unstudied and remain a black box. From the visual observation of animals such as earthworms encountered in the rooting zone during soil sampling (cf. Oldeman, 2001), this zone clearly plays a determining role in soil-plant relationship as conceived in Gedeo land use.

Table 7.3. Some multi-purpose tree species preferred for soil maintenance

Tree species	Major characteristics sought	Remark
Milletia ferruginea (*Dhadhatto*)	shade; leaf litter; deciduous	PAPILIONOIDEAE, in all zones
Albizia gummifera (*Gorbbe*)	shade; leaf litter; deciduous	MIMOSOIDEAE, in midlands
Ficus vasta (*Ode'e*)	shade; leaf litter; deciduous	MORACEAE, in lowlands
Erythrina abyssinica (*welenna*)	shade; leaf litter; deciduous	PAPILIONOIDEAE, in all zones
Cordia africana (*weddessa*)	shade; leaf litter; deciduous	BORAGINACEAE, in all zones
Vernonia amygdalina	shade; leaf litter; deciduous	ASTERACEAE, in all zones
V. auriculifera	shade; leaf litter; deciduous	ASTERACEAE, in all zones
Trichilia sp.	shade; leaf litter; deciduous	MELIACEAE, in all zones

Some species of the "weedy" flora are used as ecological barometers. Farmers read the state of their agro-ecosystems from these. For instance, farmers were highly concerned about the reduced abundance of a herbaceous "weedy" plant called *hada* (*Guzoita* sp.). Because of the cut-and-carry fodder (ch. 5), the farms were too frequently worked so that *hada* could not complete its life cycle. The fertility status of the soil is also judged from the species of the "weedy" flora that grow there. For instance, *lacee*, *doobbee* (broadleaved) and *leeddee* (monocotyledonous) herbs are used as indicators of soil fertility. On the other hand, grassy weeds such as *agarcho* (*Cynodon dactylon* GRAMINEAE), though protecting the soil with their fibrous roots, are seen as indicative of deteriorating soil conditions. Worldwide, farmers share the same interpretation of the presence of this cosmopolitan tropical grass, known as *Bermuda* grass, widely used as lawn grass because of its very persistence.

7.3.4.3. Leaf litter in soil maintenance

Leaf litter is one of the many crop by-products, because multi-purpose woody perennials are also cultivated as components of Gedeo "agroforests". The use of *ensete* architecture and physiology for moisture and soil conservation has been treated in chapter 5. The role of multi-purpose trees in soil maintenance was the cause of sorry state of a mismanaged coffee field (plate 7.2).

Most of the multi-purpose woody perennials cultivated are leguminous leaf litter trees (table 7.3). However, farmers do not discriminate between leguminous and non-leguminous species. Not relying only on the leaves falling from the woody perennials by senescence, farmers harvest tree branches by pruning (see ch. 6). The rhizosphere production of the other components of Gedeo land use was not assessed in the present study. From studies made in both natural forests and shifting cultivation (Baars, 1994) it is to be expected that the contribution of subterranean life in the ecosystem to soil maintenance is at least as important as the contribution by aboveground organisms (Young, 1976; Oldeman, 1990, 2001).

7.3.4.4. Household refuse and rotation of farmhouse (*uranee*) in soil maintenance

Domestic wastes, such as left-over food to be disposed, wood ash, unlike some of the items presented in the preceding pages, are used by every household. This makes these wastes even more important. Wastes, however, are not all directly distributed to the farm, as the amount available is not worth the trouble of transport and distribution. Therefore, these are accumulated near the house, so as to form a kind of rudimentary compost heap. However, farmers do not add any products intentionally to the heap, with the aim to assist the process of decomposition.

The problem of transport often becomes so important that most farmers build farmhouses (*uranee*) which they rotate in time from place to place, every time the need arises. Livestock are kept around such dwellings and young boys spend the night here.

7.3.4.5. Animals in soil maintenance

Like with the "weedy" flora, the general design of the agro-ecosystem provides a niche for the wild fauna. *Ensete*, with its numerous compartments, provides an ideal environment for smaller animals (plate 5.1). The contribution to soil maintenance by the diverse members encountered of the Arthropoda (insects), Annelida (earthworms) and Molluscs (snails and slugs) is known to be high. One may cite, for instance, Lavelle, 1984; Lavelle et al., 1989; Lavelle and Pashanasi, 1989; Lavelle et al., 1992; Moldenke & al., 1994; Bernier, 1995; Bernier and Ponge, 1994; Ponge and Delhaye, 1995; Moldenke, 1999). The statement by Moldenke (cited in Compara, 1999): "Bug Poop Grows Plants"(BPGP), says enough on the importance of invertebrates in the soil foodweb.

Earthworms were among the commonest organisms in Gedeo farms. These were conspicuous in the rainy seasons, when they come to the surface en masse. They are good feed for the chicken and wild birds. Molluscs from those with tiny shells to big ones and slugs concealing themselves in green coloration from predators were also common. Coprophagous beetles feed upon dung of large mammals greatly increasing the rate at which these are mixed with the soil. These are only surpassed by wood termites, which attack every dead vegetable matter, provided that there is a trace of moisture in it. These termite species do not build mounds like other termite genera from the savannahs. Diverse army ants ranging from small to giant black or brown were also present. These feed on earthworms and larvae of diverse insects. The latter also attack snakes and lizards. Ants occasionally visit farmers' huts in the evenings or at night looking for other insects such as cockroaches taking refuge in farmers' huts. Centipedes and millipedes feed upon decomposing matter and were also common, hiding in debris or mulches. These become active at the onset of the rainy season (the planting season). Please note that these are only some of the animals visible to the naked eye.

Besides livestock used as source of farmyard manure, wild mammals interacted with the soil. Two burrowing mammals were mentioned by the farmers, moles (*tuqa*) in the highlands and lowlands and wild rats (*kurree)* in the midland zone. The activities of these were conspicuous as these also consume root crops including *ensete* (ch. 6).

The primary reason for keeping livestock by the farmers is for the conversion of organic matter (leaves, twigs, crop by-products) into farmyard manure. Unlike other traditional land use systems, farm animals are not important as a source of power for working the soil. Cattle and goats were more important in the highland and lowland zones while sheep were preferred in the midlands because these grazed in the herbaceous vegetation growing there, under the shade of perennial components.

Farmyard manure was more important in the highlands and lowlands. In the midlands, use of farmyard manure was confined to vegetable gardens. Here, farmers build their dwellings on the upper slope of their land and farmyard manure, mixed with running water during rains, is conducted to the land by channels. The problem of manure transport so is solved.

In the highlands and lowlands where land is more or less level, the strategy of washing manure downstream does not work well. Here, animals are penned in an enclosure called *moonaa* (see plate 7.1). In the highlands, land in need of maintenance is enclosed step by step. Animals are housed in the enclosures during the night, dropping manure and mixing it with the soil by trampling. This is called *moonaa*. For vegetable gardening or for annual grain production, keeping animals in the same place from one to three months suffices. However, land is kept from three to six months under *moonaa* to replenish the soil with necessary nutrients for up to ten years, i.e., one rotation of *ensete*. In the lowland zone, farmers graze livestock in fields that need maintenance instead, collecting manure and urine from animals while these are grazing.

Since soil maintenance by using livestock is so important for the community, arrangements are made for those farmers who can not afford to keep their own animals. One of these arrangements mentioned by many informants was borrowing some animals for a certain period of time.

7.3.4.6. Purchased inputs in soil maintenance

Purchased inputs like mineral fertilizers are not part of the traditional soil maintenance. Therefore, their use is associated with technology packages on trial (ch. 6). Even those farmers growing relatively more annual crops (highlands and lowlands) see mineral fertilizers as "salts", to which the soil could become addicted and then fail to give yield afterwards.

7.4. Discussion

Relevance of farmers' management practices can only be judged in relation to the nature of their soils. Farmers' attitude towards the "weedy" herbaceous vegetation and their concern not to work the soil thoroughly and in rainy seasons is equivalent to a concern not to lose soil nutrients to deeper soil horizons by leaching (Kamprath, 1979). This is appropriate when seen against the background of the rugged and hilly terrain, the clayey nature of the soils (table 7.1), the concentration of plant nutrients in the upper horizons (table 7.1) and in the living mass of the vegetation (Young, 1976; Sanchez, 1976; Lamprecht, 1989; Alemu, 2001). The same focus on perennial cropping is desired today in more land use systems, including more "modern" ones (Young, 1976; Sanchez, 1979; Touber, 1989).

The clayey texture of the soils, their slight to medium acidity, and their limited supply of phosphorus, are in conformity with works on other soils in similar environments (Murphy, 1964; Lundgren, 1971, 1978, 1979; Alemu, 2000). Results are also in line with expectations when considering the general environment of the soils (Young, 1976; Sanchez, 1976), such as altitude (above 1200m to 2880m), topography (slope reaching 75%), average annual rainfall (1000mm without minima and maxima for 9 months) and average annual temperature (17-24 °C.; Ethiopian Mapping Authority, 1984). The forest maintains the tropical soil, not the other way round (Lamprecht, 1989, p22).

The importance of humic substances for the cation exchange capacity is emphasized (Young, 1976; Lamprecht, 1989; Ross, 1989; White, 1997). Lamprecht (1989) notes that, despite high organic matter production, tropical forest soils contain only little humus (about 1 – 2%), limited to the upper 20 to 30 cm, as all the litter completely mineralises within a period of a few months. This traditional scientific claim rests on the general fact that at higher temperatures chemical processes are faster, including decomposition. Richards (1952, 3rd ed. 1954, p.218), stated: "With increasing temperatures the rate of formation of organic matter by plant communities increases up to an optimum and then decreases. The same is true of the conversion of this organic matter into humus (humification) and of humus into inorganic matter (mineralization)".

However, thin organic layers are not considered to be a general characteristic of humid tropical forest soils by more recent authors such as Lavelle (1984) or Lavelle et al. (1994). Some tropical soils are rich in humus, others are poor, depending on the input of the organic material, the rate and nature of the local decomposition processes and the way of mineralization of decomposed organic matter. These are by no means homogeneous or similar over the whole tropical belt. This very variability depending on more factors than heat alone is the reason why they can be managed, as the Gedeo do.

Farmers' practice of frequent manuring is supported by experiments. Organic matter, as in natural soils, starts sustaining losses – as soon as the biomass is decomposed (Neumann; 1983; Metzger, 1987). Below C:N ratios of 20 (agricultural soil) and 25 (organic soils) microbial immobilisation of N predominates, - causing plants to suffer from N- deficiency, if no additional N-supplement is given (Ross,1989). Because of the lower C:N ratios of the leaf litter and *ensete* by-products (table 7.2) and climatic conditions (e.g., temperature of 17.0 to 24 degrees Celsius) a higher rate of organic matter decomposition (Ross, 1989) is expected. Because of the need for the constant addition of organic manure, farmers plant fast-growing, short-rotation shrubs like *Vernonia* spp. (table 7.3) alongside trees that have longer life cycles and rotations. Smallsized woody plants provide leaf litter used to mulch the soil, from time to time, besides small poles used in minor construction works (cf. Budelman, 1991). The present author observed litter in the Gedeo "agroforests" decomposing quicker than other litter. When asked why such tree species like *Erythrina*, *Albizia, Cordia africana* and *Milletia* were omnipresent in the "agroforests", farmers replied that this too was based on the observed performance of these trees. Farmers' do not discriminate between leguminous and non-leguminous species.

Nutrient dynamics in the soils of the Gedeo "agroforests" cannot be explained by the available flux of nutrients alone. Like in moist tropical forests (see fig. 6.6; plate 6.4a; block transects, appendix 4.1b and appendix 4.1c) the rooting zone consists of a 1 to 2mm thin film, the rhizosphere, surrounding the surfaces of plant roots and fed by root exudation (Ross, 1989). This should be considered as an important site of production (Ruinen, 1974; Jenik, 1978; Zimmermann, 1978; Sanchez, 1985; Oldeman, 1990, 2001). This zone remained unexamined due to the scale of the present investigation. Rhizosphere organisms such as mycorrhizae and N-fixing bacteria are an indispensable nutrient trap minimising the mineral leakage from the nutrient cycle (Redhead, 1979; Munyanziza, 1994; Baars, 1994). The roots facilitate the organic matter input, provide a mat holding the soil intact (ch. 5), and also improve the soil condition. They so pave the way for soil invertebrates such as earthworms and arthropods, which in turn have higher influences on the organic matter dynamics (Ross, 1989).

As in natural forests, the bulk of nitrogen becomes available to plants through the litter (FAO, 1975; White, 1997). Unlike the situation in conventional agriculture, much of the biomass is kept in the field and only a small fraction (ch. 6 and ch. 8) is removed. Whenever this limit is exceeded, as it happens from time to time in harvesting cut-and-carry fodder, farmers are concerned to adjust the imbalance from within the system (7.3.4).

Livestock is dual-purpose. It provides farmyard manure and income to subsistence farmers. Provided that there is space for grazing, this is an ecologically efficient strategy, as approximately 85% of the nitrogen consumed by grazing animals is returned to the land in animal excreta (White, 1997). If few animals are kept, for want of grazing land, the supply of farmyard manure is small and so is reserved for garden vegetables (Westphal, 1974).

The soil working technology of the Gedeo is based on the typical tropical African hoe (see ch. 6, fig. 6.2) with its negligible impact on soil structure (Werth, 1954; Huffnagel (1961) ex Westphal, 1974). Westphal (1974) wrote that the hoe commonly associated with *ensete* cultivation is more suited to the Ethiopian highlands than the oxen-driven plough of the seed-farming culture.

It is worth mentioning that such well-adapted tools are also socially adapted, because as said above (ch. 7.3.3) the working ethos of the Gedeo is quite unlike that of industrial peoples. The notion of unemployment is lacking, because there is no concept of short-term, fast production for money. The latter requires tools for rapid production by the least number of people, who only do the work to earn as much money as possible in the shortest time possible. This may explain why it is so difficult for industrial countries to practice the sustainability they search so seriously. Five thousand years of sustainability required also the tools of sustainability. In the industrial world, no such new tools for soil maintenance have as yet been invented, apt to improve upon the classical ones in Gedeo society.

7.5. Conclusion

The conclusion of the present chapter must bear upon the central issue of the proven long-term, sustainable, organic Gedeo method of soil management and its merits as a potential tool to meet today's land use challenges in a sustainable way.

The complex ecological and social nature of Gedeo land use prohibits the use of mineral fertilizers. Hence in Gedeo zone, the solution of land use problems due to population density, land scarcity and modern market impacts cannot be found in the introduction of synthetic fertilizers. This calls for more attention to modern organic soil management.

Oki'a is the tradition that allows cut-and-carry foraging, originally meant for one or two milk cows. This tradition has been abused for fattening beef cattle for profit. The resulting excessive extraction of plant biomass is in conflict with farmers' organic soil management. The effects of this pillage of organic matter must be corrected if the system is to remain sustainable and therefore there is a high need for the introduction of modern techniques of composting. Next to compost, farmyard manure in its turn can recharge the soil, boost crop performance and in time also initiate a new development of the "weedy" flora.

The nutrient content of the soils in the Gedeo "agroforests" has been shown to depend upon the vegetation of the "agroforests", both annual (weedy herbs) and perennial *ensete*, trees and shrubs). Further research is needed into the properties of the perennial components and their organic input, focussing in particular upon the architecture of the root system and production by the rhizosphere.

The nature of the nutrients in the biomass recycled (table 7.2) seen along with the management practices of the farmers, show promise or at least they are adequate to restore soil nutrient reserves removed by harvest. The data reported in the present chapter support the relevance of farmers' soil management practices as a base for efficient ecological and socio-economic sustainability. In view of the present challenges and pressures, this base must be strengthened as suggested above, not replaced.

It is not only, not even mainly the size of the land owned by one farm household that determines its livelihood. All depends upon the skill and knowledge of the owners to manage the soil. As a rule, soils are worked only in dry seasons and well mulched with the diverse biomass analysed above. Farmers' practice is in line with the well established fact that nutrient reserves in the soil surface are leached to deeper layers, if soils are worked during rainy seasons (Lamprecht, 1989). The soils being clayey, their structure and particularly their permeability would be destroyed by working them when wet. Working the soil with a traditional hoe on a small eco-unit (Oldeman, 1983b) or on an individual crop plant basis (Van der Wal, 1999), farmers hardly disturb the soil structure.

The practice of allowing farms during rainy seasons to be spontaneously occupied by wild plant species runs contrary to the modern agricultural practice of dealing with weeds, "unwanted plants in competition with crops". The concept of "weed" was new to the farmers. To them these were plants that normally accompany other plants, indeed consuming nutrients and moisture, but finally returning their biomass to the soil. Farmers were very quick to assert that "*weeds",* in addition to protection of the soil from rain and harmful insolation, also help in protecting humans from overharvesting. The promotion of weed control among the Gedeo therefore would harm their sustainable soil management system.

Farmers' understanding of the need to a continuous addition of organic matter to the soil is in line with the scientific understanding that biomass declines over time at approximately the same rate as it decomposes (Metzger & Yaron, 1987). The point was discussed above in connection with the former misunderstandings concerning thin tropical humus layers.

The preliminary data reported here highlight the use of vegetation in Gedeo "agroforests" as a living tool for soil enrichment and conservation, for arresting soil deterioration by recycled biomass, and for appropriate soil working methods.

The nature of the nutrients in the recycled biomass (table 7.2), if managed correctly, is promising for restoring soil fertility by harvest. However, further soil and vegetation surveys must be conducted to obtain enough data for developing a more precise model of the interactive dynamics of soil and vegetation under Gedeo management.

A second issue, related to sustainability, is the challenge of making the land yield enough to be economically and socially satisfying. The subject is extensively analysed (ch. 8), and in conclusion the all-over production levels beat everything that industrial land use can offer for the moment. There are no known ways to improve the production quantitatively in a sustainable way.

Although the tradition of using vegetation for soil regeneration is not uncommon in the tropics (Louman, 1986; Bebwa & Lejola, 1993), the use of the weedy flora for soil conservation, i.e., for checking soil erosion, co-regulating water availability for the whole ecosystem and maintaining the organic soil horizons, has not yet been reported elsewhere. This is one more reason to keep them intact, study them, and if desired, emulate them.

The Gedeo way of managing soils organically comes from the abyss of time and hence far precedes recent awareness of the importance of organic matter for the sustainability of soil systems in the tropics (Lavelle, 1984; Avnimelech, 1986; Swift, 1993). Results show that the "agroforest" soil had comparable nutrient reserves as forest soils in similar ecological zones (table 7.1). This is indicative of the nutrient supplying potential of soils under Gedeo management for the prevailing production levels.

Through unwritten rules and religious rituals the Gedeo inculcate upon the minds of their young generations the principles of soil protection. If enriched by scientific thinking, the promise of these systems and their further development is remarkable, if it were only for attaining sustainable and productive soils in the many regions in the world menaced by or suffering from hunger and poverty.

Chapter 8. The carrying capacity of Gedeo "agroforests"

Abstract

The carrying capacity of Gedeo "agroforests" is assessed. *Ensete* is emphasized in the study because of its unique position in the land use system. Because of the higher biological diversity of the "agroforests", the farmers' comprehensive approach of yield accounting was followed. On average, a yield of 6.5 and 20.3 tons (dry basis) ha^{-1} $year,^{-1}$ respectively edible and by-product biomass of *ensete* was measured. However, farmers adhered to non-maximal yield increases and to diversifying yield so as not to compromise sustainability. On the other hand, coffee on average gives 0.6 ton ha^{-1} $year,^{-1}$ multi-purpose trees, $4m^3$ ha^{-1} $year^{-1}$ wood and the yield of annual crops ranged from 0.8 to 2.0 tons ha^{-1} $year^{-1}$. The carrying capacity of land planted to *ensete* is around 0.2 ha for a household of 7. This is as opposed to 1.5 ha of land with annual grains. The present study highlights precautions that should be taken when measuring yield of multi-component systems, by citing as an example how the concept of a single yield applied to *ensete*-based Gedeo "agroforests" in the past evoked resistance rather than cooperation from the farmers. The study also proves that yield is not lost due to diversity, provided that a multi-yield approach is followed in multi-component systems. As yield in the latter is distributed over diverse components, this way of accounting is logical. Moreover, Gedeo reckoned yield not on the basis of any unit of surface, such as a hectare or acre, but on an individual plant basis. This is due to difficulties encountered in measuring yield in their multi-component system. Likewise, farmers are more concerned with future yield than with the present one. Thus, they see usefulness of crop components, e.g., "weeds", or their products, from this angle. Crop management is geared towards this principle.

Key words: *ensete*, *Gedeo*, yield, carrying capacity, sustainability, Musaceae, Ethiopia.

8.1. Background

Data on the carrying capacity of the Gedeo agro-ecosystems are required to complete the above discussion of agro-ecosystem organization (chs. 4 and 5) and management (chs. 6 and 7).

Literature on this aspect is scant. If available, it deals with monocrops of *ensete* (Makiso, 1976; Bezuneh, 1984; Pijls & al., 1995 and Tsegaye & Struijk, 2000). Even these studies focus on one particular method of *ensete* establishment, i.e., serial transplanting. No data could be found on cultures where *ensete* plants are a permanent presence in the field, e.g., of the Gedeo and Sidamo (Kippie, 1994; Asnaketch, 1997). Existing data therefore are of little relevance to the highly diverse Gedeo land use combining numerous annual- and perennial crops, including woody perennials and livestock (ch. 4, ch.5 and ch.6). Moreover, some data in literature (e.g., Tsegaye & Struijk, 2001) came from fertilized *ensete* plants. This makes these data inappropriate for the estimation of the carrying capacity. Use of fertilizers in growing *ensete* is unknown among *ensete* peoples (Godfrey-Sam-Aggrey & Tuku, 1987; Kippie, 1994; Diriba, 1995; Abate & al., 1996; Asnaketch, 1997; Almaz, 2001). Besides, *ensete* yield is also affected by ecological conditions such as soil fertility (Asnaketch, 1997) or *ensete* clones used (Makiso, 1976; Bezuneh, 1984; Taboje, 1997). All preclude the use of the existing literature data for the purpose at hand. Moreover, *ensete* yield as expressed as mere weight is affected by the use of either surface or pit fermentation (Bezuneh, 1984). Most data on *ensete* were derived from pit-fermented *ensete* biomass. In the Gedeo highlands, on the contrary, surface fermentation is specifically used.

Ensete monocropping, on which most data in the literature are based, is contrary to farmers' practice (Kippie, 1994). All *ensete* peoples either mix *ensete* with other crops spatially or temporally, i.e., by crop rotation (Abate & al., 1996; Asnaketch, 1997; Almaz, 2001) or they integrate both, like the Gedeo do (chs.5 and 6). The existing data hence concern virtual, not real *ensete* cultivation. That is why development interventions focussing on monocrops of *ensete* have been found unpopular among the farmers (see ch.1, ch.6). Therefore, all various crops among which farmers divide their efforts and resources (ch. 4 and ch.6) should be evaluated so as to understand the carrying capacity of these "agroforests". The lack of and need for such comprehensive data in designing development interventions is emphasized (UNDP/ECA, 1996; Abate & al., 1996; Brandt & al., 1997; Asnaketch, 1997). This is the subject matter of this chapter.

8.2. Materials and methods

The study was conducted between September 2000 and September 2001in the three agro-ecological zones, defined in ch. 4. Data on the yield contribution by the diverse "agroforest" components were collected from literature review, survey and case studies. Moreover, to check the data forthcoming from the farmers, mature *ensete* plants (*ganticho* type) with their flowers initiated (i.e., at *dagicho* and *idago* stages) or initiating (i.e., at *beyaa* stage) were purchased from the farmers. These were paid to harvest and to process the plants - in their own way, while measurements of the various yield parameters and other observations were recorded. Since, unlike other crops, *ensete roots* form a considerable portion of the *ensete* biomass retained on the site (ch.7), roots within a one-meter radius from the foot of the plant were uprooted, separated from the soil, counted and weighed so as to obtain an estimate of root mass. All attempts were made in this way to approximate the yield accounting used by the farmers.

8.3. Results

8.3.1. Farmers' principles of yield accounting

Gedeo farmers account yield in ways (see table 8.1) different from those used by most other conventional farming systems. To the farmers a crop field consisting of annual and perennial components is a live storage of biomass either "immediately useful" or "useful for the future". Farmers' emphasis on the "*future use* " instead of to the*"immediate use"* is related to the relative sizes of wealth meant for the future and wealth to be harvested (ch.6). It is like a supermarket shelf, which is visited when there is a need to do so (Michon, 1983). It also is a very early precursor of the classical economic division of resources in capital goods and consumables. Therefore, for these farmers no biomass is useless. Any part that falls on the soil contributes to the future yield (ch.5). Field management including harvest is therefore geared towards long term investment (ch.6). Harvest only takes part of this value out, leaving the rest stored or "locked up " in the components "for the future" of the larger agro-ecosystem.

It is essential to be aware of the exceptional economic flexibility of this system, in which each harvest allows to revise the part to be consumed versus the part to be conserved. This division is made at every harvest in function of the prevailing ecological (e.g., drought) or social (e.g., market) conditions (also see Van der Wal, 1999: interactive and iterative management).

In assessing the carrying capacity of these mixed-cropping systems, farmers take into account all wealth, both tangible and intangible. Yield from a given crop may be larger or smaller, but is seen in the context of the larger agro-ecosystem yield, only the combined yield makes sense. Like in sustained yield forestry, the farmers strive not to harvest more than the increment (Oldeman & *al*., 1995; Schütz & Oldeman, 1996). They strive to eat and/or use the "interest" rather than the "capital".

From this viewpoint, "sustenance" gets a wider meaning. It does include biological sustenance, water and food. It also comprises commodities needed to sustain a human life, such as clothing, housing and medicines. It finally covers requisites for social sustenance such as weaponry in case of hunting or war, musical instruments, drinks and special foods for celebrations, or plants for decorations and animals for company.

Table 8.1. Farmers' valuation of yield compared to that used in conventional agriculture using *ensete* as example. Note the progressive increase in the value of yield from *ensete* plant (i.e., waasa, bul'a, fiber, leaves, medicine, etc., y_1-y_5) as compared to y, representing only part of *ensete* yield, i.e., *waasaa and bu'la* (kg.plant^{-1}).

1. *Ensete* yield (*waasaa, bu'la, fiber*) per plant plus *ensete* by-products (y_1) > y

2. *Ensete* yield (*waasa, bu'la, fiber*) per plant plus *ensete* by-products plus environmental benefits (y_2) > y_1

3. *Ensete* yield (*waasa, bu'la, fiber)* per plant plus *ensete* by-products plus medicinal uses of *ensete* (y_3) >y_2

4. *Ensete* yield (*waasa, bu'la, fiber*) per plant plus *ensete* by-products plus medicinal use of ensete plus cultural uses of *ensete* (y_4) > y_3

5. *Ensete yield (waasa, bu'la, fiber)per plant plus ensete by-products plus crops accommodated because of ensete architecture (y_5) >> y_4*

N.B. Though each one of the farmers' valuations encompasses most or all more value of *ensete*, only y_4 represents farmers' value of *ensete*.

8.3.2. Yield from multi-purpose trees and shrubs

As indicated earlier (ch.4), firewood and water are as essential as food to the Gedeo farmers. The need for wood is higher than in other societies because *ensete* food is prepared twice or thrice a day and requires higher outlays of firewood, as compared to cereal bread, i.e., "*injera*" which is usually baked once or twice a week. Moreover, only wood is used by the Gedeo for construction, as stones in utilizable form are rare in the Gedeo country. Increasing population, particularly in the towns coupled with the absence of forests either in the Gedeo country or in its surroundings, has made demand for wood very high (ch.6).

Farmers use as fuel, the biomass from dried *ensete* leaf petioles (*xude*), leaf-sheaths (*oofee*), tree twigs (*haasumee*), or pods (*xibilliissa*) tree stumps (*tutume*) to conventional trunks (*jirmmeessa*). Except for the last one, all the rest are difficult to quantify. In order to obtain an estimate of wood consumption, cooperation of few farm families was solicited, in using only measured stacked wood from a 24-year-old, girdled and dried *Polyscias ferruginea* tree. It was found that households with seven members consumed 21 m^3 of wood per year on the average. The wood from this tree is low in energy and is normally used for furniture. Therefore, a cubic meter of stacked wood from the tree is taken as equivalent to 0.4 m3 stem or bole wood, on the average (Pardé & Bouchon, 1988, table xii p.87; James, 1982, p.381). Thus, 21 m^3 stacked wood is 8.4 m^3 massive wood. Wood need of a farm household engaged in an intensive construction work, i.e., house, fence, beehives, furniture, in total amounted to 7m^3 stacked wood, an equivalent of 2.8m^3. However, such a heavy construction is carried out once in ten to twenty years, the yearly need is only 0.2 m^3. This leaves 8.6 m^3 of wood per average farm households of seven. This is estimated to cost Birr 420 (US $52.5) at the price that prevailed. Fodder lopped from the trees must be added. This costs a farm household some Birr 2 (US $0.25) per week and if this continues over six months, the cost is Birr 48. Moreover, leaf litter is also added to the soil, which would have cost the farmer the same sum of Birr 48. Therefore, products from the woody components can have a financial value of Birr 516 (US $64.5), an equivalent of 172 kg of sun-dried coffee at the price of 2001.

Each household uses from 0.25 kg to 2kg of fresh kale with *ensete*. Since, *ensete* food is served at least twice a day, from 0.5kg to 4kg of kale is consumed daily. The average price of 0.25 kg kale is Birr 0.25. Each farm household consumes kale for Birr 0.50 to 2.0 per day, amounting to Birr 15 to 60.0 per month. For climatic reasons, farmers particularly in the midland and lowland zones cannot produce their own vegetables throughout the year (ch.4). Each farm household therefore has to complement its homestead supply with purchase from the market.

8.3.3. Yield from herbaceous annuals

Most of these crops are grown as vegetables (table 8.2) in homesteads (ch.4 and ch.6). The most commonly grown grain crops are maize (*Zea mays* L.) in the lowlands followed by barley, horse bean (*Vicia faba* L.), pea (*Pisum sativum* L.) kale (*Brassica* sp.) and onion (*Allium* sp.) in the highland zone. Barley (*Hordeum vulgare* L.) on average yields about 5 quintals, horse bean or peas about 4 quintals, maize from 12 to 15 quintals $ha^{-1}y^{-1}$. Some farmers participating in newly introduced packages (improved maize seeds, fertilizers and pesticides) reported a yield of 20 quintals $ha^{-1}year^{-1}$. Kale and onion are the two most important leafy vegetables with relatively high yields of up to 3 tons ha^{-1} (fresh weight). A quintal of barley fetches 150 Birr, a quintal of peas or horse bean, Birr 200, while cabbage or onion fetch Birr 30 per quintal at the price of 2001.

Table 8.2. Major crops grown along with *ensete*.

Crop	Major Use	Minor Use
Barley	food[1]	cash[1]
Leafy vegetables[a]	cash[1]	food [1,2,3]
Leafy vegetables[b]	food[2]	cash
Horse bean	cash[1]	food
Pea[c]	cash[1]	food
Coffee	cash[2,3]	beverage[1,2,3]
Godarr[d]	food[1],[2,3]	cash[3]
Spices[e]	cash [2,3]	food[1,2,3]
Maize	food [1,2,3]	cash[3]
Boyina	food [2,3]	cash[3]
Sweet potato	cash[3]	food[1,2,3]
Fruits[f]	cash[3]	food[1,2,3]
Legumes [g]	cash[3]	food[1,2,3]

Note
1,2 and 3 respectively stand for highlands, midlands and lowlands.

[a] Onion (*Allium* sp.), kale (*Brassica* sp.), garlic (*Allium* sp.)
[b] Kale (*Brassica* sp.), pumpkin (*Cucurbita* sp. (CUCURBITACEAE), pepper, maize (*Zea mays* L. (GRAMINEAE))
[c] *Pisum sativum* L. (PAPILIONOIDEAE)
[d] *Collocasia esculenta*(ARACEAE)
[e]kororima (*Aframomum korarima* (ZINGIBERACEAE)
[f] banana (*Musa parasidica* (MUSACEAE), mango (*Mangifera indica* (ANACARDIACEAE), avocado (*Persea americana* (LAURACEAE), pumpkin (*Cucurbita* sp. (CUCURBITACEAE))
[g] Horse bean (*Vicia faba* L(PAPILIONOIDEAE)), pea (*Pisum sativum* L. (PAPILIONOIDEAE)) in highlands and haricot bean (*Phaseolus vulgaris* L. (PAPILIONOIDEAE) in the lowlands and climbing beans, e.g., *P. lunatus* L. (PAPILIONOIDEAE)) in midlands ands lowlands.

Source: this study

This makes economic transactions among farmers from different zones more viable. The highlanders also sell products of bamboo such as baskets or mats. A single bamboo mat fetches from Birr 1.5 to 2.0. A farmer with 20 mats can obtain from Birr 30.0 to 40.0. Highlanders also produce good ropes and cordage as well as products made from hides and skins. A single cable (fig.6.2) made of a special fiber plant (*doobbee*) sells at Birr 25 to 30. *Ensete* is also a cash crop for the highlanders. A back-load of *ensete* food of good quality is sold at Birr 5.0 to 7.0 while a horseback load can fetch from Birr 30 to 60. Cash income from the coffee flows on to the highlanders via vegetables and to the lowlanders via animals and animal products. There is also a high demand for coffee in the highlands.

Table 8.3. Yield and value estimates per 0.25 hectare per year (average) as reported by farmers for major components.

	Component	Yield	Value in Birr (8 Birr = 1US$)
Scenario one: mixed			
1	Fodder from weedy herbaceous vegetation (kg dry basis)	896.0	90.0
2	Sun dried stacked wood (m^3) (firewood and construction)	1.0	30.0
3	Pure honey (kg)	30.0	300.0
4	Leafy vegetables (kg, fresh)	188.0	90.0
5	Root vegetables (kg, fresh)	500.0	250.0
6	Fresh fruits (bananas and/or avocado and/or climbing pulses kg)	200.0	100.0
7	Livestock (number of sheep)	2.0	100.0
8	Wild vegetables, fruits, mushrooms no. of occasions (food availability)	5.0	50.0
9	Others	200.0	200.0
	Subtotal $_1$		**1210.0**
Scenario two: monocropping			
1	*Ensete* (ton, dry weight)	1.5	876.0
2	Maize (grain, tonnes)	0.4	375.0
3	Sun-dried coffee beans (kg)	250	1000.0
4	Grains (barley, horse bean, pea) kg))	125	250.0
	Mean		**2501.0**
Weighted total yield per 0.5ha (in Birr)			**3711.0**

N.B. In order to obtain an idea about the farm efficiency, data in this table must be compared with data on labor needs of major farm activities (table 6.3, ch.6). Labor represents the major input, as the farmers pay less direct tax (between Birr 30 and 100 depending on size of holding).

From climbers such as pumpkins (*Cucurbita* sp.), *boyina* (*Dioscorea abyssinica*), *qoqee (Phaseolus lunatus L),* or *hamara (P. vulgaris L),* several weeks' supply is obtained. A single stem of pumpkin can yield from 30 to 50 fruits. The latter are often stored for the dry season, when most vegetables cannot be obtained. On the other hand, a lianescent stem of *qoqee* or *hamara* (e.g., appendix 4.1c, component no. 20) yields from 15 to 50kg dry beans. Shade tolerant crops such as sweet potato or *godarre (Colocasia esculenta (L) Schott* (ARACEAE, plate 6.6*),* provide up to a month's supplementary food, per year.

8.3.4. Yield from coffee and fruit crops

Coffee (*Coffea arabica* L. RUBIACEAE) is grown as a main cash crop in the midlands and lowlands (ch.6). About 40% of the total coffee produced is for home consumption (Agricultural Bureau for the Gedeo zone, unpublished). Drinking coffee is part of the social gathering among neighbors. Coffee is made at least twice a day, each pot taking about a quarter of a kilogram of sun-dried coffee. The first thing a guest in the Gedeo household is offered is a cup of coffee and roasted barley (*awoo)*. One of the best and highest priced *arabica* coffees of the world, "Yirga-chaffe", comes from the Gedeo highlands. Yield of clean coffee from mixed fields (see table 8.4) cannot exceed from 4 to 6 quintals per hectare in the best of production years. In lean years, farmers expect up to seventy-five per cent yield reduction.

Development interventions aiming at an increase of coffee production at the expense of *ensete* and other crops were attempted in the Gedeo country for the last three decades (ch.6). Their main result was that they only exposed farmers to food insecurity. A 75% decline of the world coffee price, from US $1.0 a to US $ 0.25 per kilogram occurred in one decade. Farmers who opted for increased coffee production then experienced vividly that coffee was not a good substitute to their *ensete*, the value of which has in the mean time increased considerably (from US $ 0.25 to US $ 0.50).

Table 8.4. Coffee (clean, metric tons) export from the Gedeo highlands. Note the oscillation around the mean quantity, representing "good" and "bad" coffee years as set against the "normal". Also note the peak in 1994/1995.

Production year	Washed	Unwashed	Total
1990/91	2049.0	12059.0	14,108.0
1991/92	3548.0	12701.9	16,309.9
1992/93	2011.9	17137.9	19,149.8
1993/94	2828.5	12684.9	15,513.4
1994/95	3030.7	28085.3	31,116.0
1995/96	3328.4	18318.2	21,646.6
1996/97	4557.1	11363.4	15,920.6
1997/98	8875.5	15,686.1	21,254.9
1998/99	8875.5	15,686.1	24,561.6
1999/00	5202.7	11186.7	16,389.4
Total	42,759.4	152,520.8	195,970.2
Mean	4,275.9	15,252.1	19,597.0

Source: Agricultural Bureau for the Gedeo Zone (unpublished).

Besides coffee, a farmer in the midlands or lowlands grows diverse fruits, such as banana, mango, avocado, guava and papaya. He may also have few livestock (one milk cow, or two goats, and/or several chickens (see ch.6). A farmer with half a hectare of land can therefore harvest about 50 banana hands within a year and obtain US $80, if he sells each hand for US $ 0.50 on the average. Such a farmer is less affected by market dynamics, because he does not rely solely on any particular demand. Therefore, farmers distribute their eggs in as many proverbial baskets as possible, as a strategy to operate sustainably in a largely unpredictable physical and/or social environment.

In these circumstances, a low yield is no big problem for farmers, as they do not depend on one single crop (table 8.3). Two scenarios, mixed cropping actually practiced by the farmers, and a hypothetical one (mono-cropping) are presented in table 8.3. In farmers' eyes, mixed cropping for Birr 4840.0 per hectare per year is superior to mono-cropping earning Birr 10,004.0 per hectare per year. The financial value of mixed cropping is low because it is difficult to assign a cash price to a number of products (e.g., herbal medicine) and services from mixed cropping (e.g., soil conservation by water-stocking *ensete* plants or cultural value of certain products (table 8.1, table 8.5d). Moreover, mixed cropping has a higher capacity to buffer fluctuations in price or environmental hazards. More insight into mixed cropping can be obtained by ranking value rather than calculating price (table 8.1).

In all cases, the proceed from whatever is available for sale is used for supplementing *ensete* food, particularly for buying high protein food as *ensete* is low in protein (Ethiopian Nutrition and Health Research Institute, 1997). It is used also for paying taxes and contributions. Having coffee as a source of cash, farmers in the midland zone do not produce grain crops for sale.

8.3.5. Yield from *ensete* (*Ensete ventricosum* (Welw.) Cheesman- MUSACEAE)

8.3.5.1. Harvesting *ensete*

Ensete production, the duty of men in the main, is discussed in chapter 6. Harvesting and processing, exclusively the duty of women and girls, are discussed here. *Ensete* harvesting and processing is the hardest of the tasks in *ensete* production. For instance, uprooting, transport and processing of a mature *ensete*, initiating flowers, takes from 5 to 7 woman-hours, depending on the size of the plant and the physical condition of the woman (table 6.3). Besides, in order to obtain a good quality processed product, several precautions must be taken. One hazard is decay, due to failure of the fermentation process. This subject is not well studied. Not knowing the causes, farmers ascribe it to several factors a few of which rests on superstition. Women are wary of this danger as their status and prestige in the Gedeo society depends on the quality of the fermented product (table 8.5).

Prior to uprooting the designated *ensete* plant, necessary preparations such as sharpening the tools (fig. 8.1) and preparation of a bedding (*hassuwwa*) and construction of a shelter over it (*dogodo*), are made. Next, the *ensete* plant(s) is harvested. This consists of removing all leaves (*hochcho*) and dried leafs-sheaths (*oofee*) (see fig.8.2a) from the plant. Removal of the interlocking leaf-sheaths requires skill and older ones are removed working from outside inwards.

Finally, the corm, partly under the ground, is uprooted by severing the roots with a sharp knife (*wormme*, fig.8.1). The corm is split using the tapering end of the *meeta* (see fig. 8.1). Depending on its size, it yields two or four equal parts using the tapered end of *meeta* (wooden board) fig.8.2b)). If the corm is so small as to be transported easily, splitting is not necessary.

In the process, the parts to be fermented and those unfit for fermentation are separated (see fig. 8.2). Leaves, dried or decaying leaf sheaths (see fig 8.2) are removed as well as roots and leaf scales (*shuulisanee*).

8.3.5.2. Processing *ensete* biomass

The product of harvest, i.e., the *ma'a* (parts of the pseudo-stem) and *ha'michcho* (intact or split corm) is transported to the site of processing (*hassuwwa,* fig. 8.3). Another part from a previous harvest or harvests, i.e., the starter (*gamama*) is also prepared beforehand. Processing then consists of reducing these parts into smaller bits, so that fermentation proceeds at the desired rate.

Parts of the pseudo-stem (*ma'a*) are spread along a wooden board (*meetaa*), itself tilted against a live *ensete* or tree (fig. 8.3a). The inner parenchymatous tissue of the pseudo-stem then is scraped (fig. 8.3a) with a bamboo or metal scraper (*sissa*, 1d, fig. 8.1). The resulting biomass is chopped with a sharp knife (*wormme*, 1a, fig.8.1). Then, the preprepared starter is also grated. Biomass from the three parts, i.e., pseudo-stem, corm and starter is mixed and remixed in this way. This marks the completion of the processing stage and the beginning of the fermentation process. The resulting biomass is sealed off from the external air with dried leaf sheaths. However, the seal is opened frequently at intervals of three to four days so as to expose the biomass to open air.

The corm (*ha'michcho*) is also grated or pulverized (fig.8.3b), working from the inside to the outside, with a wooden grater, to which is fitted a metal tooth (1e, fig. 8.1). The outer part of the corm is kept intact and this results in a bowl-shaped part called *gaamaa*, literally, a "seed". However, it has to be fermented before being used for fermentation purposes. Fermentation of this bowl-shaped part of the corm requires mixing it with a starter (*gamama*). Then, it is sealed off from the outer air, to be opened and exposed to the sun at appropriate times of the day, so as to avoid decay. This needs a lot of care as this determines the quality of *ensete* products to be obtained in the future.

The two factors that determine the rate at which fermentation proceeds are the quality and adequacy of the previously preprepared starter, mixed with the fresh biomass, and the thoroughness and frequency of mixing. With sufficient starter and frequent and thorough mixing, the fermentation process will be faster and it will lead to a higher quality end product. In case the previously prepared starter proves to be inadequate, a new starter is grated and added to the biomass. Until the new starter is fermenting and is added to the biomass, fermentation cannot proceed at full rate. Biomass in such retarded fermentation state is known as *uurro* (meaning "in a pause"). A woman farmer who sets out to harvest without sufficient starter is looked down upon, like a farmer who goes out to plant without any planting material. Like with the seed (ch.6), sharing the starter is one main aspect in which farmers express love and mutual help. Therefore, women rarely go to harvest without a starter. It is then the insufficient amount of the starter, rather than its absence that matters.

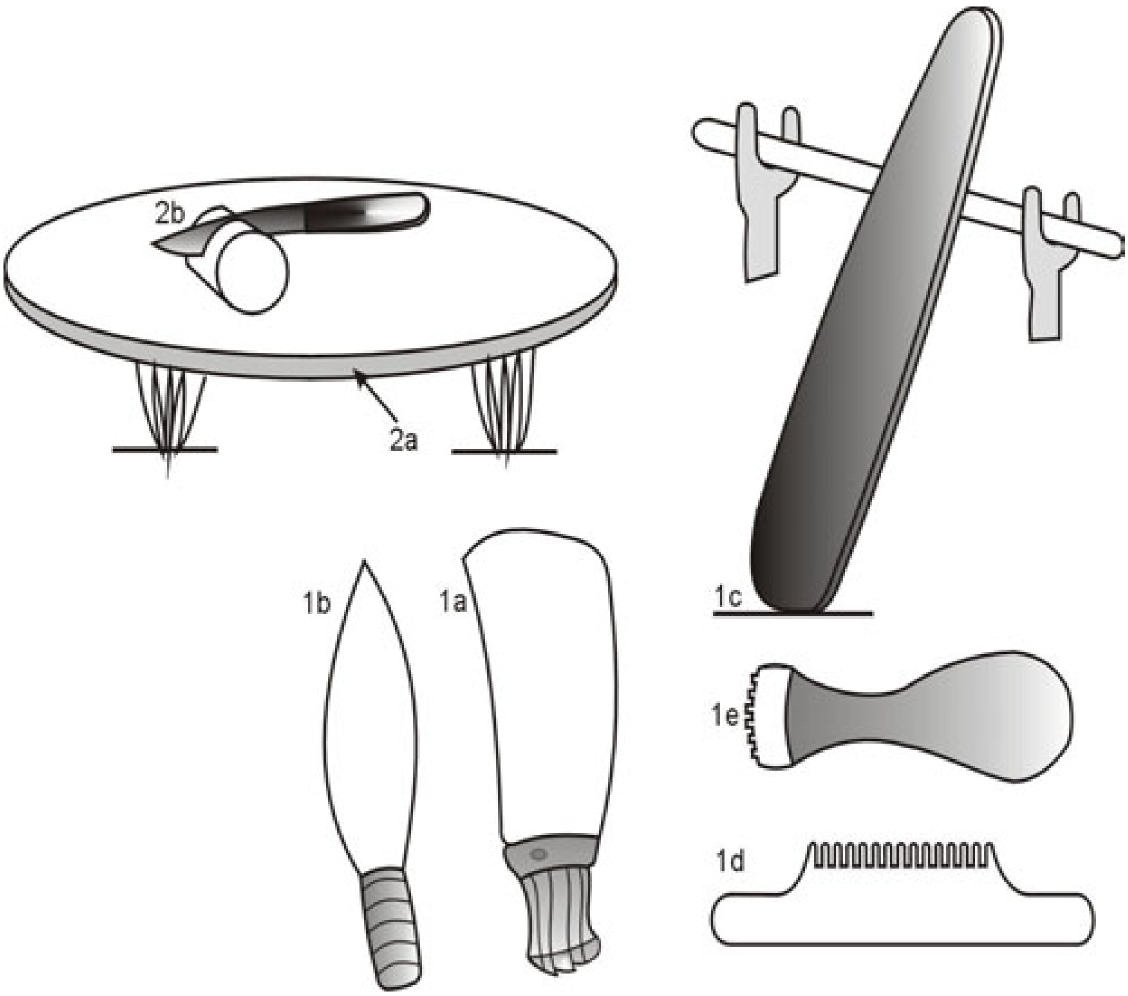


Fig. 8.1. Tools used by women in working with *ensete* and *ensete* products *Wormme* (1a) is a large knife used in *ensete* harvest, *habille* (1b) is a small knife used for chopping *ensete* biomass to promote fermentation, *meeta* (1c) is a wooden plank over which *ensete* leaf-sheaths are supported for scraping (fig 8.3a) with *sissa* (1d). The *meeta* itself needs to be supported over a live *ensete* plant (En, fig. 8.3a) or a tree. *Meeta* is also used as a wedge in splitting the corm (fig.8.2b). *Ceeko* (1e) is a tool used for pulverizing the *ensete* corm (fig. 8.3b). *Bidro* (2a) is a wooden table on which *ensete* food is prepared. A piece of *ensete* food is shown on the *bidro*.

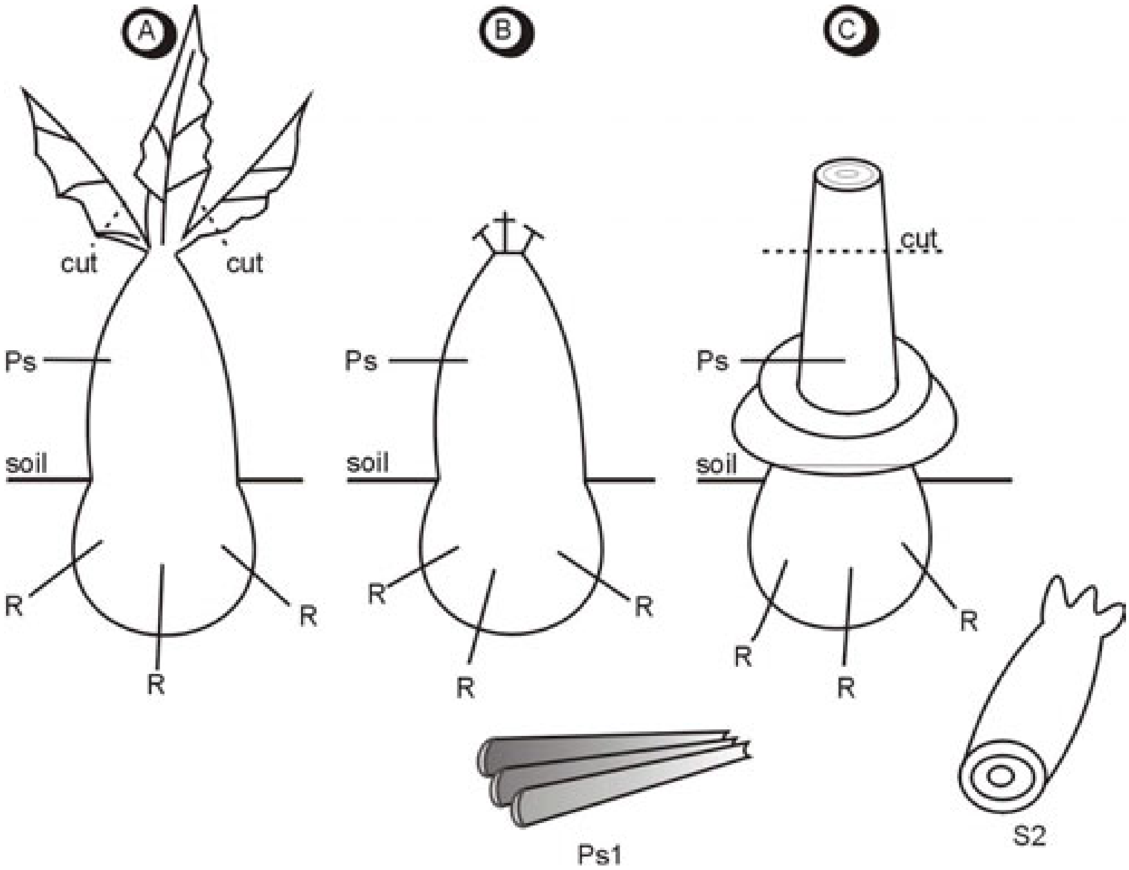


Fig.8.2a. Steps in *ensete* harvesting (above-ground parts). The latter in unflowering *ensete* plants, consists largely of the pseudo-stem. Both live leaves (L, *hochcho*) and dry leaves (*hashupha,* plate 5.3) together with dry leaf-sheaths (*oofee,* plate 5.3) are removed, in this order (A). Next, the live leaf-sheaths (PS) are removed, one by one, following their serial arrangement on the corm (B and C). Harvest of above-ground part results in PS1 and PS2, parts of the pseudo-stem to be scraped. The remaining part of the pseudo-stem is left behind, to be harvested with the below-ground corm (fig.8.2b).

Provided that everything goes all right with the fermentation process, as is most often the case, the fermented product requires at least three weeks to be ready, its quality being improved with additional time. Fermentation is completed within a month. Fermented *ensete* mass is packed in carefully prepared *ensete* leaves and dried leaf sheaths. It is transported to *gola*; a place prepared for temporary storage.

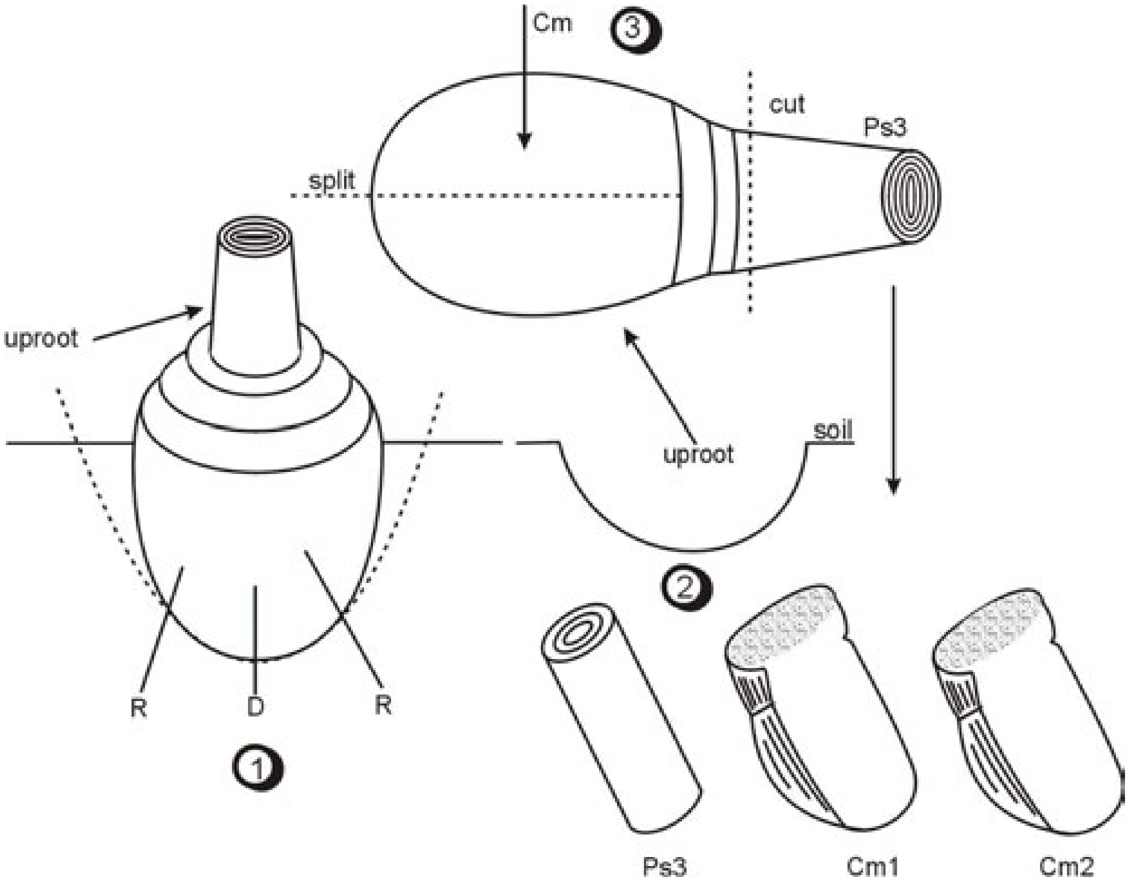


Fig.8.2b. Steps followed in harvesting *ensete* (below-ground part). The roots (R) are severed, following the circumference (1) of the corm, using *wormme* (1a, fig. 8.1). The corm is then uprooted (2). The pseudo-stem (PS3) is then separated from the corm, by cutting it, at the place shown (2). The corm is split into two equal parts (3), using the tapered end of *meeta* (1c, fig.8.1), as a wedge. Two products result from the harvest, PS3 (part of the pseudo-stem) and two pieces, CM1 and CM2, from the split corm.

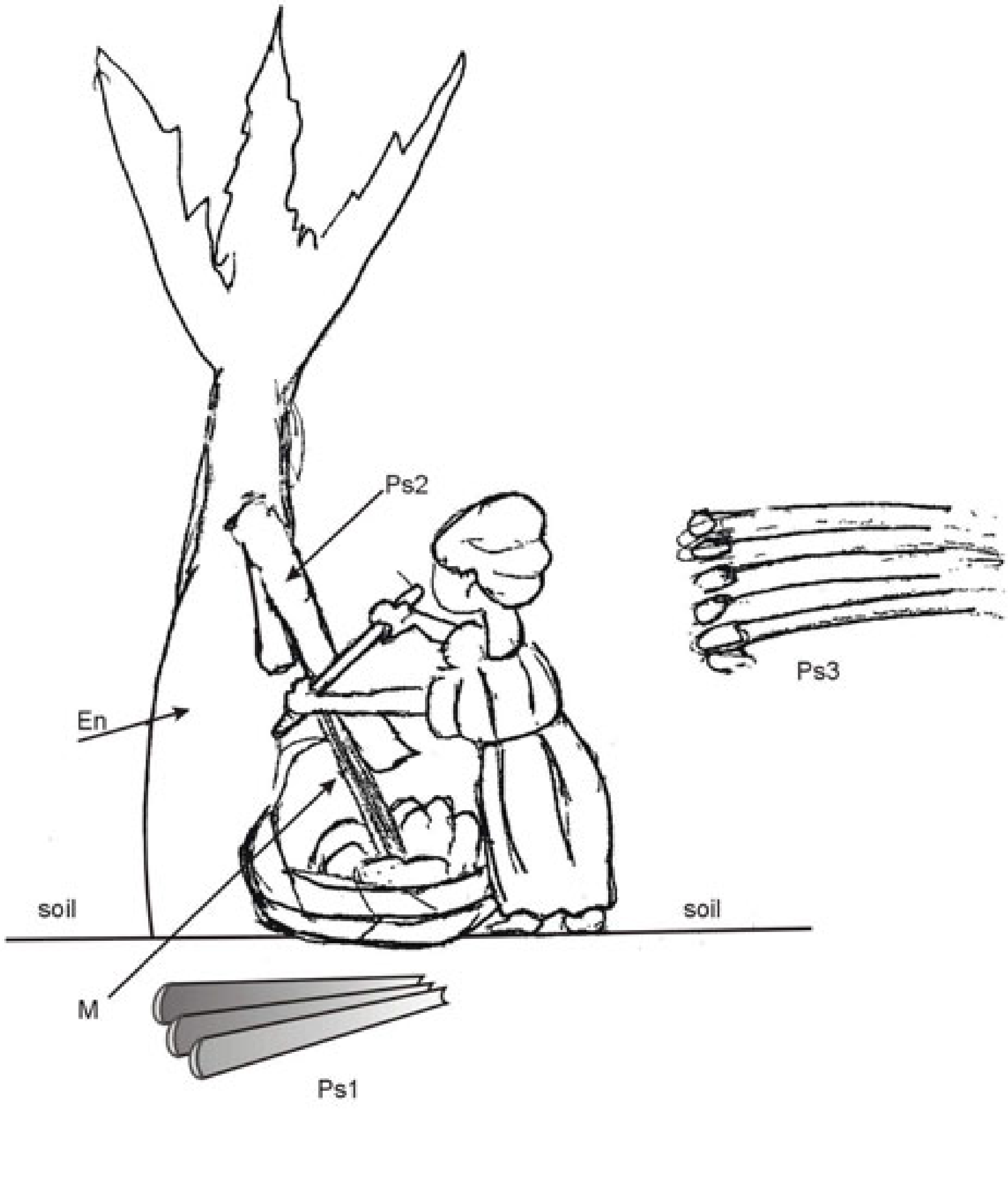


Fig.8.3a. Scraping *ensete* leaf-sheaths. First, a leaf-sheath (PS1) is wound (PS2) at the tip of the *meeta* (M), itself supported upon a live *ensete* plant (En). This helps the woman to do the scraping in an upright position. It also avoids using her legs, for supporting the leaf-sheath over the *meeta*, as is done in other *ensete* cultures in Ethiopia. The scraping is carried out using *sissaa* and results in two products, *we'e* (scraped biomass) from the leaf-sheaths (*ma'a*) and *ensete* fiber, PS3 (*haanxxa*). The *we'e* is mixed with *ha'michcho* (biomass obtained by decorticating or pulverizing the corm) and *gaamaa* (fermented starter). These then are fermented into the edible product (*waasaa*). The fiber (*haanxxa*), after sun-drying, is either sold in a market or is put to domestic use (such as for squeezing out excess moisture from *waasaa* or for making ropes and cordage).

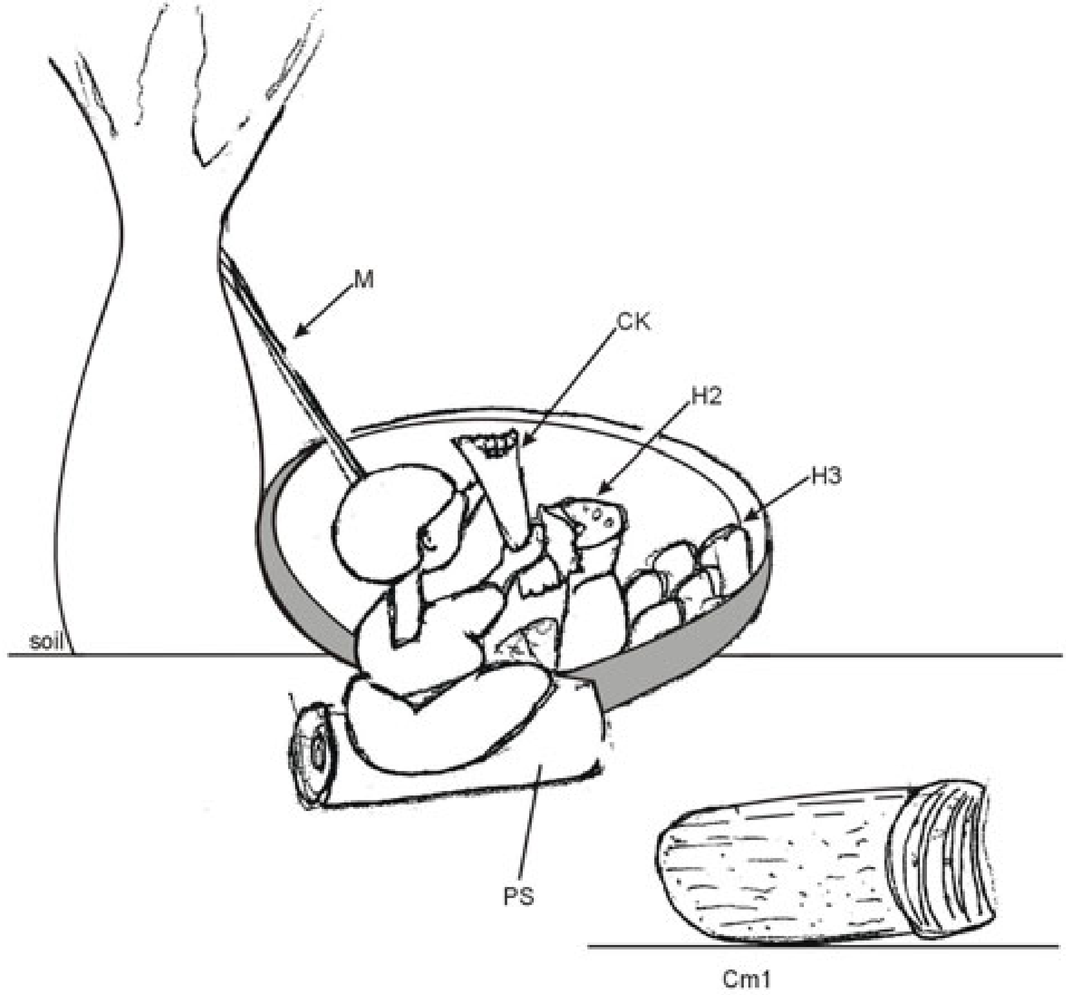


Fig.8.3b. Pulverization of the *ensete* corm. The split corms are transported to a processing site, *hassuwwa,* where they are pulverized using *ceeko* (CK). Pulverization of the corm results in two products, *ha'michcho,* biomass to be mixed with *we'e* (biomass from the scraping of *ensete* leaf-sheaths) and *gaama,* part of the corm reserved to be fermented as a *future* starter or *gamama* (CM1).

8.3.5.3. Products of *ensete*

Two kinds of food are derived from *ensete*. *Bu'la* is the unfermented product and *waasa,* or *kocho,* is the only fermented product used for food. *Bu'la is* usually obtained by squeezing unfermented biomass of a pulverized *ensete* inflorescence stalks and/or a mixture of grated or pulverized corm and chopped pseudostem. Yield of *bu'la,* food of highest quality, does not exceed 5kg (fresh weight) per plant (table 8.5a). The quantity of *bul'a* is small because all of it is not squeezed so as not to undermine the quality and the rate of fermentation of the remaining biomass. *Ensete* biomass from which all or most *bu'la* is removed not only ferments very slowly but it will also have a low quality. *Bu'la* is served on special occasions only. Squeezing *waasa* or fermented *ensete* product, also yields *bu'la* of inferior quality called *mooca.* These two unlike *waasa* or *kocho,* are fiber-free and are served boiled or baked with butter, pulses called *hamara* or *qoqee* (see par. 8.3.3) or milk, roasted meat or kale. Waasa, or the fermented product of *ensete*, is diverse. For instance, ten different kinds of *waasa*, have their proper names, *bu'a*, *mooca*, *dassa*, *qoxee*, *karssa*, *aala*, *maqita*, *haarra*, *uurro* and *doobbala*.

Waasa or *kocho* is first squeezed to remove excess moisture and the resulting flour is chopped with a sharp knife to shorten the fibers. As fibers in *kocho* form one major factor reducing the quality of *ensete* food, women spend a lot of energy and time chopping the foodstuff (fig.8.1. 2b) so as to shorten it as much as possible, as it is impossible to remove them. However, a new method consisting of dissolving *kocho* in water and sieving out the fibers therefore completely removing the fibers has recently been invented by the farmers

Table 8.5a. Yield (*waasa*, *bu'la* and fiber) of *ensete*, *gantticho* type, at three development stages, *daggicho* (D), *idago* (I) and *beyaa* (B) at three agro-ecological zones (highlands, midlands and lowlands). Average yield per plant is given in kilograms but yield per hectare per year is given in tons. *Waasa* is given as dry weight whereas *bul'a* and fiber are given as fresh weight.

Stage*	**Highland**			**Midland**			**Lowland**		
	Waasa	Bu'la	Fiber	Waasa	Bu'la	Fiber	Waasa	Bu'la	Fiber
Dagicho, mean	38.7	3.0	1.4	29.6	2.0	1.1	26.9	1.3	1.1
95% C.I. ±	**4.0**	**1.2**	**0.5**	**7.5**	**0.9**	**0.3**	**8.6**	**0.5**	**0.3**
$Ha^{-1}.y^{-1}$	**8.6**	**0.7**	**0.3**	**6.6**	**0.4**	**0.2**	**6.0**	**0.3**	**0.2**
Idago, mean	33.0	1.6	1.2	25.5	1.1	0.9	22.3	0.9	0.6
95% C.I ±	***4.9***	***0.5***	***0.9***	***2.5***	***0.3***	***0.2***	***4.8***	***0.1***	***0.1***
$Ha^{-1}.y^{-1}$	**7.3**	**0.4**	**0.3**	**5.7**	**0.2**	**0.2**	**5.0**	**0.2**	**0.1**
Beyaa, mean	28.6	1.2	0.8	22.1	0.9	0.7	20.5	0.6	0.4
95% C.I ±	***3.7***	***0.3***	***0.3***	***3.0***	***0.1***	***0.1***	***2.5***	***0.1***	***0.2***
$Ha^{-1}.y^{-1}$	**6.4**	**0.3**	**0.2**	**4.9**	**0.2**	**0.2**	**4.6**	**0.1**	**0.1**

N.B. * Number of observations (n) = 5. In calculating yield per hectare per year (**$ha^{-1}.y^{-1}$**) the average spacing of 1.5 by 3.0 m and average rotation time of ten years is used. Dry weight is 44% of wet weight, as 56 % of *kocho* as it is called in towns is moisture (Pijlls & al., 1995; Hiebsch, 1996).
Source: this study

Table 8.5b. *Fnsete* (*gantticho* type) yield (by-products, kg per plant and ton.$ha^{-1}.y^{-1}$) at three development stages, *daggicho* (D), *idago* (I) and *beyaa* (B), at three agro-ecological zones (highlands, midlands and lowlands).

Stage*	Highlands		Midlands		Lowlands	
	Root at 1m r	**Others**	**Root at 1m r**	**Others**	**Root at 1m r**	**Others**
Daggicho, mean	***8.4***	***80.1***	***5.9***	***71.7***	***6.3***	***60.2***
95% C.I. ±	***2.4***	***14.3***	***1.3***	***5.5***	***0.7***	***6.6***
$Ha^{-1}.y^{-1}$	**1.1**	**10.7**	**0.7**	**15.9**	**1.1**	**13.4**
Idago, mean	***5.2***	***63.8***	***4.4***	***55.9***	***4.3***	***51.0***
95% C.I. ±	**0.9**	**10.1**	**0.6**	**15.2**	**0.4**	**9.1**
$Ha^{-1}.y^{-1}$	**0.7**	**8.9**	**0.5**	**6.2**	**0.7**	**8.1**
Beyaa, mean	***4.3***	***57.2***	***4.1***	***54.0***	***3.6***	***46.0***
95% C.I. ±	**0.8**	**8.6**	**1.0**	**6.5**	**0.7**	**5.6**
$Ha^{-1}.y^{-1}$	**1.0**	**12.7**	**0.9**	**12.0**	**0.8**	**10.2**

N.B. * Number of observations (n) = 5. In calculating yield per hectare per year ($ha^{-1}.y^{-1}$) an average spacing of 1.5 by 3.0 m and average rotation time of ten years is used. Dry weight is 44% of the wet weight, as 56 % of *ensete biomass* is moisture (Pijlls & al., 1995; Hiebsch, 1996).
Source: this study

themselves. Then fiber-free *waasaa* is put in porous sacks over which a weight is placed so as to remove excess moisture. The resulting flour is baked in clay pans or rolled into balls, which are then boiled in large pots. Many different dishes can be prepared from the resulting *ensete* flour. Ten different dishes were named in the midlands. These were *quncissa*, *diboo*, *kebbo*, *hocoqo*, *wodhamo*, *koofoo*, *xaltta*, *oxa*, *lila* and *culuqo*. Dishes of *ensete* food (see plate 8.2) are usually served with kale leaves and/or meat, the latter often being cooked together. It can also be served with milk, butter or diverse pulses.

Ensete fiber, remaining after scraping the parenchymatous tissue from the pseudo-stem or the stalk of *ensete* inflorescence, is the third major *ensete* product. *Ensete* fiber is only second to that of abaca, the commercially grown Asian *Musa textilis* (Bezuneh, 1996). Because of the new method of removing excess moisture from *waasa*, the fiber hitherto primarily used for this purpose can now be sold for cash, augmenting family income. A kilogram of *ensete* fiber is currently sold at from 5 to 8 Birr. *Ensete* fiber is used as nail substitute in the construction of traditional thatched houses and in the making of ropes, cords, mats, bags or rags.

With a supply of mature *ensete* plants on hand, one must also take into account the way to ferment them, in order to obtain nutritious food. Fermentation is not a prerequisite for all *ensete* types. Stems or *ham'cho* of certain *ensete* types, normally reserved for emergency situations, are uprooted and directly boiled. These *ensete* types are known as "soft", reflecting their ready supply of food and the short time required for fermenting their biomass, normally half or a third of the time required for fermenting "hardy" *ensete* types, grown for fermenting. Every household strives to keep a proper balance between "soft" and "hardy" *ensete* types.

Ensete besides waasa (kocho), *bul'a,* and fiber *haanxxa* (table 8.5a) also yields *hocho* (fresh leaves), *hashupha* (dry leaves), *hacho* (fresh midribs) and *oofee* (dry midribs); (table 8.5d). Some *ensete* products are used for social and/or cultural practices. For instance, fresh butter used as an ointment in birth, circumcision or wedding ceremonies is held in fresh leaves of *ensete*. Newly married couples and women in labor sleep in beds lined with *ensete* leaves. During arbitration elders and the parties in dispute are seated on *ensete* leaves. *Ensete* leaves and leaf-sheaths are used in thatching house roofs (plate 8.1).

Without fresh leaves of *ensete*, fermentation of its biomass and packaging the end product is very difficult and traditionally incorrect. *Ensete* leaves are also used for transporting *ensete* food over long distances or for storing it during longer periods of time. Leaves are also used as plates when eating in public (table 8.5d).

Another role of *ensete* is an ecological one. It is played by its parts, deposited on the site to decay as a by-product (more than 70%, table 8.5c). Moreover, farmers rotate *ensete*-processing sites within the field, for they believe that exudates from fermenting *ensete* biomass have soil-enriching qualities (also see ch.7 for soil micro-life).

8.3.6. Livestock yield

Livestock has a role to play in Gedeo land use although its population numbers are insignificant due to the scarcity of grazing land (ch. 4 and ch.6). Livestock productivity is low. This should be seen as a consequence of the non-maximal yield approach of the farmers. Farmers raise one or two sheep or goats per year for special occasions, such as *faasika* (in April) or the new year (in September) when the price of animals rockets. From three to five liters of milk per day can be obtained from a dairy cow, and from 10 to 20 eggs per hen per two months.

Table 8.5c. Proportion 'of immediate use' and 'of future use' yield (kg.plant^{-1} fresh weight$_{)}$ in *ensete* (*ganticho* type) at three development stages (*daggicho*, *idago* and *beya*) in three agro-ecological zones (highlands, midlands and lowlands).

Stage	Of immediate use	% total	Of future use	% total	total
Daggicho					
Highland	43.1	26.1	122.0	73.9	165.1
Midland	32.7	24.7	99.0	74.8	132.4
Lowland	29.2	25.5	85.2	74.5	114.4
Mean	35.0	25.5	102.1	74.3	137.3
Idago					
Highland	35.8	28.5	89.8	71.5	125.6
Midland	27.5	26.6	77.9	72.5	107.5
Lowland	23.8	24.8	72.5	69.6	104.1
Mean	29.0	26.6	80.1	71.2	112.4
Beyaa					
Highland	30.6	27.9	78.7	72.0	109.3
Midland	23.7	24.1	74.5	75.9	98.2
Lowland	21.5	24.6	64.0	74.9	85.5
Mean	25.3	25.5	72.4	74.1	97.7
Zone	29.7	25.9	84.9	73.2	115.8

Note. Total root mass was obtained by multiplying root mass within a 1m radius by 5, the average length of *ensete* roots in meters.
Source: this study

Domestic fauna, like other agro-ecosystem components, is subsidiary to *ensete*, in most cases providing cash income for unexpected expenses. As protein is limited in *ensete* food, the need for extra protein supply is obvious. As stated earlier, too few animals are raised by the Gedeo, so they are dependent on trade with neighboring pastoralists.

Table 8.5d. Use value of some *ensete* by-products

Product		Use value
1	Live leaves /*hochcho/*	symbol of peace (meditation), and bedding and packaging and thatching
2	Dried leaves /*hashupha/*	bedding particularly for lactating mothers, used as a filler in house walls as well as in fences
3	Fresh midrib /*merecho/*	water line, livestock fodder, used during processing *ensete*.
4	Dried midribs /*xude/*	/ Fuel, fiber for making mats / *gasha* or *xaxxo* /
5	Live leaf sheaths /*hachcho/*	Container
6	Dried leaf sheaths /*oofee/*	Packaging *ensete* food and butter, fiber in house construction, fuel
7	Dried petiole /*xushsho*/	Fiber (the strongest) particularly used in construction (as nail substitute)
8	Roots /*hiddichcho*/	medicine, symbol of the truth (*dhugaa*)
9	Inflorescence /*dagaguma*/	/ Vegetable / eaten by shepherds /
10	Seeds /*gumma*/	stone in the local game, *saddeeqa*
11	Growing tip /*huumaa*/	/ Vegetable / eaten by women processing *ensete*/

Source: this study

8.3.7. Yield from wild fauna and flora

Due to their higher architectural complexity and dynamics (ch.4 and ch.5), Gedeo "agroforests" contain biotopes to accommodate wild fauna and flora (see appendices 4.1 and 4.2). This is not a side effect, as in most man-made ecosystems but it is intentional. However, these animals are not studied analytically or species by species.

Farmers do maintain a friendly attitude to most wild fauna. They believe that the well-being of their agro-ecosystems is enhanced by their co-existence with most wild fauna. Thus, many taboos are put in place not to damage wildlife in general (ch.7). Though farmers could not explain, for instance, the role of insects in pollinating crops, they very well know that birds, by feeding on insects, control insect populations. Likewise, farmers are conscious of seed dispersal by such mammals as squirrels, bats or grivets (*Cercopithecus aethiopicus*). In particular, monkeys and grivets bring fleshy seeds from faraway places and eventually end up by introducing new plant species (see ch.6). Hyenas (*Crocota crucuta*) eating carrion cleanse the environment. Green snakes (*haanjjamme*), living in the tree branches and among the herbaceous vegetation feed on fresh coffee berries and hide some coffee beans beyond the reach of humans. Wild mice sometimes also attacking root crops including *ensete* (ch.6*)*, have a share in the latter activity. As seed vectors, these animals contribute to genetic mixing of populations, for seeds are carried away to germinate elsewhere among other groups of the same plant species, with slightly varying genotypes.

Some wild fauna components also provide direct benefits, as with antelopes, wild pigs or common fowl (*gogorre*) which are trapped for meat. Honeybees also provide products for immediate use. Two kinds of honeybees, *daamoo* and *kinniisa*, are recognized. Bees in the first group are free-living insects. They burrow tunnels in the ground, usually below trees. These bees are common property. Anyone who first recognizes the swarm may claim it, to whomever the land belongs, by placing an identification mark, a piece of cloth wound up at the tip of a stick of half a meter high. Honey from these bees is regarded as a potent medicine. From 5 to 10 kilograms of pure honey can be harvested from a single nest. The yield from the second kind of honeybees, occupying beehives made by farmers (see ch.6) is already mentioned. Besides honey, the larvae of both insects (*jiisa*) are prized as a good source of protein usually consumed by male farmers, because women perceive this as the equivalent of eating children.

Honey being an essential item in all sorts of Gedeo ceremonies, be they sacred or profane every Gedeo household strives to have some at its disposal. Honey is involved in birth, male circumcision (women are not circumcised), marriage, mediation and even death. In the strict sense, the Gedeo have not domesticated the honeybees. However, considering the close interaction between the insects and farmers, this is little short of domestication (ch.6).

Honey yield which is dependent on the type of the honeybees, the nectar available and other environmental conditions is also low. On the average, a yield of 10 to 15 kg pure honey per beehive can be obtained in good seasons. This can be reduced by half or three-fourth in lean years. Honey is harvested twice a year, between January and March and in May and June. However, the yield of honey obtained in the dry season between January and March (*Ba'leessa*) is the highest and of best quality.

Wild fruits and vegetables also make up a significant proportion of farmers' diet (see ch. 4). Moreover, there are various kinds of mushrooms (e.g., *qaaqee*, *ceqe'na* and *shopha*) which are not identified by their scientific names in the present study. Like other wild products, these are harvested among the Gedeo, by anyone who first discovers them. The first two fungi are gregarious and the whole village is invited for harvest. The last one, however, is solitary and thus personal. It belongs to the person who first discovers it. The rainy period following the dry spell (*ba'leessa*), when the propagule bank (Oldeman, 1990) is activated, is the right time for mushroom hunting. Since there are many species of poisonous mushrooms, young hunters are accompanied by knowledgeable older persons. The solitary occurrence of most poisonous fungi also helps.

All these plants and animals are fairly dependable sources of food. They provide several days' supply, and so their contribution to the household and community economy should be included in calculations of local and zonal carrying capacity. Moreover, their importance emphasizes that they also are elements of food security in times of scarcity or famine. Their value hence far exceeds the mere marketable or consumable volume or weight. At irregular intervals they do not belong to the economy of markets or consumables, but they could make the difference between life and death.

This seemingly small and accessory category of organisms, which one might be tempted to consider as fun food, snacks or sweets, in reality carries functions comparable to those of social security in industrial societies. There also it is considered unethical to calculate the price of security in money, however expensive it may be, for human life is too valuable to be expressed financially. The ecological security, which for the Gedeo takes the place of social security, is judged as priceless as the latter. Indeed, both refer to the sustainability of human life, which is the hidden core of all sustainability discussions since 1990 (Oldeman, 2001).

8.4. Discussion

Waasa yield per mature (*daggicho* and *idago*) *ensete* plants each averaged over the three zones (highlands, midlands and lowlands) was 31.7 and 26.9 kg (dry basis), respectively. This is an equivalent of 7.0 and 6.0 ton ha^{-1} $year^{-1}$, using a spacing of 1.5 m by 3 m and an average rotation of ten years. There are limitations to compare this yield to literature data because of the "serial transplanting" used for the plants in the literature. Tsegaye & Struijk (2001) gave a yield of 5.7 tons ha^{-1} $year^{-1}$ for fertilized and once-transplanted *ensete* plants, which is lower compared to our data. Our data are also higher than those reported earlier (Pijls & al., 1995, Bezuneh, 1984 and Makiso, 1976). These higher yields can be attributed to either the *ensete* clones used, or the stage of development in which *ensete* was harvested, or the growth conditions (e.g., soil fertility) or the management (method of establishment), or finally the procedure used for fermenting *ensete* biomass (Bezuneh, 1984). For instance, Tsegaye & Struijk. (2001) fermented *ensete* biomass for 88 days while in our case one month was the maximum period needed to have a complete fermentation of *ensete* biomass.

However, since monocropping of *ensete* is rare among the Gedeo, yield per hectare does make little sense, unless related to yield from other components that accompany *ensete*, such as firewood, coffee, or vegetables (table 8.3). For the need for *ensete* food of an active adult person, about six mature (flower – initiated, i.e., at *daggicho* or *idago* stage) plants are sufficient. Using the average spacing of 1.5 * 3.0 m per plant, this translates into an area of 27 m^2. *Ensete* comes to maturity in ten years on the average. Therefore, cohorts of *ensete* plants aged from one to ten years are required in order to have a sustainable flow of *ensete* food (ch.5). The area must be multiplied by ten, i.e., 27 * 10 = 270 m^2. Thus, a farm household of seven will need 42 such plants and an area of 270 * 7 = 1890 m^2, i.e., ca. 0.2 hectare.

Whatever extra land is available can be planted to other crops that accompany *ensete* (table 8.3). This calculation comes close to the current population density in the Gedeo zone. Depending on the agro-ecological zone in which the farm household is operating, it can either mix all the crops, as is the case in the midland zone or various crops can be grown in sequences, as in the highland zone (table 8.3). Supported by other farm components which among the Gedeo are considered as subsidiary, it can now be seen why *ensete* sustains the highest human density.

Stanley (1966 ex Westphal, 1974) put the carrying capacity of *ensete* at 30 to 100 *ensete* plants for the yearly needs of a family of 5 to 6 persons. This cannot be directly compared to our data , showing 42 mature flower-initiated *ganticho* type plants to cover the yearly needs for the household of seven. Indeed, we do not know the type and growth stage of the *ensete* plants used for Stanley's calculations. But the pattern is clear, i.e., 30 to 100 plants are needed if mature, large-sized *ensete* types with initiated flowers, like the *gantticho,* are used. The precise number to feed the farm household of seven depends on the extremely variable environmental and management conditions under which *ensete* is currently and locally grown.

The yield of *ensete* by-products is also very high. Mature *ensete* plants (at *daggicho* or *idago* stage) gave 91.6 kg (dry weight) biomass per plant. This is an equivalent of 20.3 tons ha^{-1} $year^{-1}$, using a spacing of 1.5 by 3.0 m and a rotation of 10 years, on the average. More than 30% of the by-product yield was roots (table 8.5c). *Ensete* by-products in the past were neglected when calculating *ensete* yield, thus undervaluing *ensete*-based systems.

By-products deposed on the site, sustain the productivity of the system without purchased inputs. The proportion of root mass averaged 30%. The fact that this mass is secured in the site, i.e., is not normally harvested, indicates its significance in soil maintenance (ch.7). These data also show farmers' insistence to be left alone with their *ensete.* Many environmental benefits are claimed implicitly to exist under high human population density in *ensete* growing areas in Ethiopia (Amare, 1984; Kippie, 1994; Wolde-Aregay & Holdinge, 1996). This was never substantiated, but it can be better appreciated now, in the context of the data presented in the present book.

Farmers mix crops to sustain and /or increase yield. That the Gedeo land use system does not lose and, on the contrary, adds yield is in contrast to the commonly held view that yield is lowered by crop diversity (table 8.3). The present study shows that calculating yield as if there were only one or a few useful components undermines the realism of the yield calculations in a multi-component system. To farmers, the concepts of 'useful' and 'not useful' are relative because what is considered 'useful' now may be 'useless' tomorrow, and vice versa, depending on time and situation. Therefore, the farmers know only one yield with two modes, i.e., yield for 'immediate use' and 'yield for future use'. Farmers also apply this concept when dealing with "weeds". Among the Gedeo, "weed" (*badda'a)* denotes a crop plant of a different category, i.e., containing those organisms that "save" resources for the future because they accompany crop plants.

Our data on the ecological range of *ensete* (1500 and 3200m asl) are in line with literature data (Huffnagel, 1961 *ex* Westphal, 1974). *Ensete* yield is claimed to decrease above 2000 m asl and *ensete* is assumed to be unsuitable to be grown without irrigation below 1500 m above sea level. However, our data prove otherwise. Higher yields per plant were observed at 2800 m asl than at 2000 m (see table 8.1a. and 8.1b) and *ensete* can also be grown below 1500 m without irrigation. Therefore, our data show that both limits of *ensete* growth can be extended. At higher altitudes, plant size, and the time needed to reach maturity increased and so did yield. Higher yield per plant in the higher altitudes is due to the longer life span, which gives the plants time to consolidate themselves using the local site resources (soil nutrients, incoming rainwater and radiation). In other words, the plants at this altitude invest in biomass rather than in seeds.

The opposite trend was observed in plants at the lower altitudes. *Ensete* plants there grew faster and attained relatively smaller sizes, judged by the parameters of basal pseudo-stem circumference and basal corm circumference. Both parameters are used by farmers to measure *ensete* performance (see table 8.3). Growth acceleration and plant mass reduction here are due to the heat and scarcity of moisture due to higher evapotranspiration. *Ensete* plants in the lowland zone, like other crops, adopt a strategy of quickly completing their life cycle. In other words, these plants invest in seeds rather than in vegetative biomass.

However, these calculations cannot tell the full story of *ensete* as grown by the Gedeo. They are only useful to show the theoretical carrying capacity. Asumptions behind these data, i.e., a prior investment in *ensete,* invoke a well-known rule in sustained yield forestry, that people should not eat the forest but eat from the forest (Oldeman & al. 1993), which is equally essential in *ensete* cultivation. Therefore, *ensete* is not harvested until it attains maturity, when the highest 'interest' on investment made is obtained (ch. 5 and ch. 6). The carrying capacity of land planted to *ensete* is implicitly defined by this principle. *Ensete* is said to be mature when it initiates flowering, beyond which this hapaxanthic plant, conforming to Hollttume's model, (Hallé & al., 1978), dies after flowering. However, farmers are well aware of this and harvest *ensete* at *idago or beyaa* stage, when it begins to initiate flowering but does not flower as yet. If kept beyond this stage, the plant will allocate all its biomass to conversion and investment in building the inflorescence, in seeds and populations. Harvest is carefully directed at deflecting the use of *ensete* biomass, from investment in seeds to human consumption, at the moment of vegetative biomass culmination.

The high carrying capacity of Gedeo "agroforests" should also be related to the way the Gedeo cultivate, harvest and process *ensete*. This is quite different from other *ensete* cultures. Instead of serial transplanting (Tsegaye & Struijk, 2000, 2001) the Gedeo use permanent transplanting (chs 5,6). The Gedeo also minimize their dependence on manure (ch.7) and if manure is applied, then only in the initial stages of *ensete* establishment (ch.6). Storage of *ensete* biomass in the living, standing plants, as practiced by the Gedeo, also helps them in securing a sustainable flow of biomass, as this procedure guarantees minimum losses, if any. Pit storage of *ensete* food which is common among other *ensete* peoples (Westphal, 1974; Bezuneh, 1984; Asnaketch, 1997; Brandt & al., 1997) is unknown among the Gedeo. Nor is there any specific harvesting season for *ensete*. Harvest and replacement are possible anywhere, at any time. Surface fermentation of *ensete* requires from three weeks to one month, as opposed to pit fermentation requiring from three to four months or even up to more than a year. Moreover, high quality *waasa* is obtained by surface fermentation, whereas pit fermentation is suspected to result in a bitter taste of the fermented product. This is probably one reason why surface-fermented *ensete* food from Gedeo highlands and from the Guraghe is highly sought after in markets as far away as Addis Ababa.

The concern of farmers for the future yield of their "agroforests" is deeply-rooted in their day-to-day practices. For instance, mast flowering of coffee worries farmers rather than make them happy. This is due to the behavior of the coffee, which "rests" without flowers for one to three years after the mast or may even die due to overproduction. This is also related to the cyclic nature of coffee prices which are low in most years. Sometimes, weeds are used as moderators in price cycles of commodities and between non-marketed, present and future yields of consumables. Yield forgone due to the presence of the "weeds" represents yield conserved for the future (see chap.6). Weeds hence are used as carriers of potential future yield, provided they are not "weeded" from the site.

Our data demonstrate that farmers decide to harvest only those plants that have initiated flowers (*daggicho or idago*). These represent plants of the *past,* i.e., those having completed their potential of expansion and hence progressing to senescence and death (Oldeman, 1974, 1983, 1990). Plants of the *present*, representing those expanded to maximum vegetative size before flower initiation (*beyaa* and *saxaa* stages) are rarely harvested, as these have not yet culminated to full potential biomass. Plants below these stages (*guume* and *kaassa*) are not even fit for fermentation except for the corm, which is boiled, as a vegetable in time of dearth.

8. 5. Conclusion and recommendation

Data from the case studies support the conclusion forwarded by Tsegaye & Struijk (2001) that *ensete,* even at the present unimproved state, yields more "useful" biomass than any other crop plant currently promoted in Ethiopia. Adding to this, the role *ensete* plays in the maintenance of the production base (ch.5, 7) makes it more than a mere crop. The latter aspect of *ensete,* deriving from its architecture which helps it to buffer against destabilizing factors as well as to accompany other crops hitherto neglected in research, provides the key for sustainability of *ensete* land use over millennia. *Ensete* therefore represents a potential solution to the recurring food crises in most parts of the erosion- and drought-prone Ethiopian highlands. Now the yielding potential of *ensete* is proven beyond the shadow of a doubt, only cultural barriers remain to its development. This indeed is a challenge to agricultural professionals and also to the international community that want to assist Ethiopia in its efforts towards food security.

Chapter. 9. General Discussion, Conclusions and Recommendations

The discussions in each of the preceding chapters have touched on the major points. However, there is a need to integrate these points. In particular, points connected with the origin and development of Gedeo land use and whether these fulfil the criteria of sustainable land use or not are essential. Moreover, the question will be raised where, in this complex agricultural land use, past development events fit and where is the place for future ones.

9.1. On the origin and development of Gedeo land use

The material presented in the preceding pages can be used to trace the origin and development history of Gedeo "agroforests". Absence of other *ensete*-based land use systems with comparable complexity makes this an optimal material for study in order to condense our knowledge concerning the design and functioning of these systems.

Agro-ecosystem design consists of putting together resources, living ones such as plants and animals and non-living ones, e.g., incoming energy from the sun, incoming rainwater, soil, atmospheric air, for a purpose, using available technology and following a certain attitude to nature (Oldeman, 1983, 1990; Kippie, 1994; Neugebauer & al., 1996; Pinto-Correia, 1996; Faust, 1996; Van der Wal, 1999). Where and how did such designs originate? This question usually receives a very simple answer, taught at primary school and university alike. First there were hunter-gatherers, then shifting farmers then permanent farmers and finally city dwellers. The core of the acceptance of this sequence is the misunderstanding that farming is just planting food plants instead of gathering them from the wild, and that the way of planting is accessory. In other words, the vast majority of contemporary humans ignore the above definition of agro-ecosystem design. This is due tot the perspective of modern industrial and information society, in which the agricultural world lies far away in time, as proven by the popular vision of the famous author Alvin Toffler (1991). His three "waves" of civilization, the first of which is agricultural, the second industrial, the third information-based, are more precisely analyzed and understood in the present than in the "far" agricultural past. The present study, on the contrary, was made in the heart of the live society of that first "wave", living and thinking in terms of agricultural civilization.

The development of land use over millennia then cannot be grasped by using such generalizations. It is rather visualized here as a long time process (Leaky & Lewin, 1979). It is also viewed as a social process in which societies, in the face of increasing resource constraints, find a way out, following observed patterns and processes in the natural world surrounding them. The following reconstruction of the developmental steps in agro-ecosystem history over millennia rests on such scarce literature as could be found, on logical reasoning based on general knowledge of ecological and social constraints, on solid local empirical farmers' knowledge and only if inevitable on plausible assumptions.

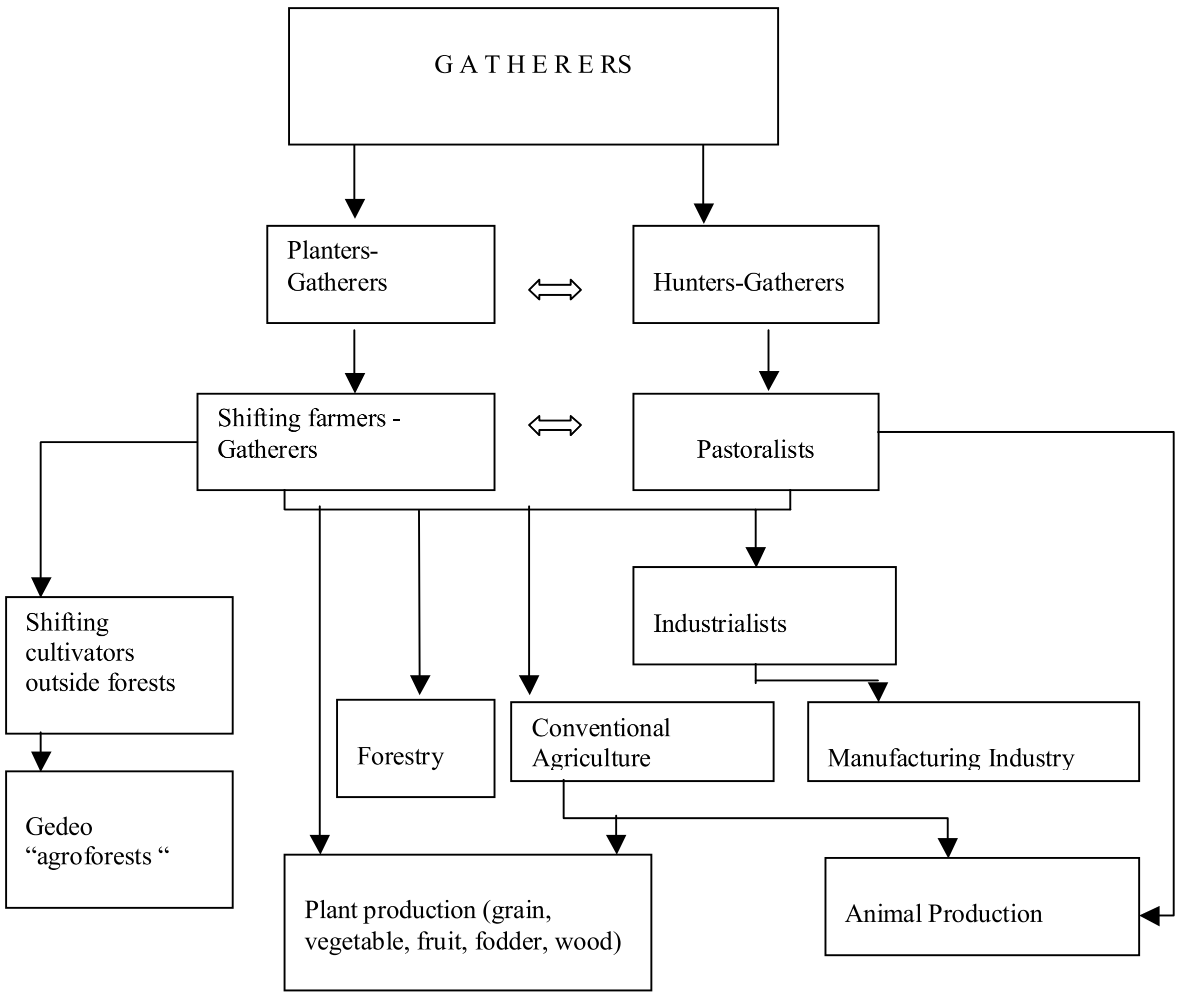


Fig.9.1. The evolutionary sequences in human land use. Note how the Gedeo have taken a different course, diverging from shifting cultivators, in response to the disappearance of forests. Empirical experimentation with controlled fallowing, i.e., resting part of the agricultural land, must have lead to the discovery of important principles such as used by the Gedeo in soil maintenance through a permanent vegetation cover. Gedeo land use hence is no direct ancestor of specialized land use; both have shifting cultivation as a common ancestor.

The emerging historical hypothesis of the development of Gedeo land use therefore rests on an ample supply of solid elements of proof.

The first land use must have been gathering (fig. 9.1) such as picking carrion or fallen or dead plant parts, dead wood becoming most important after the discovery of fire (Leaky

& al, 1989). Then hunting must have started, while the activity of gathering continuing until coming to the stage of *hunters-gatherers*. While combined with gathering, the latter stage might have marked cultivating plants, until such people became *planters-gatherers. Ensete*, which until now must have been restricted to the homestead as a minor root crop, might have come to the stage (Brandt, 1996) at this time. This must have boosted food production and with it the size of human population. Increased human consumption of meat therefore reduced the population of game animals, making this activity more costly. Therefore, domesticating some of those scarce animals became more efficient. In the meantime, planting crops and picking dead wood for fuel must have continued with normal farmers-gatherers. Obviously, some groups must have specialized in herding animals, becoming *pastoralists-gatherers*. Increased carrying capacity of the land must have prompted increased settlement and corresponding social developments. Decline of forests and in some instances their disappearance must have led to caring, through religious sanctions and taboos (ch. 1, ch. 7), for the remnant forest vegetation as a source of wood and food as well. Increasing differentiation in the land use (see fig. 9.1) must have finally led to the emergence of towns and cities with manufacturing industries and trade besides the agrarian societies.

Differentiation in the agrarian societies must have continued. Increasing scarcity of wood and other forest products must have led to the cultivation of trees (fig 9.1), giving rise to forestry, e.g., European coppice forests (Oldeman, 1990; Ciancio, 1997). In parallel to this, developments in cropping and herding animals must have given rise to forms of conventional agriculture such as the dominant western ones today. However, the originally more comprehensive and complex land use must have also continued, resulting in mixed systems such as Gedeo "agroforests" (fig. 9.1). It must be noted from hindsight that true agroforestry is represented by this integrative land use. But how did the Gedeo come to their present self-regenerating systems?

The answer to this question requires reconstruction. The original land use leading to the present mixed *ensete*-based Gedeo land use must be reconstructed, as was done for the *Mayan land use (chinampa system)* by Gomez-Pompa (1991).

The focal point here is scarcity of land occupied by an ever-expanding population. For such a population, growing communal forests would not have been a viable option. The only alternative would seem to be integration of trees with crops. However, tree cultivation alongside agricultural crops cannot have been a straightforward step either, given the different requirements of the food crops and the trees themselves. Therefore, there must be a transitional stage where these two components could accommodate each other. A system of shifting cultivation in the vicinity of limited forestland must have represented a suitable transitional condition. Shifting cultivation is defined as a general form of land use whereby fields for cropping are prepared by clearing tracts of forest, usually by slashing or burning, followed by one or more seasons of cropping before it is abandoned (Van der Wal, 1999, p12). In the case of the Gedeo, however, the field can not be abandoned. It is rather "rested", i.e., left to the growth of the herbaceous vegetation, so that it can be rehabilitated (Sanchez, 1976; Louman, 1986; Ramakrishnan, 1992). In other words, it must have also served as an empirical experimental plot for the farmers (Gomez-Pompa, 1991).

This can be called “controlled shifting cultivation”. Control is exerted in essence by the farmer relying on his ingenuity and skill to earn a livelihood from his plot, as he has no-where else to go, unlike a shifting cultivator who operates in a forest frontier (Amanor, 1994; Van der Wal, 1999). Therefore, there is a need for inward reflection in this settled agriculture rather than an outward one prevalent in the preceding eras where the strategy of foraging and “opening up new lands” was pursued. This process over an elongated period of time must have led to the discovery of ways of permanent use of a plot of land, without resorting to fallowing.

“Controlled shifting cultivation” itself must have passed through several stages. At first, annual grains or root crops must have been accompanying *ensete*, mainly because of the larger per capita land holding that must have prevailed and as an inherited tradition from earlier times. But as both human and animal populations increased, this strategy must have become untenable. The response of farmers at first might have been an increasing use of animal wastes, including human excreta and household refuse, a strategy still used by the Gedeo in the relatively less densely populated highland and lowland areas (chs. 4 and 7). However, with an ever- increasing population, this strategy too must have reached a dead end. In the face of this challenge, farmers must have realized the rehabilitative capabilities of certain vegetation components. *Ensete* itself must have been the first candidate (ch. 5) followed by multi-purpose trees and shrubs as well as the “weedy” herbaceous vegetation (Kippie, 1994). This must have certainly amounted to “killing two birds with one stone”, as the farmers say worldwide, because the trees and shrubs while helping to maintain soil fertility also provide wood and fodder. The Gedeo are highly dependent on wood, mainly for cooking *ensete* food which requires high amounts of energy (ch. 8) and also for heating the house in the cold highlands. The fact that most of the trees selected by farmers are leguminous and better than or equivalent to those recommended by modern scientific research (Huxley, 1983) shows how close farmers' empirical observation approaches scientific reality.

Integration of trees, shrubs and food crops must have therefore altered the whole sequence of evolution of *ensete*-based Gedeo land use. Instead of fallowing part of the cropland, or relying on animal manure, land is put under permanent plantation, which goes through a system of multiple rotations (cf. ch. 5 and Oldeman, 1992b; Neugebauer & al., 1996). Sustained yield is obtained following this calendar, because it integrates rotations ranging from a year for annual crops, 10 years for *ensete*, 30 years for coffee and over a hundred years for *Podocarpus gracilior* (ch. 5). Continuous harvest is ensured because of the available mature components or their consumable parts at any given moment (ch. 6, ch. 8).

Ensete-based Gedeo systems therefore are more than forestry, agriculture or agroforestry systems (Huxley, 1983). They are more than forestry systems because they do not only deal with wood production, as conventional forestry does. They are more than conventional agriculture, because unlike the latter they combine annual crops, animals and woody perennials as well as providing living space for a gamut of highly diverse forms of life. They are more than conventional agroforestry systems, because though the latter combine food and wood production, these neglect the provision of living space (ch. 4, ch. 6) for other life forms. It should be noted here that the holistic design concerns the whole ecosystem and so cannot but use crops in their *pacemaker* role (regulation of agro-ecosystem rhythm), to wit *ensete* (ch. 5) *spacemaker* role (provision of biotope space for other organisms) e.g., multi-purpose tree species used for hanging beehives (plate 6.7), and/or *placemaker* role (provision of living space or niches for other organisms), e.g., multi-purpose trees (fig. 6.6, appendix 4.1b and appendix 4.1c). Farmers therefore could not discriminate between crop plants and others, e.g., weeds and/or pests, but manage them, so their agro-ecosystem design also accommodates these. There are niches for the wild fauna and flora. This is management of complexity, i.e, biotopes are arranged in such a way that unfavorable effects are minimized or nullified by favorable ones. Thus, *ensete*-based Gedeo "agroforests" can be regarded as an indirect progenitors of the modern day agriculture and forestry, the latter being as overspecialized off-shoots (fig. 9.1).

As to the dynamics of Gedeo "agroforests", we find processes that operate in a similar way as in forests (ch. 5). Forests regenerate by patches which Oldeman called *eco-units* or regeneration units (see Oldeman, 1983; 1990; Van der Wal, 1999). As explained (ch. 5), an equivalent term used for a one-plant space by the Gedeo is *hofa* (Kippie, 1994; plate 6.5). The implication for *hofa* is *wobbisa* or replacement with ready-made seedlings. This is similar to the situation of a one-tree opening in forests (Oldeman, 1990) which is overtaken either by the expanding trees surrounding the gap or from below by newly emerging seedlings and saplings. The farmers' objective here is to minimize impact, be it from natural processes or from human activity, on the soil and/or on the components. Moreover, in Gedeo "agroforests", smaller units of regeneration are also related to labor requirements, not only for planting but also for the harvest and storage of biomass in these multi-component systems (ch. 6, ch. 8). As a result, optimization of the temporal and spatial distribution of these units within the farm takes the most part of the farmers' time (ch. 6).

It is important to compare and contrast Gedeo land use with other *ensete*-based systems. Except for the Gedeo, *ensete* is grown in monocrops in all other described systems in Ethiopia (see Bezuneh, 1996; Rhamato, 1996; Asnaketch, 1997; Taboje, 1997; Tsegaye & Struijk, 2001) and in the homestead. Only the Gedeo do not practice the serial transplanting of *ensete* (ch. 6). Only among the Gedeo *ensete* is grown as a field crop, in mixed and uneven-aged plantations (ch. 5). Only among the Gedeo *ensete* and other biomass is stored in the live crop (ch. 5, ch. 6 and ch. 8). Unlike other *ensete* cultures, the Gedeo do not practice pit fermentation and pit storage of *ensete* food (ch.6). Only among the Gedeo, *ensete* is grown in combination with multi-purpose trees. Only among the Gedeo "weeds" and "pests" are integrated as indispensable components into the agro-ecosystem (ch. 4, ch. 5, ch. 6 and ch. 7). In most respects, *ensete*-based Gedeo land use diverges from other *ensete* cultures. Therefore, Gedeo land use is not only the indirect progenitor of conventional forestry, agriculture or agroforestry but also of all other present-day *ensete*-based land use systems (fig. 9.1).

9.2. On *ensete* domestication

This is another area where literature is extremely meager. What we know is based on accounts of travelers (Pankhurst, 1996). In the history of *ensete* is hidden the missing link between *ensete* agriculture and Ethiopian history in general and between *ensete* agriculture and the diverse peoples of the Southern Nations, Nationalities and Peoples' Regional state in, all in one way or another dependent on *ensete* (ch. 1; Purseglove, 1972 ex Westphal, 1974). It is expected that further research (anthropological and archaeological) would reveal this link.

However, from the oral history of the Gedeo tracing the their ancestors to the aboriginal tribe *Gosallo* and from their love for trees and life in general there is ground to assume these are representative of the earliest people who have first started settled agriculture. Most ways of the Gedeo, e.g., love for trees, for sheep and an intricate *ensete* culture, relate them to ancient Egypt. *Ensete* culture as practiced by the Gedeo represents one of the possible influences of ancient Egyptians, extending up to the Rift valley. The closer and longer contact between ancient Egypt and Ethiopia (see Murray, 1964), heightens this theory.

Areas in Ethiopia surrounding the Rift Valley harbor great mysteries. This for instance is the place where the earliest (3.1 million years old) hominid, Lucy (*Australopithecus afarensis*) yet known, was discovered (Fortey, 1998, p297 & ff.). Moreover, there have been contacts between the ancient Egyptians and Ethiopians as established by Egyptologists, e.g., Murray (1964). It is mentioned that the Pharaonic Egypt was once under the occupation of the Ethiopians (ibid., pp.49, 68). Setekh, God of ancient Egypt was the God of the aboriginal people from the south that conquered Egypt. These contacts could not have passed without leaving traces in the lives of both societies, one of which could be *ensete* agriculture. Furthermore, megaliths claimed to predate the Egyptian pyramids are also being excavated in the Gedeo zone, at sites where the present study was conducted.

Westphal (1974, p78), citing Vavilov (1951) notes Ethiopia as the primary gene center for *ensete* along with coffee (*Coffea arabica* L. RUBIACEAE), and *teff* (*Eragrostis teff* L. GRAMINEAE). It is known that *ensete* exists in the wild in several parts of the world (Simmonds, 1958 ex Westphal; Rossel, 1998). However, no convincing evidence has so far emerged as to the cultivation of *ensete* outside Ethiopia (Bezuneh & Feleke, 1967; Bezuneh, 1984; Sam-Aggrey & Tuku, 1987; Abate & al., 1996). Ethiopia and the people today practicing *ensete* agriculture would be legitimate sources of information. *Ensete* agriculture is the complex management of natural resources including *ensete* processing and fermenting. A more correct name for it, as some authors (Shack, 1963 ex Westphal, 1974; Smeds, 1955) have suggested, would be *ensete* civilization. Its complexity obviously represents one obstacle, making easy adoption by non-*ensete* groups very difficult.

The first people to domesticate *ensete* are not known with certainty (Stiehler, 1948, Simoons, 1965 and Stanley,1966, all ex Westphal,1974). However, there is consensus among authors that these people must be sought in one of the two groups, (1) the Cushitic speaking Sidamo peoples (including the Gedeo along with the Sidama, Kmabata and Hadiya) and (2) the people of the Bako highlands (Gamo Gofa) and the people of Gimira, Maji or Keffa (Westphal, 1974). Simoons (1965 ex Westphal, 1974) considered the first group as candidates rejecting the earlier view forwarded by Stiehler (1948 ex Westphal (1974) that Negritic or pygmean populations were the first to cultivate *ensete*. Westphal (1974), supporting the idea presented by Simoons, also notes that neither the present Negroes of south Ethiopia, nor those of the northern part cultivate *ensete*. Stanley (1965 ex Westphal (1974)) on the other hand traces *ensete* cultivation to the second group, noting that these are people from Neolithic times and even earlier. He therefore rejects the hypothesis of Cushitic *ensete* domestication. Stanley (*ibid*.) mentions that Cushitic traditions do not satisfactorily explain the use of the *ensete* plant.

From the foregoing, we understand that *ensete* agriculture would be at least ten thousand years old, dating back to the Neolithic emergence from the last glaciation (see also Brandt, 1996). However, discussion on the initiators of *ensete* agriculture needs revision in the light of available evidence. Earlier literature on *ensete* represents a precursory view of travelers and therefore most of it is shallow (Pankhurst, 1996). If anything of value is to emerge regarding the origin of *ensete* agriculture, a detailed study of *ensete* cultures is needed. Moreover, a passing note is also in order regarding the connection between Gedeo traditions and *ensete* cultivation. *Ensete* being their livelihood, the Gedeo have no aspect of life, from cradle to deathbed that is not connected with *ensete*. The Gedeo receive the newborn on dried *ensete* leaves (*hashupha*). The placenta is also received in an *ensete* leaf sheath (*hachcho*) within the house. The birth of the new baby is announced by placing an *ensete* leaf (*cichcha*) on the door. During the first three to five months, the excreta of the infant are collected on *ensete* leaf sheath and fibers (*haanxxa*) until the time of initiation of the infant. The excreta is mulched underneath three *ensete* plants (*bululo*) that are planted to mark the initiation (*cichcha fula*). During marriage, the couples spend their first night in a bedding of *ensete* leaves. When constructing a house, the Gedeo plant *ensete* at the place of the future pillar (*utupha*). A dying person is placed on a bedding of *ensete* leaves and midribs. Thus, all aspects of Gedeo life are connected with *ensete*. Similar traditions are reported among other *ensete* peoples (for the Sidama and Guraghe (see Asnaketch, 1997; for the Sheka, see Almaz (2001).

This overlapping of cultural traditions (Westphal, 1974) makes the latter of little value as a criterion for tracing the origin of *ensete* agriculture. This is not, however, surprising as *ensete* is "everything" (food, feed, fiber, medicine, etc.) to the *ensete* peoples and all *ensete* peoples may therefore be expected to have similar cultural traditions.

Thus, design and functioning of *ensete* farms provide the alternative to trace domestication of *ensete*. There are in general two major aspects to examine. One aspect is the place of *ensete* plantations in relation to the homestead (fig. 4.2, fig.9.1). Today, most peoples grow *ensete* in the homestead. These include, the Guraghe (Pijls & al., 1995; Bezuneh, 1996; Asnaketch, 1997); the Sidamo (Yeshi, 1991; Asnaketch, 1997; Keffa

(Almaz, 2001); the Wolaita and the Gamo (Rhamato, 1996). This was always the way for *ensete* cultivation, as depicted in the literature (see Westphal, 1974; Pankhurst, 1996), a century back from now. This strategy may be related to the prevalence of pests or to cultural aspects like the need for manuring. But, it cannot explain for the popular *ensete* cultivation in Ethiopia. The Gedeo are the only people growing *ensete* outside the homestead, in the field (see ch. 4, 5 and 9.1). It was argued above that the Gedeo adopted this strategy because of land shortage. Though the latter indeed is a crucial problem among the Gedeo (ch. 6), it cannot be taken to be the sole explanation. Gedeo farmers settled in forests (Hageremariam area) had no land problem but were observed to follow field planting of *ensete*, just as their brothers in the Gedeo zone. Therefore, it is argued that *ensete* plantation in the homestead represents not the main stream of *ensete* cultivation, but only an insurance in case of failure of other crops, which in most cases are cereals. *Ensete* in these areas has a marginal status, perhaps due to pressure from the seed culture (ch. 1). Insurance planting is also a strategy adopted by peoples starting *ensete* cultivation anew, e.g., some Oromo tribes in southwestern Ethiopia (Brandt, 1996). Growing *ensete* in the field as practiced by the Gedeo shows the dominant, not accessory position of the *ensete* plant in their lives. To the Gedeo, *ensete* is more than a crop.

The second aspect of *ensete* agriculture to be considered is related to intercropping of *ensete* with other crops. *Ensete* monocrops practiced by most *ensete* peoples can be considered as a recent development of simplification in *ensete* agriculture, as opposed to the earlier, complex mixed cropping systems as practiced by the Gedeo. This could also be ascribed to environmental conditions but here again, the explanation does not cover all *ensete* peoples. As stated above, Gedeo "agroforests" are not only composed of annual crops but also contain woody perennials and "weedy" herbaceous vegetation. Added to the aboriginal *Gosallo* origin of the Gedeo (ch. 4), the latter most probably were the first people to cultivate *ensete*.

No people in present day Ethiopia cultivate trees as the Gedeo do (Westphal, 1974; Kippie, 1994). This relates them to ancient Egyptians, who believed that the first object to meet their eyes on entering the world of the dead was a beautiful and shady tree from which a godess welcomes them with food and water, the food being the fruit of the tree (Murray, 1964, p83). *Ensete* cultivation in a species-mixed and uneven-aged plantations makes the Gedeo the only candidates for *ensete* domestication.

9.3. Gedeo "agroforests" and sustainability

Sustainable agriculture is defined as one that is ecologically sound, economically viable and socially just and humane (UNCED, 1993; Kada, 1994). Though the focus in the present study has been on the first criterion, some aspects of the latter two criteria still have received a passing remark. It could not have been otherwise, given the integration of the three aspects in Gedeo land use. Thus, the mutual reinforcement of the three aspects is discussed below.

The ecological soundness of the Gedeo "agroforets" is proven (chs. 4, 6 and 7 and this ch., Section 9.2). Gedeo "agroforests" are resource-conserving, self-reliant and productive, their design integrating these aspects in that order. Therefore, other things (e.g., biophysical and social basis) remaining unchanged, sustainability of these "agroforests" is ensured, as supported by all available data. However, this should not be understood as implying undue glorification of traditional ways of farming. Comparisons and contrasts with the available modern technologies have been made and the "agroforests" came out as the best option in the farmers' context. Moreover, results of past development interventions, all of them based on conventional agricultural technologies (ch. 6) have shown that farmers' ways are more sustainable by far.

Though economical viability of Gedeo "agroforests" has not been assessed using numerical and economic models, comparison of available data (chs. 6 and 8) with literature leaves little doubt that these are also economically viable. This is supported for example by the economics of traditional land use systems in general (e.g., Ellis, 1988; Demme & Overman, 2001; Gatzweiler, 2001; ch. 6). The balance between resources spent and recuperated is clearly discernible in Gedeo "agroforests" (ch. 8). Farmers operating at their own responsibility or risk follow accounting procedures that ensure that harvested yield is not jeopardizing future yield (ch. 6). A farm in this context is not only a means of production in the conventional economic sense (Ellis, 1988; Gatzweiler, 2001) but also a tool, determining the livelihood of the farm household. For such farmers, conventional neoclassical economic accounting focussing on demand and supply will have little relevance (Gatzweiler, 2001).

Gedeo "agroforests" are also socially just and humane (ch. 6). Gedeo tradition ensures that every household has its own land, no matter the size of the land (ch. 6). *Rubbana*, i.e., the principle that gives usufruct right to somebody else's land (ch. 6) aims to minimize appropriation of land in few hands. Therefore, every household is its own master. Members have the opportunity to exercise their potential. Moreover, human values expressed in loving one another and love of nature is expressed in their day to day activities (see ch. 6 and 7). Those who have are prompted to give away and this, for instance, are expressed in *oki'a* (sharing fodder) or in *shefille* i.e., sharing farm produce, such as coffee or wood or *ensete* food (ch. 5). Moreover, there is always readiness to receive guests, who in Gedeo tradition cannot depart without eating and drinking. There is free exchange of planting material, for instance young farmers entering farming are provided with planting materials as well as land with mature *ensete* and/or trees.

Gedeo land use provides opportunities for participation for both men and women, young and old, adult and children, rich and poor. The notion of unemployment makes no sense in Gedeo society, there being no real equivalent to monetary wages.

The elderly, who are highly respected assume the role of teaching from their experience. In the afternoons, it is normal to find several elderly men surrounded by the young who relax from the day's work, engaging in oration in the *songgo*, a meeting place for the village. Mediation is also the responsibility of the elderly. Elderly women assist in taking care of small children.

Children assist their parents, young boys assist their fathers and daughters their mothers. There is often overlapping in the duties of the children.

Women manage the household. Perhaps, the Greek word, "*eco*", implying the wisdom and authority to manage the house in the best interests of the household, obtains application among the Gedeo women. One should remember that the English term *manager* originates from the French "*ménagère*", meaning housewife. *Ensete* harvesting and processing it into food is a complex process that is as artful as cheese- or wine-making. Therefore, there is unlimited potential for the women to exercise their creativity. No two *ensete* dishes from different women working on identical materials are identical, as a result of which successful women in Gedeo society are accorded admiration and prestige. This is perceived to be in harmony with women's reproductive functions.

Assistance among farm households is common. Wives are assisted by their husbands, for instance, in *ensete* harvesting while wives in turn assist their husbands in transporting *ensete* suckers or household resfuse to the field). All products fall under the jurisdiction of a wife as soon as harvested and stored in the house.

The relationship between *ensete* agriculture and the duties of women among the Gedeo needs clarification so as to avoid misunderstanding. It is true that the present condition of women needs improvement. However, the ancestral Gedeo philosophy in assigning *ensete* to women is to compensate women who are prohibited from inheriting tribal land (ch. 6). Similar situations are reported among other *ensete* peoples (e.g., the Sidamo (Asnaketch, 1997). Recently, Almaz (2001) found the same to be true among the *Sheka* people of southwestern Ethiopia. This can also be seen as gender division of power in the society, economic power vested in women while men deal with defending the household (politics), a development that can be traced back to the hunting-gathering era (section 9.1, this chapter and Leaky & Lewin, 1979).

Since men are totally excluded from the knowledge of harvesting and processing *ensete*, they are at the mercy of their wives. Unfortunately, without understanding the culture, some outsiders tend to jump to the conclusion that since *ensete* agriculture is oppressive to women, its promotion should be considered in the light of women's right. It can be argued that development of *ensete* agriculture rather favors women's position among *ensete* peoples. To the contrary, disregard for *ensete* agriculture has drastically weakened the position of Gedeo women. Therefore, gender division of labor in *ensete* agriculture should be seen in the context of the larger socio-economic environment. For instance, among the Gedeo who controls *ensete* controls society. Thus, *ensete* development is also the key to women's development (Almaz, 2001).

9.4. Gedeo "agroforests" and development interventions

The agro-ecosystems in the three agro-ecological zones provide clues as to the potential existing for farmers' innovative practices. Excluded from the main stream of agriculture (see ch. 1), the Gedeo exclusively relying on local resources and local capacity have followed an endogenous developmental approach (Remmers, 1998). Whereas this approach has widened the gap between the Gedeo and the larger society on the main, sometimes inviting misunderstanding and mistrust in the others and themselves (ch. 1), it has also helped them to survive difficult times in their history. The main purpose of this approach however lies in fostering development of farmers' potential. Gedeo "agroforests" can be viewed, as a positive result of such development and farmers' resistance to outside pressures (ch. 1) should be understood in this context. The sad story of traditional land use in Andalucia (Spain), opposed to the industrial agriculture of the European Union, as told by Remmers (1998) may be conceived as a European parallel.

Local biophysical environment dictates the type of the general farm design. Therefore, farmers within a given locality follow a similar farming design (ch. 4). A general farm design consists of sets of culturally shared notions as to how farm components (plants, animals) should be organized and farming activities should be carried out, as exemplified by the farming calendar (ch. 4). However, differences arise when each farm household tries to implement this general design by precise farm practices. Indeed, each farm household is different from the other, local site conditions, material resource endowments, as well as in creativity, i.e., capacity to perceive the relevance of certain aspects with regard to the general design (Remmers, 1998). This is an asset for the land use system as it provides evolutionary dynamics to the farm design in that particular zone. This is so because successes or failures among farmers provide opportunities for learning. By means of social networks and meetings, the resulting information is exchanged. This leads to either adoption or rejection of ideas generated by farmers.

Farmers hence are not simply producers, they also engage in pursuit of knowledge. Disregard for this point in the past has led to failure of many development interventions. This also shows the need to conserve traditional ways of farming as a tool to conserve farmers' empirical knowledge about the functioning of the natural world surrounding them. Since different cultures have different visions of the environment surrounding them (Nguyen Thi Ngoc An, 1997), conservation of indigenous cultures is essential for the well-being of humanity (Gomez-Pompa, 1991).

This also shows a need to reconsider development interventions aimed at replacing "subsistence agriculture". In the past, subsistence agriculture was widely condemned as wasteful of resources and unfit for areas with large human populations. While there is a need to increase productivity so as to feed the population, the all-out war on subsistence agriculture should cease. Subsistence agriculture morally is more appropriate than any other system in fragile environments such as most parts of Ethiopian highlands, where water erosion poses severe threats to the whole ecological base of agriculture (Amare, 1984; Wolde-Aregay & Holdinge, 1996). Though most of these areas have already lost most of their productive capacity (Amare, 1984; Wolde-Aregay & Holdinge, 1996), there is still a chance to rehabilitate these lands using *ensete* with its water-stocking and soil enriching capabilities. There is also a need to check whether the tools used by subsistence farmers, be they antique, are more appropriate than industrial ones in the context in which they are being used (ch. 6). Inconsiderate comparison of subsistence agriculture with highly subsidized western style farming is risky, as this has been the main cause for the neglect of subsistence agriculture in Ethiopia so underming the country's food security. For backward economies like Ethiopia, of which agriculture forms the main livelihood for the majority of the population (ch. 1), the viable path of agricultural development lies in supporting subsistence farmers.

If the latter are sufficiently assisted, so that they can use indigenous knowledge and other local resources, most of them would be able to feed themselves. This can reduce Ethiopian food import to less than 20 % of the present quantity. Food import can so be limited to the needs of the population engaged in the non-agricultural sector of the economy. That is less than 10% (CSA, 1999) excluding the nomadic population. Provided that such an approach is sufficiently implemented, food deficits could only be expected in exceptional conditions, such as prolonged droughts. The scenario of supporting subsistence farming could even be more sustainable by the use of environmentally friendly crops like *ensete* and by using modern composting technologies, like the ones in operation in the Southern Nations, Nationalities and Peoples Region, Gurage Zone (Bierwirth, 2000).

Available data (Kippie, 1994; Pijls & al., 1995; Central Statistical Authority, 1996; Abate & al., 1996 and Asnaketch, 1997) show that *ensete* agriculture can be viable in almost in all parts of the Ethiopian highlands. Therefore, there is a great opportunity to expand *ensete* agriculture and, with it, environmental rehabilitation. In this context, trying to replace *ensete*-based systems with production of crops such as annual grains in the Gedeo Zone highlands must be seen not only inappropriate but also deleterious for the welfare of the people of whom the whole way of life depends on *ensete*.

In the Gedeo case, replacement of *ensete* by cereal crops is regression to a remote past, some 5000 years back. Indeed, these systems have long passed that stage (see 9.1 and 9.2, this chapter). A view that *ensete*-based systems are primitive systems with primitive technology cannot be maintained facing the facts, as it plays down the intrinsic dynamic nature of social and biological systems as well as the higher carrying capacity of *ensete* (ch. 8); which is more than 5 times of that of monocultures in Ethiopia. Also, *ensete* is not only a source of useful products of immediate value, but also of incalculable environmental and social values (see Gatzweiler, 2001). This capability for self-regeneration inherent in *ensete*-based systems, if destroyed by transforming them into annual monocrops, needs to be reconstructed by resources from the outside. This is not feasible for poor farmers in a poor country.

Instead, there are niches in Gedeo "agroforests" that can be enriched. There are two ways of doing this, without undermining the integrity of the whole-ecosystem design of the "agroforests", as mentioned in ch. 6. The first is efficient utilization of the canopy space. This can be done either by introducing more multi-purpose tree species such as *Morinaga* sp. the leaves of which can be used as vegetable in many parts of southwestern Ethiopia or intensifying the use of climbing vines such as *Phaseolus lunatus* L. The other way of intensifying useful production is through a judicious use of the root floor. Here, shade-tolerating crops such as *colocasia esculenta* or cultivation of the diverse mushrooms, and/or micro-organisms such as bacteria or yeast can be emphasized.

9.5. Harnessing cyclic change of agro-ecosystems

Endurance of agro-ecosystems through cyclic change is enhanced in two ways, i.e., by optimizing the spatial and temporal arrangement of their components and by selecting components that provide both sustenance and maintenance. Crops that provide both useful products and at the same time enhance the maintenance of the production base are a good example of the latter. Crop plants like *ensete* playing key roles fit in this context (ch. 5 and ch. 8). These are used as basic working materials in the design of agro-ecosystems (ch. 4 and ch. 5). Their selection is carried out in ways similar to selecting materials for building a house. As there are corners in a house where only the strongest of materials are placed, there are also places in the agro-ecosystem for these key components. As the quality of the materials used for the building to a large extent determines the longevity of the building, components with *pacemaker*, *spacemaker* and/or *placemaker* roles (Neugebauer & al., 1996) placed in the appropriate points in the agro-ecosystem help to keep up its capacity to buffer destabilizing forces.

The concept of eco-units, i.e., small ecosystems within the larger agro-ecosystem (Oldeman, 1990) is also important in the identification of corners (mini-sites) within agro-ecosystems to put these core components. The arrangement of these eco-units in the agricultural field is important, as it determines how the agro-ecosystems undergo cyclic changes. If the agro-ecosystem is an annual crop field or an even-aged plantation monocrop, the whole field becomes on eco-unit that rotates every cropping season (Oldeman, 1983). In this arrangement, a planted field remains intact until the time of harvest, after which the whole plot is exposed to external forces such as rains or scorching heat of the sun or livestock grazing (ch. 5). The situation for mixed uneven-aged crop plantations is, however, quite different. Here, too, there is of course rotation but of a different kind, i.e., a system of multiple rotations (see ch. 5, ch. 6).

Here, the canopy remains closed, except for only smaller eco-units such as those made by harvesting and replacement of one mature tree or another perennial crop (see ch. 5). This farm-level picture can also be extended to zonal or landscape level (Rossignol & al. 1998), where landscape can be visualized as a mosaic of different eco-units, ranging in size from one plant to one-fourth of a hectare. It can be proven (ch. 6) that this scheme renders a higher buffering capacity for the agro-ecosystem (ch. 5). While the higher complexity of the agro-ecosystem favors higher diversity of life-forms (ch. 4), it hinders the build-up of the populations of pests or disease-causing organisms. This is explained by the healthy functioning of the agro-ecosystems, as these have a higher capacity to resist perturbing factors, be it proliferation of disease and/or pest organisms (ch. 6), or rainwater erosion or prolonged drought (ch.5).

Based on the understanding of agro-ecosystem design (ch. 4) and agro-ecosystem management (chs. 5, 6, 7 and 8), interventions that fit the complexity inherent in *ensete*-

based systems can be designed. Past attempts to replace these complex systems with simpler ones, e.g., coffee or grain monocrops were beset with the problem of valuation (Gatzweiler, 2001). Although the "agroforests" provided more useful products than any of the proposed systems (ch. 8), outsiders applying a neoclassical economic valuation system could not "see" the full value, as shown by Gatzweiler (2001) for the *Dayak* (Indonesia). A standing *ensete* plant, for instance, besides providing food and fodder, has several functions. The reader is reminded of soil protection by fibrous roots and the water harvesting and conservation by its leaves and also harboring diverse life-forms (ch. 4). Most specialists cannot see beyond the food and fodder value. This conflicts with the farmers' valuation system. "More food per hectare", "more cash income per hectare", etc., confuses farmers, who soon find that those proposed benefits are to be obtained not in addition to but in exchange of their other agro-ecosystem values (chs. 5 and 8).

Thus, projects like the Coffee Improvement Project could have really played a much more beneficial role in the development of Gedeo zone, if they were only designed with a broader perspective, i.e., integrating instead of isolating *ensete* and coffee, for instance, supplying farmers with the planting materials for both coffee and *ensete* at a cost farmers could afford. As explained earlier (ch. 4), annual grains and vegetables for the Gedeo are subsidiary or complementary crops, mainly grown in the highland and lowland zones. Therefore, development models that focus on these components breaches this principle. It does not only expose land to erosion (ch. 1), but also works against the economical and cultural risk aversion strategy of the farmers (chs. 6 and 8). Farmers want not only yield increases but they are also concerned with the future capacity of their agro-ecosystem. A farmer's strategy is not "gluttony today and starving to death tomorrow", as one farmer has expressed how outsiders wrongly judge farmers' intention.

9.6. Conclusions and Recommendations

9.6.1.Conclusions

(1) Gedeo "agroforests" contain an organized mix of mosaics of crops (starting from annual herbs through medium-aged *ensete* (10 years) and coffee (30 years) to long living multi-purpose trees (over a century old). This disposition allows farmers to derive maximum benefits on a sustainable basis, as different components at different phases of development provide continuous harvests. Also, most of the useful biomass is stored in the living components. High biomass production is ensured because of the capacity of the land use system for self-maintenance. Perturbing forces are thus well buffered too. This also explains the high carrying capacity of these systems (500 persons per km^2, CSA, 1996) in an undulating and rugged terrain.

(2) Like in shifting cultivation systems, the functioning of the *ensete*-based Gedeo "agroforests" depends on the performance of their floral and faunal components, but without either any frontier or buffer zone. This is possible because the functions of production and protection are fully integrated. By

optimizing the balance between the production and protection components, the Gedeo do not only secure their food supply but also the endurance of their systems.

(3) The evolutionary development of Gedeo "agroforests" shows how farmers have judiciously harnessed certain processes of iterative change of ecosystems (Oldeman, 1990). This demonstrates that farmers, though averse to inappropriate agrarian reforms, will be able to examine and accept technologies that build on their experience and circumstances, instead of contradicting them.

(4) The history of different peoples is associated with different crop plants such as rice for south-east Asian peoples (Kada, 1994), maize for the Americans (Gomez-Pompa, 1991), and Hobhouse (1992) discusses five plants, quinine, sugar, tea, cotton and the potato, as plants that transformed mankind. *Ensete* deserves a similar place in the lives of the Gedeo people and other southern peoples dependent on *ensete*. The history of these peoples is linked with the history of *ensete*, and so is their development potential linked with the development of *ensete*.

(5) While Gedeo "agroforests" are most ancient, at least five thousand years old, they cannot be said to be primitive, i.e., archaic or unfit for the present age, as their capacity of production is comparable to most high input conventional modern agricultural systems. There is a lesson to be learned from these "agroforests" that maximum yield can be obtained also from complex systems. Therefore, *ensete*-based Gedeo systems today, contemporaries of modern day agriculture and forestry, have retained the qualities of the original ecosystem, so conserving their capacity for high biomass production. Unlike agroforestry systems proper which only cast a bridge between specialized agriculture and specialized forestry (Neugebauer & al., 1996), Gedeo "agroforests" fully integrate aspects of forestry and agriculture which became isolated by specialization. The Gedeo systems can therefore be thought of as indirect progenitors of modern-day agriculture and forestry.

(6) The model presented for the development history of Gedeo "agroforests" (9.1) provides possibilities for future development interventions. It also provides insight in the failure of past interventions, most of which were attempts at treating symptoms but not the illness. Diagnosis of the sickness should be the first priority. What Chase observed of conservationists playing God in the Yellowstone park (Chase, 1987) equally applies to development intervention by modern experts among the Gedeo.

(7) Given the findings discussed in the preceding pages, farmers' subscription (even by a few of them) to the interventions all geared towards increasing cash income (as in coffee farmers), shows that some farmers have a low view of their own system. This quite nicely relates to a saying " a golden ring looks like a brass one but only as long as it is on a hand".

(8) *Ensete*-based Gedeo systems are unique. The author has not come across any report describing a similar system, either in Ethiopia or outside. Their all-encompassing model integrating development and conservation makes their principles of relevance for world conservation movements, as recently highlighted (cf. Van Helden, 2001).

(9) The Gedeo manage agro-ecosystem complexity, and through it agro-ecosystem properties such as biodiversity, productivity, sustainability, and so take care of themselves. The success of this strategy is for instance manifested in the high diversity of life-forms giving these ecosystems the appearance of forests due largely to "place-making" by woody perennials and diverse herbaceous "weedy" ground flora.

(10) Gedeo resistance to inappropriate interventions (ch. 1.) should not be misunderstood as a complete dislike of farmers to change. But they have their own way of evaluating whether a proposed change is feasible and advantageous or not.

(11) Gedeo "agroforests" are land use systems that have evolved through the agency of the Gedeo people, from a pre-existing vegetation, slowly modifying the structural and architectural make-up of the original forests while retaining their essential features (ch. 1).

(12) The present agro-ecosystem design (choice of components and their spatial and temporal organisation) helps farmers to obtain sustainable products and this at low cost of energy and time.

9.6.2. Recommendations

1. On future studies

a. A missing link, among the diverse *ensete* peoples (about 64 ethnic groups speaking related languages) needs detailed anthropological, historical and archaeological study.

b. Studies aiming at the micro-level (rhizosphere, phyllosphere) of the Gedeo "agroforests" are essential so as to broaden available knowledge.

c. Furthermore, studies aimed at improvement of *ensete* processing (fermentation), as the quality of the end product depends on it, are needed.

2. On development and conservation

a. Since *ensete* offers the cheapest remedy to the recurrent drought and food problems in Ethiopia, it is wise to establish a special institution mandated with its development.

b. In the Gedeo zone, *ensete* production should be promoted by supplying farmers with planting material at reasonable cost, and publicizing benefits of *ensete* to non-*ensete* growing areas. Establishment of an *ensete* fund, which could be used as a revolving fund, is important.

c. Farmers should be involved in the design and administration of change into their system.

d. Because of their educational value for humanity, Gedeo "agroforests", the international community should be involved in their conservation.

e. So as to avert shortages of fodder in the Gedeo zone, non-forage species (tree, shrub and herb species) should be replaced or supplemented with forage species of the same biological types.

f. Better marketing opportunities should be provided to farmers in the Gedeo zone, for farm products such as coffee, wood, *ensete* and other crops.

g. Composting technologies should be disseminated among farm households in the Gedeo zone, so as to reduce or eliminate loss of crop by-products and to avoid dislocation of biomass resources by cut-and-carry foraging.

h. In the Gedeo zone, improved wood stoves and charcoal-making technology should be introduced, so as to increase the essential factor of use efficiency of wood. On the other hand, to diminish the ever-increasing demand for construction wood, introduction of local brick-making technologies should be assessed.

i. In the Gedeo zone, a comprehensive program of development should be aimed at

- Reducing pressure on the agricultural land by creating alternative sources of employment, decreasing rural population through increasing awareness among the farming communities, not bring people to cities with dreams of money.
- Promote utilization of available production niches such as canopy farming (honey, climbing pulses, *boyina* (*Discorea abyssinica*), epiphytes and micro-organisms)) and using the ground layer for shade tolerating crops such as *godarre* (*Colocasia esculenta* L.) and/or useful soil micro-organisms such as composting bacteria or mycorrhizal fungi, i.e., "root floor farming" (Oldeman, 1993).
- Promote currently unfocussed "agroforest" components such as mushrooms and underground nesting honeybees (*damoo*).

References

Abate, T., Hiebsch, C., Brandt, S.A., Gebremariam, S. (eds.). 1996. *Ensete*-based sustainable agriculture in Ethiopia. Proceedings, Int. Workshop on *ensete*, Addis Ababa, 13-20 Dec.1993. IAR. Addis Ababa. 334pp.

Agricultural Bureau for the Southern Nations, Nationalities and Peoples' Region. 1998. Agriculture in the Southern Nations, Nationalities and Peoples' Region, Annual Bulletin, vol. **1** No. 2. Awassa. 40pp.

Ahn, P. M. 1979. The optimum length of planned fallows. In: Mongi, H.O. & Huxley, P.A.(eds.). Soils research *In*: Agroforestry, Pp. 15 – 40. Proceedings of an expert consultation, held at ICRAF, Nairobi, Kenya, March 26-30, 1979.

Alemu, B., T. Mamo, R. Larsson. 2000. Effects of natural forest conversion to plantation and secondary forests on soil chemical properties in *Munessa Montane* Forest, Ethiopia. *In*: Ethiopian Journal of Natural Resources. **2**(2): 165 – 187.

Almaz, N. 2001. Diversity and conservation of enset (*Ensete ventricosum* Welw. Cheesman) and its relation to household food and livelihood security in south-western Ethiopia. Ph. D. Thesis. Wageningen University. Wageningen. 247pp.

Amanor, K.S. 1994. The new frontier: farmers' response to land degradation, a West African Study. UNRISD & Zed Books Ltd. Geneva. 244pp.

Amare, G. 1984. Stability and instability of mountain ecosystems in Ethiopia. *In*: *Mountain Research and Development* **4** (1): 39 – 44.

Asfaw, Z. & Nigatu, A. 1995. Home-Gardens in Ethiopia: characteristics and plant diversity. SINET: Ethiop. J. Sc., **18** (2): 235 – 266.

Asfaw, Z. & Woldu, Z. 1997. Crop Associations of Home – Garden in Wolayita and Gurage in Southern Ethiopia. SINET: Ethiop. J. Sc. **20** (1): 73 – 90.

Asnaketch, W. 1997. The ecology of *Ensete ventricosum* in Ethiopia. Doctoral dissertation. Department of soil sciences, Swedish University of Agricultural Sciences. Acta Universitatis Agriculturae Sueciae. Agraria 78.

Atkinson, C., Dubourg, R., Hamilton, K., Munasinghe, D., Pearce, D., Young, C. 1997. Measuring sustainable development, macroeconomics and environment. Edward Elgar Pubs. Cheltenham.252pp.

Avnimelech, Y. 1986. Organic residues in modern agriculture. *in*: Chen, Y. & Avnimelech, Y. (eds.). The role of organic matter in modern agriculture. Pp1-10. Martinus Nijhoff pubs. Dordrecht.

Barker, T.C. 1990. Agroforestry in the Tropical Highlands. Chapter 6. *in*: MacDicken, K.G. & Vergara, N.T.(eds.), Agroforestry: classification and management. John Wiley & Sons, New York.

Bayush, I. 1991. Community management of crop genetic resources in the *ensete* complex farming system of southern Ethiopia: a case study from Sidama Region. MSc Thesis. University of Norway.

Besrat, A., Mehansho, H., Bezuneh, T. 1979. Effect of varietal difference and fermentation on protein quantity and quality of *Ensete*. Nutrition Report International **20**(2): 245-50.

Bebwa, B.& Lejola, J. 1993. Soil organic matter dynamics and mineral nutrients content in a traditional fallow system in Zaire. *in:* Mulungoy, K. & Merckx, R. (eds.). Soil organic matter dynamics and sustainability of tropical agriculture, pp.135-142. Proc. Internat. Symp. Laboratory Soil Biol. Katholieke Universiteit, Leuven & International Institute of Tropical Agriculture (IITA). John Wiley & Sons, Chichester.

Bernier, N. 1995. Functionnement biologique des humus et dynamique des fortês d'altitude . Doctoral Thesis, University of Savoie (France). 208pp.

Bernier, N. & Ponge, J.F. 1994. Humus form dynamics during the sylvogenetic cycle in a mountain spruce forest. Soil Biology and Biochemistry **26**: 183-220.

Bezuneh, T. 1971. The germination and seedling development of *Ensete* spp. East African Agricultural and Forestry Journal 21:97-101.

Bezuneh, T. 1984. Evaluation of some *Ensete ventricosom* clones for food yield with emphasis on the effect of fermentation on carbohydrate and calcium content. *in*: Tropical Agriculture (Trinidad): **61** (2): 111 - 16.

Bezuneh, T. **1996**. An overview of *ensete* research and future technological needs for enhancing its production and utilization. *in:* Abate & al., *this bibliography*.

Bezuneh, T. & A. Feleke. 1967. The cultivation of the genus *Ensete* in Ethiopia. Soil and Crop Science Society of Florida. Proceedings **27**:133-41.

Bierwirth, J. 2000. Composting experiments in the Biovillage Project, Gurage Zone, Southern Ethiopia. http:/WWW.WIZ.uni-kassel

Brady, N.C. 1984. The nature and properties of soils. The Macmillan Pub. Co. 9th edition. New York. 750pp.

Brandt, S.A. 1996. A model for the origin and evolution of *ensete* food production. *in*: T. Abate & al., *this bibliography*.

Brandt, S.A., Spring, A., Hiebsch, C., McCabe, J.T., Taboje, E., Diro, M., Wolde-Michel, G., Yntiso, G., Shigeta, M., and Tesfaye, S. 1997. The "tree against hunger": *enset*-based agricultural systems in Ethiopia. American Association for the Advancement of Science with Awassa Agricultural Research Center, Kyoto University Center for African Area studies and University of Florida. Florida. 56pp.

Breitenbach, F.V. 1963. The indigenous trees of Ethiopia, Ethiopian Forestry Association, 2nd revised edition, Addis Ababa.

Budelman, A. 1991. Woody species in auxiliary roles in live stakes in yam cultivation.Wageningen Agricultural University, Doctoral Thesis, Amsterdam, Royal Tropical Institute. 152pp.

Byerlee, D. & Collison, M. 1980. Planning Technologies appropriate to farmers' concepts and procedures. Mexico. CIMMYT. 71pp.

Cannel, M.G.R. & J.E. Jackson (eds.). 1985. Attributes of trees as crop plants. Proceedings of a conference held at Middleton Hall Conference Centre Gore-bridge, Midlothian, Scotland, between 15th and 21st July, 1984. Institute of Terrestrial Ecology, Natural Environment Research Council. Huntingdon, England. 592pp.

Carter, V.J. & Dale, T. 1976. Topsoil and civilisation, Oklahoma University Press, Norman, revised edition.

Casley, D.J. & Kumar, K. 1987. Project monitoring and evaluation in agriculture. The Johns Hopkins University Press. Baltimore & London.

Casley, D.J. & Lury, D.A. 1987. Data collection in developing countries. Oxford University Press, New York, USA.

Castro-Dos Santos, A. 1977. Tentative de classification des arbres selon leur capacité de réitération. MSc. thesis. Académie de Montpellier. Montpellier. 44pp.

Castro-Dos Santos, A. 1981. L'appareil végétatif des Monocotyledones. Un essai de synthèse. Thèse de Doctorat. Academié de Montpellier. Montpellier. 249pp.

Central Statistical Authority. 1996a. The 1994 Ethiopian Population and Housing Census: results for Southern Nations, Nationalities and Peoples' Region: Volume I part , statistical report on population size and characteristics, CSA, Addis Ababa. 349pp.

Central Statistical Authority. 1996b. The 1994 Ethiopian Population and Housing Census: results for Southern Nations, Nationalities and Peoples' Region: Volume I Part II, statistical report on education and economic activity. CSA. Addis Ababa. 209pp.

Central Statistical Authority. 1996c. The 1994 Ethiopian Population and Housing Census: results for the Oromiya Region. CSA. Addis Ababa.

Central Statistical Authority. **1979**. Statistical Abstracts. CSA. Addis Ababa.

Central Statistical Authority. 1997. Agricultural Abstracts. CSA. Addis Ababa.

Central Statistical Authority. 1998a. The 1994 Ethiopian Population and Housing Census: results for Southern Nations, Nationalities and Peoples' Region: Volume II Analytical Report. CSA. Addis Ababa. 335pp.

Central Statistical Authority. 1998b. The 1994 Ethiopian Population and Housing Census: results for the Oromiya Region. Volume II Analytical Report. CSA. Addis Ababa.

Central Statistical Authority. 1999. Statistical Abstracts. CSA. Addis Ababa.

Cernea, M. 1985. Sociological knowledge for development projects. *in*: M.M. Cernea (ed.) "Putting People First". p.3-18. Oxford University Press. 430pp.

Chambers, R., 1985. Shortcut methods of gathering social information for rural development projects. Chapter 13, p399-415. *in*: Cernea, M.M. Putting the people first. Oxford University. New York. 430pp.

Chase A. 1987. Playing God in Yellowstone, the destruction of America's First National Park. A Harvest Book. Harcourt Brace & Company. San Diego. 464pp.

Ciancio, O. (Ed.). 1997. The Forest and Man. Accademia Italiana di Scienze Forestali. Florence. 331pp.

Clark, J.D. 1988. A review of the archaeological evidence for the origins of food production in Ethiopia. *in*: Tadesse Beyene (ed). Proc. of the 8th International Conference of Ethiopian Studies. Institute of Ethiopian Studies. Addis Ababa.

Coffee & Tea Development and Marketing Authority and International Agricultural Training Program. 1985. Ethiopian Coffee Handbook: a practical guide for subject matter specialists and development agents. IATP, Somerset, UK. 56pp.

Compara International. 1999. Ecology of Hope. Reader of a seminar, Nov. 1999. Compara International, Postbus 110, 2394 ZG HAZERSWOUDE (NL) [WWW.compara.nl]

Conway, G.R. 1985. Agroecosystem analysis. *in:* Agricultural Administration. **20** (1985) 31-55.

Cook, R.L., B.G. Ellis. 1987. Soil management, a worldview of conservation and production. John Wiley & Sons. New York and Toronto. 413pp.

Corner, E.J.H. 1964. The life of plants. Weidenfeld and Nicholson. London.314pp.

Corner, E.J.H. 1966. The natural history of palms. Weidenfeld and Nicholson. London.393pp.

Coste, R. 1992. Coffee: The Plant and the Product. Macmillan. London.328pp.

Demme, J. & Overman J.P.M. 2001. Indigenous people conserving the rain forest? The effect of wealth and markets on the economic behavior of Tawahka Amerindians in Honduras. Tropen Bos International. Wgeningen. 382 pp.

Dengler, A. 1935. Waldbau auf Okologischer Grundlage, Verlag Von Julius Springer, Berlin. 556pp.

Dent, J.B. & McGregor, M.J. (eds). 1994. Rural and farming systems analysis, European perspectives. CAB International.Wallingford.361pp.

Dillebo, G. 1985. Times of hardships in Ethiopia and the Eritrean Question (in Amharic). Commercial Printers. Addis Ababa. 193pp.

Diriba, G. 1995. Economy at the crossroads: famines and food security in rural Ethiopia. CARE International in Ethiopia. Commercial Printing Enterprise.

Division of Timber management Research Forest Service. 1965. Silvics of forest trees of the United StatesAgriculture Handbook No. 271. US Department of Agriculture & Forest Service. Washington D.C. 762PP.

Dubois, O. 1997. Rights and Wrongs of Rights to Land and Forest Resources in Sub-Saharan Africa: bridging the gap between customary and formal rules. In. Forestry and Land Use Programme. Forest Participation Series No. 10. International Institute for Environment and Development. London.

Ehret, C. 1979. On the antiquity of agriculture in Ethiopia. Journal of African History, **20**: 161-177.

Ellis, F. 1988. Peasant economics, farm household and agrarian development. Cambridge University. Cambridge. 257pp.

Eppel, J. 1999. Sustainable development and environment: a renewed effort in the OECD. *Environment, Development and Sustainability.* **1**:41-53.

Ethiopian Health and Nutrition Research Institute (EHNRI). 1997. Food composition tables for use in Ethiopia, part II. Addis Ababa. 34pp.

Ethiopian Mapping Authority. 1979. Meteorological maps of Ethiopia.18pp.

Ethiopian Mapping Authority. 1984. National atlas of Ethiopia. Berhanena Selam Printers. Addis Ababa.

Ethiopian Mapping Authority. 1988. National Atlas of Ethiopia. Berhanena Selam Printers, Addis Ababa.

FAO. 1975. Organic material as fertiliser, report of the FAO/SIDA expert consultation, Rome, 2-6 December, 1974. Soil Resource Development and Conservation Service, Land and Water Development Division. Soil Bulletin 27. 394pp.

FAO. 1976. A framework for land evaluation. Soil bulletin 32. Soil resources development and conservation, land and water division, Food and Agriculture Organization, Rome.

FAO. 1988. Traditional food plants. Food and Nutrition Paper **No. 42**: 269-273.

Faust, R.H. 1996. Ancient Hawaii: A model of sustainable agriculture. In. H. Kristensen & H. HØgh-Jesen. New Research in organic agriculture. Pp. 106-109, Proc. Of the 11th International IFOAM Conference. August 11- 15, 1996. Copenhagen. Vol.2. IFOAM Tholey - Theley. Pp291.

Fekadu, D. 1996. Potential of *ensete* (*Ensete ventricosum*) in ruminant nutrition in Ethiopia. MSc Thesis. Swedish University of Agricultural Sciences, Department of Animal Nutrition and Management.

Fekadu, D. & Ledin, I. 1996b. Weight, chemical composition and degradability plant parts of *ensete* (*Ensete ventricosum*). MSc. Thesis. Swedish University of Agricultural Sciences, Department of Animal Nutrition and Management.

Fortey, R. 1998. Life, a natural history of the first four billion years of life on Earth. Alfred, A. Knopf. New York. 346pp.

Gatzweiler, F.W. 2001. The changing nature of economic value – the case of tropical forest ecosystem values from the perspective of indigenous Dayak in Kalimantan, Indonesia. Ph.D. Thesis manuscript. University of Berlin. Berlin. 281pp.

Gebremariam, S. 1996. *Ensete* research in Ethiopia:1976-1984. In Aabte & al., *this bibliography.*

Godfrey-Sam-Aggrey, W. & Tuku, B.T. (eds.). 1987. Review of *enset* research in Ethiopia, p324-338. *In*: W. Godfrey-Sam-Aggrey & B. T. Tuku (eds.). Proceedings of the First Ethiopian Horticultural Workshop. Held in Addis Ababa, 20-23 Feb 1985. Vols. 1-3, IAR, Addis Ababa.

Goewie, E.A. 1978. Regulation of caste differentiation in the honeybee (*Apis mellifera* L.). Mededelingen Landbouwhogeschool Wageningen 78-15 (1978). Wageningen.76pp.

Goewie, E.A. 1995. Redesigning methodology for conversion of current farms into ecological farms. Course reader MSc Ecological Agriculture. Department of Ecological Agriculture. Wageningen Agricultural University. Wageningen. 56pp.

Gomez, K.A. & A.A. Gomez. 1984. Statistical procedures for agricultural research. 2nd ed. An International Rice Research Institute Book. John Wiley & Sons. New York. 678pp.

Gomez-Pompa. A. 1991. Learning from tradional ecological knowledge: insights from Mayan Silviculture. Pp335-341 In. A. Gomez-Pompa, T.C. Whitmore & M. Hadley (eds.). Rainforest regeneration and management. Man & Biosphere Series. Vol.6. The Parthenon Pub. Group. Unesco, Paris. 457.

Hallé, F. & Oldeman, R.A.A. 1975. An essay on the architecture and dynamics of growth of tropical trees (translated from the French), Penerbit Universiti, Kuala Lumpur. 156pp.

Hallé, F., Oldeman, R.A.A. & Tomlinson, P.B. 1978. *Tropical trees and forests: an architectural analysis*. Springer Verlag. Heidelberg. 441 pp.

Hiebsch, C. 1996. Yield of *ensete* (*Ensete ventricosum* (Welw.) Cheesm. MUSACEAE, a concept. *in*. Abate T. & al., *this bibliography.*

Hladik, C.M., Hladik,A., Linares,O.F., Pagezy,H., Semple, A. & Hadley, M. (eds.). 1993. Tropical forests, people and food: biocultural interactions and applications to development. Man & Biosphere Series, vol.13. Unesco Paris and The Parthenon pub. Group. Paris. 852pp.

Hobhouse, H. 1992. Seeds of change, five plants that transformed mankind. Papermac. London. 252pp.

Houba, V.J.G., Lee, J.J., Novozamsky, I. & Walinga, I. (eds.). 1989. Soil and Plant analysis, a series of syllabi, part 5 Soil analysis procedures, Department of Soil Science and Plant Nutrition, Wageningen Agricultural University, Wageningen.

Husch, B. 1971. Planning a forest inventory. Forestry and Forest Products Studies, no. 17, FAO, Rome.

Huxley, P.A., (ed.). 1983. Plant research and agroforestry. Proceedings of a Consultative Meeting held in Nairobi 8 to 15 April, 1981. ICRAF, Nairobi, Kenya.

Huxley, P. & Houten, H. Van. (eds.). 1997. Glossary for agroforestry. International Center for Research in Agro forestry, Nairobi, Kenya, 128pp.

James, N.D. G. 1982. The forester's companion (3rd edition). Basil Blackwell. Oxford. 381pp.

Jenik, J. 1978. Roots and root systems in tropical trees: morphologic and ecologic aspects. In. P.B. Tomlinson and M.H. Zimmermann (eds.). Tropical trees as living systems. Pp323-349. The proceedings of the Fourth Cabot Symposium held at Harvard Forest, Petersham Massachusetts on April 26-30, 1976.

Kada, R. 1994. Issues and prospects of sustainable agriculture in Asia. *in*: Asian Productivity Organization. Report of the study meeting held from Feb. 23 - March 5, 1993, in Tokyo (Japan). Pp146-152. Asian Productivity Organization, Tokyo. 488pp.

Kahn, F. & de Granville, J. 1992. Palms in forest ecosystems of Amazonia. Springer-verlag. Berlin. 226pp.

Kamprath, E.J. 1979. Monitoring soils in agrofotrestry: chemical properties. In. H.O. Mongi & P.A. Huxley (eds.). Soil research in agroforestery. Proceedings of an expert consultation held at the International Council for research in Agroforestry in Nairobi, March 26-30, 1979. 590pp.

Kennedy, G. 1983. Invitation to statistics. Martin Robertson. Oxford. 211pp.

Kippie, T.K. 1994. The Gedeo agroforests and biodiversity: architecture and *floristics*. MSc Thesis. Wageningen Agricultural University. Departments of Tropical Forestry and Ecological Agriculture. AUA. Wageningen. 89pp.

Kippie, T.K. 1994b (unpubl.). The Gedeo agroforests and biodiversity: vegetation and soil fertility. A report presented to the Department of Ecological Agriculture. Wageningen Agricultural University. Wageningen. 8pp.

Kippie, T.K., Romeijn, P., Nezry, E. & Yakam-Simen, F. 2001. Radargrammetry helps fight hunger in Ethiopia. Treemail Publishers. Heelsum (The Netherlands). Paper presented at SPIE Conference (Toulouse). 9pp. http://www.treemail.nl/download/opto01a.pdf

Koop, H. 1989. Forest dynamics : SILVI-STAR, a comprehensive monitoring system. Springer, Heidelberg.

Kosko, B. 1993. Fuzzy Thinking, the new science of fuzzy logic. Flamingo HarperCollins Publ. London. 318pp.

Kotschi, J. 2001. Poverty alleviation and food security – can organic farming help? *in*. Agriculture + rural development, pages 9 – 11, published by Technical Centre for Agricultural and Rural Cooperation, vol. 8, no.2/2001.

Kronendak, 2002. Website Stichting Het Kronendak. http://www.treemail.nl/kronendak

Kuiper, L.C. 1994. Architectural analysis of Douglas-fir forests. Ph.D. Thesis. Wageningen Agricultural University, Wageningen. 188pp.

Kuper, J.H. and Maessen, P.P.T.M. 1998. *Sustainability the pro silva way*, Proc. 2nd Internat. Pro Silva Congr. Apeldoorn, publ. By The Dutch Pro Silva Congress Foundation. 277 pp.

Lamprecht, P. 1989. Silviculture in the tropics. GTZ, Eschborn. 296pp.

Lavelle, P. 1994. The soil system in the humid tropics. Biology International **9**: 2-17.

Lavelle, P., Barios, I., Martin, A., Zaidi, Z. & Schaefer, R. 1989. Management of earthworm populations in agro-ecosystems: a possible way of maintaining soil quality? *in*: Clarholm, M. & Bergstrom, L. (eds.). Ecology of arable lands: 109-122. Dordrecht, Kluwer.

Lavelle, P., Blanchart, E., Martin, A., Spain A.V. & Martin, S. 1992. Impact of soil fauna on the properties of soils in the humid tropics. *in:* Soil Science Society of America & American Society of Agronomy, Myths and Science of soils in the tropics. SSSA. Spec. pub. **29**: 157-185.

Lavelle, P. & Pashansi, B. 1989a. Soil microfauna and land management in Peruvian Amazonia (Yurimaguas, Loreto). Pedobiologia 33:283-291.

Leaky, R. & Lewin, R. 1979. People of the Lake: Man; his origins, nature and future. London. Collins, 223 pp.

Leibundgut, H. **1985**. Der Wald in der Kulturlandschaft. Bedeutung, Funktion und Wirkungen des waldes auf die umwelt des Menschen. Verlag Paul Haupt Bern und Stuttgart. Zürich. 205pp.

Lockeretz, W. (ed.). 1983. Environmentally sound agriculture. Selected papers from the Fourth International Conference of the International Federation of Organic Agriculture Movements, Cambridge, Massachusetts, August 18 t0 20, 1982. Praeger pubs. New York. 430pp.

Logan, W.E.M. 1946. An introduction to the forests of Central and Southern Ethiopia. Institute Paper no. 4. Imperial Forestry Institute. London.

Louman, B. 1986. Structural and floristic composition of the lithocarpus fallow in Papua New Guinea, an MSc thesis, Department of Forestry, Wageningen Agricultural University, Wageningen. 31 + 27 (appendices) pp.

Lundgren, B. 1971. Soil studies in a montane forest in Ethiopia, Department of Forest Ecology and Forest Soils, Royal College of Forestry, Stockholm, research note no. 11.

Lundgren, B. 1974. Soil studies in the Montane Forest in Ethiopia. Research Notes. College of Forestry. Stockholm.

Lundgren, B. 1978. Soil conditions and nutrient cycling under natural and plantation forests in Tanzanian highlands, Department of Forest Soils, Swedish University of Agricultural Sciences, Upsala.

Lundgren, B. 1979. Research strategy for soils in agroforestry. Pages 523-538 *in*: H.O. Mongi & P.A. Huxley (eds.). Soil research in agroforestry, proceedings of an expert consultation March 26-30, 1979, held at ICRAF, Nairobi.

MacDicken, K.G. & Raintree, J.B. 1990. An overview of multipurpose tree species. *in:* Taylor, D. & K.G. MacDicken (eds.). Proceedings of an Int. Workshop. November 19-23,. p.5-16. held in Los Banos, Philippines. Winrock International Institute for Agricultural Development. Los Banos.260pp.

MacDicken, K.G. & Vergara , N.T. (eds.). 1990. Agroforestry: classification and management. John Wiley & Sons, New York.

Makiso, T. 1976. Study on the yield of *enset. in*: Institute of Agricultural Research. Proc. 6th Annual Seminar, 12-14 November 1975, held in Addis Ababa. Institute of Agricultural Research. P. 246-54.

Makiso, T. 1980. Agronomic report for 1979. Pub. no. 63. Wolaita Agricultural Development Unit.

Mayer, H. **1980**. Waldbau. Gustav Fischer Verlag. Stuttgart. 483pp.

Mcabe, J.T. 1996. The ecological and cultural significance of livestock in the *ensete* agricultural complex. *in:* Abate, T. & al., *this bibliography*.

Mead, R. & Curnow, R.N. 1983. Statistical methods in agriculture and experimental Biology. Chapman and Hall. London. 335pp.

Mersha, E. 2000. A desertification convention-based classification of moisture zones of Ethiopia. *in*: Ethiopian Journal of Natural Resources, **2** (1-9).

Messele, T.**1992**. The effect of soaking, temperature and other treatment on the germination of enset seeds. Seed Science and Technology **20**:533-538.

Metzger, l. & Yaron, B. 1987. Influence of sludge organic matter on soil physical properties *in:* Stewart, B.A. (ed.). Advances in soil science, **7 (**141-163).

Michon, G. 1983. Village-forest-gardens in West Java. Chapter 2 *in*: P.A. Huxley (ed.) Plant research and agroforestry, Proceedings of a Consultative Meeting held in Nairobi April 8-15, 1981, ICRAF, Nairobi.

Michon, G. 1985. De l'homme de la forêt au paysan de l'arbre: agroforesteries indonésiennes. Montpellier (F), Dr. thesis, Université de Montpellier II.

Moldenke, A.R. 1999. Soil-dwelling arthropods: their diversity and functional roles.USDA Forest Service, Pacific Northwest Research Station, Gen. Tech. Rep. PNW-GTR- 461: 33-44.

Moldenke, A.R., Baumeister, N., Estrada – Venegas, E. & Wernz, J. 1994. Linkages between soil biodiversity and above-ground plant performance. Transactions 5th Wolrld Congress of Soil Science (ISSS), 4A: 186-204.

Mongi, H.O & Huxley, P.A. (eds.). 1979. Soil research in Agroforestry. Proceedings of an expert consultation held at the International Council for Research in Agroforestry in Nairobi, March 26-30, 1979. ICRAF. 500pp.

Mulongoy, K., Kunda, K.N., Chiang,C.N.K. 1993. Effect of alley cropping and fallowing on soil fertility parameters in Southern Nigeria, *in:* Swift, M.J. & al. (eds.), ibid., pp47-56.

Munyanziza, E. 1994. Miombo Trees and mycorrhizae, ecological strategies, a basis for afforestation. Ph. D. Thesis. Wageningen Agricultural University. Wageningen. 193pp.

Murdock, G.P. 1959, Africa: Its peoples and Their Culture History. New York: McGraw Hill.

Murphy, H.F. 1968. A report on the fertility status and other data on some soils of Ethiopia, Experimental Station Bulletin no. 44, College of Agriculture, Haile Sellassie I University & an Oklahoma State University-USAID contract Publication, Oklahoma. 558pp.

Murray, M.A. 1964. The splendour that was Egypt. New and revised ed. Sidgwick & Jackson. London. 256pp.

National Office of Population, Ministry of Economic Development and Cooperation. 2000. The Ethiopian Population Profile. Artistic Printers. 68pp.

Neugebauer, B., Oldeman, R.A.A. and Valverde, P. 1996. 'Key principles *in*: ecological silviculture'. **In**: T.V. Ostergaard (ed.), *Fundamentals of Organic Agriculture.* p. 153-175. IFOAM, Okozentrum Imsbach. Thole-Theley.

Neumann, I.F. 1983. Use of trees in small holder agriculture in Tropical Highlands. *in:* W. Lockeretz (ed.). Environmentally sound agriculture, selected papers from the Fourth International Conference of the International Federation of Organic Agriculture Movements, Cambridge Massachusetts, August 18 to 20, 1982. 430pp.

Nezry, E., Yakam-Simen, F., Kippie, T. & Romeijn, P. 2000. Gedeo Zone Mapping Project. Phase 2 Final Report. Treenail. Heelsum (The Netherlands). 15pp.

Nigatu, A. & Gash, A.B. 1996. Inhibitory activity of fermented kocho on spoilage and pathogenic bacteria. *in*: *Ensete*-based sustainable agriculture in Ethiopia. Proceed. Int. Workshop on *ensete,* A. Ababa, 13-20 Dec. 1993 (eds. T. Abate et al., 321-327.

Obatolu, C.R. & Agboola, A.A. 1993. The potential of siam weed (Chromolaena adorata) as a source of organic matter for soils in the humid tropics. *in:* swift, M. j.& al. (eds.). pp89-100.

Odum, E.P. 1975 (2nd ed.). Ecology. Holt Rinehart and Winston. London, New York. 244pp.

Oelhaf, R.C. 1978. Organic agriculture: economic and ecological comparisons with conventional methods. Allanheld, Osmun & Co., a halsted press book, John Wiley & Sons. New York. 271pp.

Oldeman, R.A.A. 1979. Field guide for the research group " Scale drawing and architectural analysis of vegetations". Bandung, Lembaga Eklogi & Wageningen, Landbouwhgeschool, Dept. Silviculture, mimeogr., 42pp.

Oldeman, R.A.A. 1983. The design of ecologically sound agroforests. Chapter 14 *in*: P.A. Huxley (ed.). Plant research and agroforestry, Proceedings of a Consultative Meeting held in Nairobi, April 8-15, 1981, ICRAF, Nairobi.

Oldeman, R.A.A. 1985. 'The programme 'TROPENBOS' for tropical forest research stimulation'. *Biology International* **12:** 7-10.

Oldeman, R.A.A. 1986. The programme ‘Tropenbos’ for tropical forest research stimulation. Vakblad voor Biologen, 66: 14-17.

Oldeman, R.A.A. 1987a. Tropical forests: the ecosystems. *in:* Van Beusekom, van Goor & Schmidt (eds.). Wise utilisation of tropical forest lands: 46-67. Ede, TROPENBOS Scient. Ser. 1.

Oldeman, R.A.A. (ed.). 1987b. Tropical rainforest Canopy research. Proposal for participation in a Research and Development Program “Science and Technology for Development”, subprogr. “Tropical and subtropical Agriculture” submitted to the Commission of the European Communities, DG XII (Science, Research and Development). Ca 65 pp.

Oldeman, R.A.A. 1990. Forests: elements of silvology. Springer-Verlag, Heidelberg. 624pp.

Oldeman, R.A.A. 1992a. Bosarchitectuur en diversiteit: wat is er gemengd in gemengde bossen? [in Dutch; ‘Forest architecture and diversity: what's mixed in mixed forests?”]. Werkdocument IKC-NBLF **12**:1-12 (ISBN 90-72168-07-0)

Oldeman, R.A.A. 1992b. Architectural models, fractals and agroforestry. *in:* Agriculture, Ecosystems and Environment **(41)** 1992, 179-188.

Oldeman, R.A.A. 1993. (unpubl.). New directions in silviculture. First Beyond UNCED Global forest conference Bandung, main paper. 7pp.

Oldeman, R.A.A. 1995. 'New scope and Objectives for European forestry and rural conservation: "Ecoland and Ecoforest'", Warszawa, *Contribution XIII Congress of the Union of European Foresters (May 1995):* pp1-8.

Oldeman, R.A.A. 1998. Diagnosis of complex ecosystems, version 2.1. InfoBase publ. by Easy Acess Software, Wageningen.

Oldeman, R.A.A. 2001. Diagnosis of complex ecosystems. Interactive Book on InfoBase; CD-Rom, software DICE 5.0, Wageningen, publ. by Easy Access Software [eas@planet.nl]

Oldeman, R.A.A., Clement, C.R. & Kabala, D.M. 1993. Food and the Future of Tropical Forest: Management Alternatives, pp. 685-690. *in:* C.M. Hladik, A. Hladik, O.F. Linares, H. Pagezy, A. Semple & M. Hadley (eds.). Tropical Forests, People and Food: Biocultural Interactions and Applications to Development, Man & Biosphere Series, vol. 13, Parthenon Publishers, Paris. 852pp.

Oldeman, R.A.A., Parvianen, J. and Stephan, K.-H. 1994. 'Les traitements forestiers', Naturopa, **75:**15-19.

Oldeman, R.A.A. & Schmidt, P. 1986. Silvicultural design: an exercise for students. *In*: Fanta (ed.), Forest dynamics research in western and central Europe: 205-210. Wageningen, PUDOC.

Oldeman, R.A.A. & Van Dijk, J. 1991. Diagnosis of the temperament of tropical rainforests trees. *in*: A. Gomez-Pompa, T.C. Whitmore & M. Hadley (eds.). Rainforest regeneration and management. P.21-65. Unesco. The Parthenon Pubs. Paris. Man & Biosphere Series, Vol.6. 457pp.

Olmstead, J. 1974. The versatile ensete plant: its uses in the Gamo highlands. Journal of Eth. Studies. **12** (2): 147-153. Addis Ababa.

Oneka, M. 1996. On park design: looking beyond the wars. Tropical Resource Management Papers, 13: 146pp.

Ong, C.K. & Huxley, P.A. (eds.). 1996. Tree crop interactions: a physiological approach. CAB Int. & ICRAF, Nairobi, Kenya.

Otto, W.M. 1987. 'Forestry and agriculture: an alliance for survival'. *in*: C.F. van Beusekom et al. (ed.), Wise Utilization of Tropical Rain Forest Lands. pp94-102. Wageningen, TROPENBOS Scient. Series, **1**. ISBN 90-5113-002-3.

Oxford dictionary of English grammar. 1994. The new authoritative guide, edited by S. Chalker and E. Weiner.London. 448pp.

Pankhurst, R. 1985. The history of famine and epidemics in Ethiopia prior to twentieth century. Relief & rehabilitation Commission, Addis Ababa. 120pp.

Pankhurst, R. 1996. *Enset* as seen in early Ethiopian literature: history and diffusion. *in*: T.Abate et al., *this bibliography*.

Pardé, J. & Bouchon, J. 1988. Dendrométrie (2nd ed). Ecole Nationale du Génie Rural (ENGREF). Nancy. 328pp.

Parnes, R. 1990. Fertile soil, a grower's guide to organic and inorganic fertilizers, agAccess, Davis, California.

Parr, F. & Papendick, R.I. 1983. Strategies for improving soil productivity in Developing Countries with organic wastes. Pp.131-143. *in:* W. Lockeretz (ed.). Environmentally sound agriculture, selected papers from the Fourth International Conference of the International Federation of Organic Agriculture Movements, Cambridge Massachusetts, August 18 to 20, 1982. 430pp.

Pijls, L.T. J., Timmer, M.A.A., Wolde-Gebriel, Z. & West, E.C. 1995. Cultivation, preparation and consumption of *Enset* (*Ensete ventricosum*). Journal of Science, Food & Agriculture. **67**: 1-11.

Pinto - Correia, T. 1996. The preservation of traditional agro-systems as a way to sustainability- how to manage it. *in:* N.H.Kristensen & H. Hogh-Jesen (eds.). New Research in organic agriculture. Pp. 110-116, Proc. Of the 11th International IFOAM Conference. August 11- 15, 1996. Copenhagen. Vol.2.pp291. IFOAM Tholey - Theley. Pp.272.

Ponge, J.F. & Delaye, L. 1995. The heterogeneity of humus profiles and earthworm communities in a virgin beech forest. Biological Fertility of Soils **20**: 24-32.

Raintree, J.B. 1987. D & D User's Manual: an introduction to agroforestry diagnosis and design. ICRAF, Nairobi, Kenya.

Raintree, J.B. 1990. Procedures for agroforestry diagnosis and design. Chapter 3. *in*: MacDicken, K.G. & Vergara, N.T. (eds.). Agroforestry: classification and management. John Wiley & Sons, New York .

Ramakrishnan, P.S. 1992. Shifting agriculture and sustainable development, an interdisciplinary study from North-Eastern India. UNESCO and The Parthenon Pub. Paris. Man & Biosphere Series. Vol. 10. 424pp.

Redhead, J.F. 1979. Soil mycorrhza in relation to soil fertility and productivity. *in:* H.O. Mongi & P.A. Huxley (eds.). Soil Research in Agroforestry. Pp79-124.

Proceedings of an expert consultation held at the International Council for Research In Agroforestry in Nairobi, March 26-30, 1979.590pp.

Remmers, G. G. A. 1998. Con cojones y maestría, un estudio sociológico-agronómico acerca del desarrollo rural endógeno y procesos de localización en la Sierra de la Contraviesa (España) (In English: With balls and mastery: a sociological-agronomical study of endogenous rural development and localization processes in the *Contraviesa* Mountains (Spain). PhD Thesis, Wageningen University, Wageningen. 380pp.

Rhamato, D. 1996. Resilience and vulnerability: *enset* agriculture in Southern Ethiopia. *in:* Abate, T.& al., *this bibliography*.

Richardson, B.A. 1999. The Bromeliad Microcosm and the assessment of Faunal Diversity in a Neotropical Forest. Biotropica **31**:321-336.

Richards, P.W. 1952 (3rd repr. 1964). The Tropical Rain Forest. Cambridge (UK), The University Press. 450pp.

Romeijn, P. 1999. Green Gold.On variations of truth in plantation forestry. Treebook No. 2, Treemail Publishers. Heelsum, The Netherlands. 221pp + CD-ROM. http://www.treemail.nl/download/luther.pdf

Rossel, G. 1998. Taxonomic-linguistic study of plantain in Africa. Research School CNWS, Leiden University, The Netherlands. 277pp.

Rossignol, M., **Rossignol, L., Oldeman, R.A.A. & Benzine-Tizroutine, S. 1998.** Struggle of life or the natural history of stress and adaptation. Treebook No. 1. Treemail Publishers. Heelsum. The Netherlands. 237pp.

Ross, S. 1989. Soil processes, as systematic approach. Routledge. London and New York. 444pp.

Ruinen,J. 1974. Nitrogen fixation in the phylosphere. In Quispel, A. (ed.). The biology of nitrogen fixation: 121-167. Amsterdam. North Holland Publ. Company.

Sanchez, P.A. 1976. Properties and management of soils in the tropics. A Wiley-Interscience Publication. John Wiley & Sons, New York and Toronto. 618pp.

Sanchez, P.A. 1979. Soil fertility and conservation considerations for agroforestry systems in the humid tropics of Latin America. *in:* H.O. Mongi & P.A. Huxley (eds.). Soil Research in Agroforestry. Pp79-124. Proceedings of an expert consultation held at the International Council for Research In Agroforestry in Nairobi, March 26-30, 1979. 590pp.

Sanchez, P.A. , Palm, C.A., Davey, C.B. , Szott, L.T. & Rossel, C.E. 1985. Trees as soil improvers in the humid tropics? *in*: Cannel, M.G.R. & J.E. Jackson (eds.). Trees as Crop Plants. Institute of Terrestrial Ecology. Titus Wilson & Sons. Ltd. Kendal, Cumbria. 592pp.

Sandford, J. 1991. *Enset* in north Omo region. Farmers' Research Project, Technical Phamplet. No.1. Farm Africa. Addis Ababa.

Sandford. 1996. Livestock in ensete complex. *in:* Abate, T &. al., *this bibliography*.

Sansonnens, B. 1994. Structure et dynamique agroforestiers en Asie tropicale humide. Dr. thesis, Lausanne University (Switzerland), 349 pp. + annexes.

Schütz, J.-Ph. and Oldeman, R.A.A. 1996. 'Gestion durable par automation biologique des forêts'. *Revue Forestière Française*, **48**, Special volume: 65-74.

Shack, W. 1966. The Gurage: A People of the *Enset* Culture. Oxford: Oxford University Press.

Shigeta, M. 1990. Folk *in-situ* conservation of *ensete* (*Ensete ventricosum* (Welw.) Cheesman) Musaceae: Towards the interpretation of the indigenous agricultural science of the Ari of Southwestern Ethiopia. African Study Monographs, **10**(3): 93-107, February 1990.

Shigeta, M. 1991. The ethno botanical study of *ensete (Ensete ventricosum)* in Southwestern Ethiopia. Ph. D. dissertation, Center for Africa Area Studies, Kyoto University.

Shigeta, M. 1996. Multi-purpose utilization of *enset* among the Ari of southwestern Ethiopia. *in:* Abate, T. & al., *this bibliography*.

Singh, A. 1975. Use of organic materials and green manures as fertilizers in developing countries. *in*: Organic Materials as fertilizers. Report of the FAO/SIDA Expert Consultation, Rome, 2 –6 December 1974, 19-31.

Singh A. & Nigatu, A. 1995. Home-Gardens in Ethiopia: characteristics and plant diversity. SINET: Ethiop. J. Sc., 18 (2): 235 – 266.

Smits, W.Th. M., Oldeman, R.A.A. & Limonard, T. 1987. Mycorrhizae and Diperocarpaceae in East Kalimantan rain forests. The Hague, WOTRO, yearbook 1986: 67-78.

Smits, W.T.M. 1994. Dipterocarpaceae: Mycorrhizae and Regeneration. DSc thesis, Wageningen, 243pp.

Simmonds, N.W. 1958. *Ensete* cultivation in the southern highlands of Ethiopia: a review. Tropical Agriculture: **35**:302-307.

Simmonds, N.W. 1962. The evolution of the bananas. Longmans Green. London.

Silva de, S.B.D. 1982. The political economy of underdevelopment, Routledge & Kegan Paul, London, 645pp.

Smeds, M. 1955. The *ensete* planting culture of the eastern Sidamo, Ethiopia. Acta Geographic Helsinki 13 (4): **2-39**.

Southern Nations Nationalities and Peoples' Region, Office for Population Affairs. 1998. Southern Nations, Nationalities and Peoples' Region: Population profile (in Amharic), memo. 60pp.

Sutton, P.B. & Zimmerman, M. H. (eds.). 1978. Tropical trees as living systems. The Proceedings of the Fourth Cabot Symposium held at Harvard Forest, Petersham Massachusetts on April 26-30, 1976. Cambridge University Press. Cambridge. 675pp.

Sutton, S.L., Whitmore, T.C. & Chadwick, A.C. 1983. Tropical rainforest: ecology and management. Special Publication no. 2 of the British Ecological Society. Blackwell Scientific Publishers. Oxford. 498pp.

Swift, M.J. & Woomer, P.L. 1993. Organic matter and the sustainability of agricultural systems: definitions and measurement. Pages 3-18 *in*: Mulongoy, K.& Merckx, R. (eds.). Soil organic matter dynamics and sustainability of tropical agriculture, proceedings of an international symposium organized by the laboratory of soil fertility and soil biology, Katholieke Universteit, Leuven & International Institute of Tropical Agriculture (IITA), John Wiley & Sons, Chichester.

Taboje, E. 1997. Morphological characterization of *enset* (*Ensete ventricosum* (Welw.) (Cheesman) clones and the association of yield with different traits. MSc. Thesis. Alemaya University of Agriculture. Alemaya (Ethiopia). 89pp.

Thi Ngoc AN, N. 1997. A study on the Home garden Ecosystem in the Mekong River Delta and the Hochiminh City (Viet Nam), UNESCO, South-South Co-operation Programme. Paris. 28pp.

Tigot, D. 1986. Is Ethiopia's *Ensete ventricosum* crop her greatest potential food? *Agriculture International* **38:** 362-365.

Toffler, A. 1990. Powershift: knowledge, wealth and violence at the edge of the 21st Century. Bantam Books. New York. 601pp.

Tolo, A. 1989. Sidama & Ethiopian; the emergence of the Mekane Yesus Church in Sidama, Studia Missionalia, Upsaliensia LXIX, Uppsala, 312pp.

Tomlinson, P.B. 1978. Branching and axis differentiation in tropical trees *in*: Tomlinson, P.B. & Zimmerman, H.M. (eds.) 1978. P.187-207 Tropical trees as living systems:. Cambridge Univ. Press. Cambridge. 675pp.

Tootill, E. (ed.). 1984. Dictionary of botany. Penguin. London. 391pp.

Touber, L., Smaling, E.M.A., Andriesse, W. & Hakkeling, R.T.A. (eds.). 1989. Inventory and classification of tropical forest land, guidelines for a common methodology. The Tropenbos Foundation. Ede (Netherlands). 170 pp.

Tsegaye, A. & Struijk, P.C. 2000. Influence of repetitive transplanting and leaf pruning on dry matter and food production of enset (*Ensete ventricosum* (Welw.) Cheesman), *Field crops research J.* **68** (2000): 61-74.

Tsegaye, A. & Struik, P.C. 2001. Enset (*Ensete ventricosum* (Welw.) Cheesman) kocho yield under different crop establishment methods as compared to yield of other carbohydrate - rich food crops. *Netherlands J. Agri. Sc*.**49** (*2001*) 81 – 94.

UNCED. 1993. Agenda 21: programme of action for sustainable development: statement of forest principles: the final text of agreements negotiated by governments, at the United Nations Conference on Environment and Development (UNICED), 3-14 June 1992, Rio de Janeiro. Brasil. United Nations. New York.

UNDP/ECA Project. 1996. Manual on production and Utilization of *ensete* (*Ensete ventricosum*) in south and southwestern Ethiopia, joint publication of the southern Nations, Nationalities and Peoples Regional Government and the Economic Commission for Africa, in Amharic language, vol. 2, October, 1996, pp102.

Van der Wal, H. 1999. Chinantec shifting cultivation: InTERAcTIVE landuse, a case study in the Chinantla, Mexico, on secondary vegetation, soils and crop performance under indigenous shifting cultivation. Treemail Publ. Treebook no. 3. Heelsum. The Netherlands. 162pp.

Van Helden, F. 2001. Through the thicket, disentangling the social dynamics of an integrated conservation and development project in Mainland New Guinea. Ph.D. Thesis. Wageningen University. Wageningen. 398pp.

Vester, Hans. 1997. The trees and the forest, the role of tree architecture in canopy development; a case study in secondary forests (Araracuara, Colombia). Ph.D. Thesis. University of Amsterdam, The Netherlands. 180pp.

Vogt, K.A., Gordon, J.C., Wargo, J.P., Vogt, D.J., Asbjornsen, H., Palmiotto, P.A., Clark, H.J., O'Hara, J.L., Keaton, W.S., Patelweynand, T. & Witten, E. 1997. Ecosystems: balancing science with management. Springer Verlag, New York.

Walinga, I., Vark, W., Houba, V.J.G., Lee, J.J. (eds.). 1989. Soil and plant analysis, a series of syllabi, part 7 Plant analysis procedures, Department of Soil Science and Plant Nutrition, Wageningen Agricultural University, Wageningen.

Webster's 7th new collegiate dictionary. Based on Webster's third new int. dictionary. G. & C. Merriam Co. Springfield. 1224pp.

Werth, E. 1954. Grabstock Hacke und Pflug. Verlag Eugen Ulmer. Ludwigsburg. pp434.

Westphal, E. 1974. Agricultural systems in Ethiopia. Agricultural University Wageningen and Alemaya University College, Haile Sellassie I University (Ethiopia), Agricultural Research Report 826, Centre for Agricultural Publishing and Documentation, Wageningen.

White R.E 1997. Principles and practices of soil science, the soil as a natural resource. Third edition. Blackwell. Oxford and Victoria. 348pp.

Wilson, E.O. 1992. The diversity of life. Allen Lane. The Penguine Press. London, New York. 424pp.

Wit, C.T. de & al. 1978. Simulation of assimilation, respiration and transpiration of crops. PUDOC. Wageningen. 141pp.

Wolde-Aregay, B. & Holdinge, C.A (ed.). 1996. Twenty years of soil conservation in Ethiopia: a personal overview. Regional Soil Conservation Unit, Swedish International Development Cooperation, Kenya. 24pp.

Wolde-Mariam, M. 1972. An Introductory Geography of Ethiopia. H.S.I. University. Addis Ababa. 215pp.

Woody Biomass Inventory and Strategic Planning Project. 1996 (draft). The Southern People' State: Towards a Strategic Plan for the Sustainable Development, Conservation and Management of the woody biomass resources. The Woody Biomass and Strategic Planning Project, Awassa (Ethiopia). 117pp.

Wrigley, G. 1988. Coffee. Longman Scientific & Technical. London. 639pp.

Young, A. 1976. Tropical soils and soil survey. Cambridge University Press. Cambridge. 468pp.

Zewudu,T. 1996. Comparative tissue culture study on banana and plantain (*Musa* sp.) and development of in vitro methods for the propagation of *ensete* (*Ensete* sp.). Faculty of Agriculture and Horticulture of Humboldt University of Berlin. 109pp.

Zimmermann, M.H. 1978. Structural requirements for optimal water conduction in tree stems. In: Tomlinson, P.B. & M.H. Zimmermann (eds.). Tropical trees as living systems. p517-532. Proc. The fourth Cabot Symp. Held at Harvard Forest, Petersham Massachusetts, April 26-30, 1976. Cambridge University Press. Cambridge. 675pp.

Software Packages used

Adobe Acrobat Distiller
Corel Photo Paint
Corel Word Perfect 9
Eudora-Pro
Jasc Paint Shop-Pro
Linux, various
Mc-Affee Virus Scan
Microsoft Access 97
Microsoft Excel 97
Microsoft Windows 98/2000/ME
Microsoft Word 97/98
Netscape 4.6
PRIVATEERS NV satellite data processing programs
SPSS-10 Statistical Package
WS-FTP

Summary

The present volume is a study of an ancient way of land use, over five thousand years old, by the Gedeo in Ethiopia. The Gedeo country covers highlands between 5^{o} and 7^{o} North and 38^{o} and 40^{o} East, in the escarpment of the Rift Valley facing Lake Abaya. The altitude ranges from 1200 m near Lake Abaya to 3000 m asl, near Bule town. Gedeo land use emphasizes perennial cropping. Emphasis on trees lends the "agroforests" a forest-like appearance. Gedeo land use imitates nature to a great extent. One of the best coffees of the world, Yirga-Chaffee coffee (cultivar of *Coffea arabica* L. RUBIACEAE) is grown under these trees. So is *ensete* (*Ensete ventricosum* (Welw.) Cheesman MUSACEAE), yielding high quality food appreciated in large cities including Addis Ababa. Honey, timber, and a superior race of highland sheep are also produced here. Moreover, their unique cropping system makes the Gedeo immune to drought-induced famines, ravaging the Ethiopian highlands at intervals. Moreover, the Gedeo highlands are densely populated with some 500 persons/km^2. Notwithstanding the steep slopes, erosion risk from rainwater is well buffered by a judicious use of the vegetation.

The central theme of the present ecological study is to understand holistic land use better, and to contribute to the design capability of the farmers, so as to cope better with the problems of rural development. Such are dwindling land resources and increasing influences from market forces. Farm design and functioning are especially emphasized. Aspects often overlooked in conventional agricultural research are emphasized, such as the reasons behind farmers' aversion to adopt new technologies, and frequent under-valuation of products and services. Relevance of farmers' practices *vis-à-vis* their ecological and socio-economic constraints are examined. These factors are crucial to understand the situation of farmers better. The study focuses on both theoretical and practical aspects of farm design and performance. Theoretically, farm design is examined from the perspective of forest ecology (chs. 4, 5 and 7). Empirically, the design is examined as farmers' day-to-day management of natural resources (chs. 6, and 8). The development history of the Gedeo system also receives attention.

The agricultural background in Ethiopia is presented in chapter one. Recurrent food and environmental problems are traced back to the undulating and rugged terrain in the highlands, unsuitable to modern agricultural practices. Still, the otherwise mostly well-adapted subsistence farming systems were ignored. This chapter highlights the potential of subsistence agriculture, if backed by enough assistance, in staving off hunger and in protecting the environment. It shows how the place of *ensete* worsened, due to historical and cultural prejudices. Then it presents Gedeo society, its environment, history, religion and contacts with the outside world. Some reasons are given why the Gedeo, with their unique land use, remained isolated like a socio-ecological island, and why they survived nonetheless.

Context and scope of the present study are given in chapter two. Methodological hurdles in past studies are discussed. Methods developed for the investigation of natural forests and their use in the present study are exposed. Gedeo land use offers both unique opportunities to learn about sound land use practices in marginal areas and a chance to broaden the

conceptual framework of agroforestry, one stated objective of the International Centre for Research in Agroforestry.

Chapter three builds on the methodological framework and the research questions raised. Inter-disciplinarity was achieved by linking the study with the development objectives of the Agricultural Bureau for the Gedeo Zone. The latter was handicapped by the lack of appropriate guidelines for its development efforts, as available research was ill suited to the reality of Gedeo land use. Directing the Bureau for the last six years, the investigator knows the problems first-hand. The human resources of the bureau were essential in the conduct of the present research.

It is highly significant that the present study comes at a time the world is witnessing many a change in the two traditional land use systems, namely, agriculture and forestry. The old paradigm of strict separation of agricultural and forestry research, is now breaking down under the weight of accumulated “anomalies”. Agroforestry, the fledgling interdisciplinary science, has arisen recently to fill the gap. However, agroforestry as conceived today does not integrate the two disciplines, but only casts a bridge. There is a call for a more integrative conceptual background.

Now such wholeness is the key attribute of traditional systems that persisted for millennia, such as those practiced by the Gedeo. Indeed, before agriculture and forestry, there was a kind of agroforestry and not the other way round. Agriculture and forestry are later phenomena, i.e., overspecialized offshoots of a common ancestor, which is a very flexible form of polyvalent land use. Gedeo land use, with its complex mix of elements, is such a polyvalent land use and the present study provides a strong theoretical basis in favor of its being an ancestor.

The study also provides practical as well as theoretical background to problems of agricultural development in mountainous areas with sufficient rainfall.

The basic method was Hallé & Oldeman’s (1970; also Hallé & al. 1978; Oldeman 1990) architectural analysis. Architecture is the spatial distribution of the interacting components and their forms in a system, expressing its organization. The parameters are graphical, not numerical. This framework provides more insight in agroforests as blocks of forests, with humans performing the roles performed by some natural forces in forests. The two concepts useful for integration are the *eco-unit*, the smallest ecosystem possible after one “disturbance”, and the *agro/silvatic mosaic*, the mosaic composed by natural, agricultural or “agro-natural” eco-units.

An *eco-unit* is one ecosystem, developing on one surface, cleared by one impact, at one specific moment, and following one development process (see Rossignol, 1998, p152). An agroforest with sufficient surface to contain all possible numbers of eco-units (of different development stages and size classes) constitutes a complete *agro/silvatic* mosaic. It is assumed that agroforests have a similar resource regime, and a management dictated by this regime. The three altitudinal agro-ecological zones bordering the Rift valley are considered as landscapes, the highest level of organization in the present study.

Farms are managed one level lower, the *agro/silvatic* mosaic. This is completely different from a situation with monocrop fields where each field is an eco-unit by itself, harvested at one moment (initial impact) and replanted at once (same development). Unlike Gedeo land use, where each field is a mosaic containing many small near-natural eco-units, monocropping needs many large fields to form one *agro/silvatic* mosaic of sorts, all units having the same age.

The results of the above analysis are in chapters 4 to 8. Agroforest design (chs.4) perfectly fits in with the foregoing system levels, as demonstrated by block transects through agroforests in each of the three agro-ecological zones. Organisms with core and subsidiary functions, ecologically, socially and economically, could so be identified.

The significance of *ensete* in the three zones rests on biological diversification. *Ensete* gives farmers subsistence as well as sustainable production. In the highlands, annual crops accompany *ensete*. Such are barley (*Hordeum vulgare* L.), horse bean (*Vicia faba* L.), pea (*Pisum sativum* L.) and vegetables like kale (*Brassica* sp.), onion (*Allium cepa* L.), garlic (*Allium sativum* L.); there also is livestock. In the lowlands, maize (*Zea mays* L.), *qoqee* (*Phaseolus lunatus* L.), haricot bean (P. *vulgaris* L.), sweet potato (*Ipomoea batatas*), and root vegetables like yam (*boyina*, *Discorea abyssinica*), *godarre* (*Colocasia esculenta*), and/or pumpkin (*Cucurbita* sp.), are grown alongside *ensete*. In the midlands, coffee (*Coffea arabica* L.) is the most important *ensete* subsidiary component. Woody species and livestock are ubiquitous throughout the three land use versions, although their shares vary.

Chapter four also discusses "agroforest" components. The design of Gedeo land use harmonises production and protection. Agroforest components therefore are divided into core and subsidiary components. The first type has a pacemaker role (regulation of agro-ecosystem rhythm), a *spacemaker* role (provision of biotope space for other crops) and/or a *placemaker* role (provision of living space, or niche for other organisms). *Ensete* and various species of multipurpose trees represent core components. These are therefore like cornerstones, holding the whole agro-ecosystem intact. Components with subsidiary role are regarded as "fillers", because these put to good use the extra agro-ecosystem functions still unoccupied. These are annual crops, coffee, or farm animals.

Chapter 5 builds on the design concept and discusses the practical application, using *ensete* as example, of agro-ecosystem architecture. The pacemaker role of *ensete* is highlighted. Its rotation, of 7 to 12 years depending on altitude, maintains in each zone the basic rhythm of management, to which all other rotations are attuned. With its anatomical water-stocking and storage mechanisms, with its fibrous root system forming a mat-like structure 30 to 60 cm deep, with soil decomposition yielding organic matter for soil maintenance, *ensete* is more than a mere crop. Moisture conserving mechanisms in *ensete* make it the biological solution for the erosion-prone steep slopes of the Gedeo highlands. It captures rainwater with its fan-shaped leaves, stores it in the tank-like structure formed by interlocking leaf-sheaths, and releases it slowly. Chapter five also discusses the system of multiple crop rotation. It explains, using *ensete* as an example, how a farm family can store a decade's need of biomass in cohorts of crop plants.

Chapter six concerns principle and practice of natural resources management by farmers, and how they achieve sustained products and services from “agroforest” components The farmers’ effort is mainly directed at optimisation of the interrelationships among diverse components. Number and/or mass of “agroforest” components to be harvested and planted are balanced. The Central-European concept of sustained yield forestry corresponds fully to what the farmers do. They only harvest mature components, as pre-determined by the “agroforest” design. Crop rotations are either single or multiple.

Gedeo land use hence shows both mixed cropping with a single crop rotation, and mixed cropping with multiple rotations. Single rotations combine annual and perennial crops separately, i.e., group-wise, one part of the farm being given to annuals and another part to perennials. Both kinds of crops are harvested totally at the same moment. This is single rotation per field. Grain crop fields with diverse land races, even-aged *ensete* plantations with diverse clones or tree lines with diverse species express this. This method is emphasised in the highlands and, to a limited extent, exists in the lowlands. Multiple crop rotation, emphasised in the midlands, consists of mixed, uneven-aged plantations of mainly perennials, harvested selectively when mature. Only consumable biomass is harvested, the rest is left in the field. After decomposition it is absorbed by plant roots and stored in the living plants. The soil is so maintained as a production base.

Since only a small proportion of the farm area is harvested and replanted, damage to the site by rainwater erosion or by sunburn is also minimised. This type of agroforest management needs high precision. A farmer who bypasses planting *ensete* for a single season is like a marathon runner, who looses a few seconds, so meeting formidable difficulties to catch up, and risking to lose the race. Since the Gedeo store much of their products in living plants and animals, storage is no problem for the farmers.

Chapter six also touches on pest or disease treatment, marketing and related problems. No organism is intrinsically harmful to the farmers. It only can be made harmful. The weedy flora, for instance, is used to protect future yields, first by providing physical cover, second by conserving soil nutrients in its biomass, later sharing them with “crop” plants after the nutrients return to the soil by mulching the weeds.

Chapter seven deals with soils and soil management by farmers. The soils are clay-loam, their pH (H_2O) ranging between 5 and 6. The limiting factor is available phosphorus (range 1.0 to 4.0 ppm). Organic matter (%) ranged between 4 and 5, total nitrogen (%) between 0.3 to 0.5, and cation exchange capacity (meq/100g soil) from 21.0 to 25.0. Gedeo soil management is organic, using crop by-products, leaf litter from multipurpose trees and “weeds”, household wastes, rotation of dwelling sites and farmyard manure. Most farmers do not know mineral fertilisers. The complex crop mixture would make their use highly unreliable and risky.

Chapter eight reviews the carrying capacity of Gedeo “agroforests”. High productivity of *ensete* and judicious use of accompanying crops makes for a very high carrying capacity. Six mature *ensete* plants (*ganttícho* type) feed an adult during a year. A farm household of seven persons then needs an area of no more than 0.2 hectare for a sustainable yearly supply of 42 *ensete* plants, *gantticho* type. Extra land is used for other crops.

Synthesis

Chapter nine synthesizes the different findings and their implications. Gedeo land use contains elements of shifting cultivation. This is inherent in management at the level of an *agro/silvatic-mosaic*, which like shifting cultivation maintains part of the land under fallow. Like shifting cultivators, Gedeo farmers use eco-units at different stages of development. Whereas shifting cultivators burn and convert mature forest plots, the Gedeo harvest and replant mature components in "agroforests". In shifting cultivation, exhausted fields revert to fallow, whereas cultivation and regeneration are spot-wise and simultaneous in Gedeo farms. The farmers achieved this by selecting crop components with *pacemaker*, *spacemaker* and/or *placemaker* roles, such as *ensete* and multipurpose trees with more than mere production value. This is proof that the system developed from shifting cultivation and also explains their millennia of sustainability. Diversity and spatial and temporal arrangement of crops are the pillars that sustain the design. Diversity in crops and in their organization leads to high diversity in and among eco-units. The buffer capacity of the system to destabilizing forces depends on this whole constellation

Land use design is fundamentally similar in the three agro-ecological zones. The basic theme is mixed cropping, managed at a high level of complexity, i.e., the level of the *agro/silvatic* mosaic. However, two different strategies may lead to one objective, sustained yield (Ch. 6). The first is using a single crop rotation. This strategy stands out in the highlands, less so in the lowlands. Eco-units (small ecosystems) are quite large-sized under single rotation, because crops are annual, such as grains and leafy vegetables. Trees are then planted along farm edges or roadsides and isolated in farmlands. Single rotation crops are grown once during every cropping season.

For instance, a highland plot under barley in the previous year is now put to pulses, vegetables, or onion, after applying farmyard manure. A similar sequence is followed in the lowlands, where a maize plot is planted next year to haricot or sweet potato. Perennials are more frequent in the lowlands than in the highlands, because other perennial crops such as coffee and *ensete* require shading. Single rotation cropping is favored on relatively moderate slopes and flat landscape, particularly in the highland plateaux, with lesser risk of erosion by rainwater. The strategy is evidently appropriate.

The system of multiple rotations belongs to the midlands, undulating and with steep slopes. Due to the average growth conditions, this zone combines elements from both highlands and lowlands. It supports the most complex cropping system, with a forest-like appearance. A rich mixture of short-rotation crops of annuals, crops like *ensete* and coffee with moderate rotations, and diverse species of woody perennials with long rotations is present. This is multiple rotation, each of the many crop components being harvested and replaced as it comes to maturity, following its own rotation. Eco-units are smaller and are similar to one-tree *eco-units* in natural forests (ch.5 and 6).

Ensete proved to be the highest-yielding Ethiopian food crop. *Ensete* yields over 5.6 tons ha^{-1} $year^{-1}$ under Gedeo "agroforests". Areas of Ethiopia today without *ensete* could benefit from the species by introducing it as a homestead crop for times of hardship. *Ensete* clones selected as vegetables can be planted as fodder in good times and for human consumption during drought. *Ensete* can also conserve and/or restore soils in erosion-prone highland areas. Soil conservation then goes with *ensete* consumption in good and bad times.

Though *ensete* is essential for food security of Gedeo farmers and town populations, no development projects commensurate with its importance exist. This should change. A comprehensive development effort should be based on *ensete*. For instance, *ensete* farmers can be assisted by subsidizing prices for *ensete* planting materials and compost, like the Coffee Improvement Project supplied coffee seedlings to farmers.

Obstacles to *ensete* development mainly emanate from the mind. Raising awareness among farmers in non-*ensete* areas hence should have priority. *Ensete* does have some problems, such as *ensete* wilt (*Xanthomonas musacearum*), in *ensete* monocultures. It is believed to have originated with *ensete* and to attacks bananas too. Due to the high number of mixed crops grown with *ensete*, the disease is minor among the Gedeo. Only sanitary precautions work, such as separating affected plants from healthy ones, and/or disinfecting tools before entering an *ensete* field. Improved control techniques are indispensable if *ensete* is to be cultivated on a wider scale. So is improving the traditional *ensete* processing technology, in concertation with the farmers.

The main obstacle to *ensete* development is historical prejudice. Ethiopia is fortunate to have a solution at hand to her twin problems of food shortage and soil erosion. These could directly and simultaneously be solved by *ensete* development. The need to invent new methods of processing *ensete* food will be strong with the promotion of wider *ensete* cultivation, and also the need of development of technologies using *ensete* products, such as fibers and starch, as raw materials.

New education curricula should focus on better uses of local resources. The level of employment provided by *ensete*-based systems is inadequate by any standard. It is worsening with growing population. Agro-industries, in tune with *ensete*–based land use as a source of raw materials, should be designed and built. Organically grown arabica coffee of the Gedeo should be certified and processed *in situ*. Woodworking shops in towns now exploit multi-purpose trees unsustainably. These shops need incitements to assist farmers in getting equitable value for producing quality wood.

Unused biotopes for integrating components in the system still exist or can be opened up in Gedeo "agroforests", e.g., for a multipurpose tree species such as *Morinaga* sp. (locally called *shiferaw*), a leguminous hardwood, the leaves of which are eaten as a vegetable. Diverse species of wild mushrooms can be domesticated.

Given the high capacity of the systems to produce biomass with high diversity, it is urgent to enhance the productivity of these systems by carefully redesigning existing composting processes. Generally, ways and means should be found for cultivation of miniature crops of high value in the soil and the canopy, particularly tiny organisms such as nitrogen-processing bacteria, mycorrhizal fungi or medicinal lichens.

Conditions are favorable to initiate such developments among the Gedeo. The federal system of government in Ethiopia supports development of local initiatives. However, in the Gedeo zone this opportunity was not fully used, despite favorable conditions.

Three institutions of higher education exist in Dilla town; the Dilla University College of Teacher Education and Health Sciences, Dilla junior Agricultural College and Dilla College of Vocational Training. Their manpower and facilities qualify for planning Gedeo development. Nothing forbids initiating Gedeo Development Studies. *Ensete* is endemic to Ethiopia. The educational value to mankind of *ensete*-based Gedeo land use is obvious and significant. The international community can profit from the exemplary value of Gedeo land use, if organisations such as UNESCO's Man and the Biosphere Program (MAB) initiated *in-situ* conservation, extension and education.

Full understanding of Gedeo systems needs insight in the complex background of historical, socio-economic, cultural and political factors. The present, broad study is the first of its kind in *ensete* land use. It offers a theoretical and practical framework, and baseline data for designing ecologically sound land use in marginal areas, such as mountainous regions beset with soil erosion. It offers a theoretical background for the study of other *ensete*-based systems in Ethiopia. It also shows how the in-built high productivity and high maintenance qualities of *ensete* can be enhanced by a cropping design that favors better expression of these qualities. Gedeo land use is self-regulating and self-regenerating. From the farmer, it demands harmonization between protection and production functions. The present findings support farmers who in the past decided not to participate in ill-fitted alternatives presented to them.

Gedeo farmers also produce for the market. They use cash in most transactions. They pay taxes, buy items they do not produce, contribute to local insurance schemes (*olla'a* or *iqqub*), or invest in the long term, such as house construction.

The Rift Valley and its inhabitants were a source of civilized human development for millennia. The present study demonstrates that principles of sustainability were successfully woven in at least some of their societies. It therefore advocates building on this basis by studying and teaching these principles as a base for new, sustainable land use design in the twenty first Century.

SAMENVATTING

Dit boek omvat de studie van landgebruik zoals het Ethiopische Gedeo volk dat al vijfduizend jaar lang beoefent. Het land der Gedeo ligt in de hooglanden tussen 5^{o} en 7^{o} NL en 38^{o} en 40^{o} OL, op de flanken van de Riftvallei tegenover het Abaya-meer. De hoogte varieert tussen 1200 m boven NAP nabij dat meer en 3000 m boven NAP bij Bule. De Gedeo benadrukken meerjarige gewassen. Door de vele bomen zien hun akkers eruit als bos. Gedeo landgebruik volgt in hoge mate de natuur. Beneden de bomen groeit een der beste koffie-variëteiten ter wereld, Yirga-Chaffee, een cultivar van *Coffea arabica* L. Er groeit ook ensete (*Ensete ventricosum* (Welw.) Cheesman), die voedsel van zeer hoge kwaliteit produceert, hoog gewaardeerd tot in Addis Abbeba. Ook worden hier honing en zaaghout voortgebracht, en een superieur ras schapen. Verder maakt hun unieke landgebruikssysteem de Gedeo immuun voor hongersnood door droogte, de gesel van de Ethiopische hooglanden. Tenslotte is de streek van de Gedeo dicht bevolkt met rond 500 inwoners per km^2. Ondanks steile hellingen wordt het erosierisico door vernuftig gebruik van de vegetatie gebufferd.

Het centrale thema van de huidige ecologische studie is het opdoen van meer inzicht in holistisch landgebruik om zo bij te dragen aan de bekwaamheid tot ontwerpen van de locale boeren, die zo de problemen van plattelandsontwikkeling beter aan kunnen. Dat zijn verminderend reserveland en toenemende marktinvloed. Ontwerpen van teelt en andere functies wordt benadrukt. In gangbaar landbouwonderzoek vaak vergeten aspecten krijgen aandacht, bv. redenen van afkeer van boeren van nieuwe technologie, en veelvuldige onderwaardering van hun producten en diensten. De resistentie van de boerenpraktijk tegen ecologische en sociale druk wordt beschouwd. Deze factoren zijn essentiëel om boeren beter te begrijpen. Het huidige onderzoek richt zich op theoretische en praktische aspecten van ontwerp en prestatie van farms. De theorie stoelt op die van de bosoecologie (Hfd. 4, 5 en 7). Praktisch is het ontwerp bekeken vanuit het dagelijks boerenbeheer van natuurlijke hulpbronnen (Hfd. 6 en 8). De ontwikkelingsgeschiedenis van het Gedeosysteem krijgt aandacht.

Hoofdstuk 1 gaat over de landbouw in Ethiopië. Herhaalde problemen met voedsel en milieu zijn te wijten aan het ruwe, bergachtige terrein van de hooglanden, voor "moderne" landbouw ontoegankelijk. Niettemin werd meestal het goed aangepaste plaatselijke landgebruik genegeerd. Dit hoofdstuk belicht nu juist het potentiëel van locaal traditioneel landgebruik, mits ondersteund, om ook honger te bestrijden en het milieu te beschermen. Het toont hoe de rol van *ensete* achterbleef door historische en culturele vooroordelen. Dan wordt de schijnwerper op de Gedeo-samenleving gericht, haar omgeving, godsdienst, geschiedenis en contacten met de buitenwereld. Enkele redenen worden besproken waarom de Gedeo, met hun unieke landgebruik, niettemin als op een eiland geïsoleerd bleven en het toch overleefden.

Hoofdstuk 2 presenteert context en veld van de huidige studie. Methodologische kwesties van vroeger onderzoek worden besproken. Bosecologische methoden voor onderzoek van natuurbos, en hun gebruik in dit werk, worden uiteengezet. Het Gedeo landgebruik biedt een unieke kans om iets te leren over landgebruik in marginale gebieden en het begrippenkader van de agroforestry te verbreden. Dit laatste is een openlijke doelstelling van ICRAF.

Hoofdstuk 3 bouwt voort op bovengenoemde methoden en vragen. Er ontstond een interdiciplinaire invalshoek door het Landbouwbureau voor de Gedeo Zone (ABGZ) en zijn ontwikkelingsdoelen in te schakelen. Dit bureau werd gehinderd doordat de juiste richtlijnen voor zijn ontwikkelingsinspanning ontbreken. Beschikbare resultaten van onderzoek pasten immers niet bij de realiteit van het landgebruik der Gedeo. De huidige schrijver weet er alles van, na zes jaar directeur van dit bureau te zijn geweest. De medewerkers van het bureau waren onmisbaar bij het onderzoek.

Het is veelbetekenend dat dit onderzoek komt op een tijd waarop de wereld grote verandering ziet komen in twee gangbare landgebruikssystemen, land- en bosbouw. Het oude beeld van scheiding tussen landbouw- en bosbouwonderzoek zakt nu in, onder de accumulatie van "vervelende afwijkingen". Agroforestry, een zeer jong interdisciplinair wetenschapsgebied, moet het gat vullen. Niettemin integreert de agroforestry zoals zij op het ogenblik wordt opgevat, de twee gebieden niet en slaat slechts een brug. Een verder geïntegreerde conceptuele achtergrond is nodig.

Zulk een compleet beeld is een sleuteleigenschap van traditionele, duizenden jaren oude systemen zoals dat van de Gedeo. Inderdaad moet er, voor de wegen van landbouw en bosbouw zich scheidden, een soort agroforestry hebben bestaan en niet andersom. Land- en bosbouw zijn van later tijd, overgespecialiseerde nakomelingen van een meer omvattende voorouder, een zeer complexe vorm van landgebruik. Het gebruik van land door de Gedeo, met rijke menging van soorten en structuren, is een dergelijk landgebruik, waarbij het huidige onderzoek theoretische aanwijzingen bevat voor de hypothese dat het Gedeo systeem inderdaad zo'n voorouder is. Het onderzoek verschaft ook een theoretische en praktische achtergrond voor problemen van landgebruik en –ontwikkeling in berggebieden met genoeg regen.

De basis van de onderzoekmethode was de architectuuranalyse van Hallé & Oldeman (1970; Hallé & al. 1978; Oldeman 1990). Architectuur is de ruimtelijke verdeling van interactieve ecosysteem-componenten en hun eigen vorm, die samen de organisatie uitdrukken via grafische, niet numerieke parameters. Deze benadering verschaft meer inzicht in agroforestblokken als waren het blokken bos, waarin mensen een aantal krachten van het natuurbos vervangen of sturen. Twee nuttige noties voor ecologische integratie zijn *"eco-eenheid"*, minimaal ecosysteem ontstaan na simpele "verstoring", en *"agro/silvisch mozaiek"*, het mozaiek dat uit interactieve, natuurlijke, kunstmatige, of "agro-natuurlijke" eco-eenheden is samengesteld.

Een *eco-eenheid* is één ecosysteem, dat zich op één moment op één oppervlak begint te ontwikkelen en daarbij één ontwikkelingsproces volgt (Rossignol & al. 1998, p.152). Een voldoende groot agrobos om alle mogelijke varianten van eco-eenheden (alle leeftijden en ontwikkelingsstadia) samen te omvatten bevat een compleet *agro/silvatisch mozaiek*. Men neemt aan dat agro-bossen en natuurbossen een vergelijkbaar patroon van hulpbronnen hebben, waarvan het beheer door dit patroon wordt bepaald. De drie agro-ecologische hoogtezones langs de Rift-vallei worden gezien als *landschappen*, het hoogste ecologische organisatieniveau in deze studie.

Het beheer van een stuk land van een Gedeo ligt een niveau lager, dat van het mozaiek. Dit .verschilt compleet van de monocultuur, waarin elk veld een eco-eenheid op zichzelf is, tegelijk geoogst (initiële gebeurtenis) en direct daarop ineens beplant (een zelfde ontwikkeling zet in op dat moment). Op door Gedeo's beheerd land is daarentegen elk veld een mozaiek met vele kleine, natuurlijk aandoende eco-eenheden. Monoculturen beslaan zodoende veel land, want hun gelijkjarige eco-eenheden zijn groot en talrijk.

Hoofdstukken 4 t/m 8 geven de resultaten van deze analyse. Ecosystemen ontwerpen (hfd. 4) gaat prachtig in het kader van bovengenoemde niveaus. Dit is aangetoond met bloktransecten door agrobossen in elk van de drie agro-ecologische zones. Daarop kan men makkelijk organismen met hoofd- en bijfuncties onderscheiden.

De betekenis van ensete in de drie hoogtezones berust op biologische diversificatie. De plant verschaft boeren hun dagelijkse behoeften en maakt ook de productie duurzaam. In het hoogland groeien eenjarige gewassen bij *ensete*, gerst, bonen, erwten, en groenten zoals *kale* (koolsoort), ui en knoflook. Ook is er vee. In het laagland worden, samen met *ensete*, mais, *qoqee* (*Phaseolus lunatus*), andere peulvruchten, zoete aardappelen (*Ipomoea batatas*), knolgewassen zoals *boyina* (yam, *Dioscorea abyssinica*), *godarre* (*Colocasia esculenta*) en/of pompoenen geteeld. In de middelhoge streken is Arabische koffie de belangrijkste subsidiaire plant bij *ensete*. Houtige planten en vee zijn overal door de drie zones aanwezig, maar hun aandeel en rangschikking zijn verschillend.

Hoofdstuk 5 bouwt voort op het concept achter het ontwerp en bespreekt toepassing ervan in agro-ecosysteem architectuur rond het voorbeeld van *ensete*. De rol van *ensete* als *pacemaker* wordt belicht. Zijn omloop van 7 tot 12 jaar, afhankelijk van de hoogteligging, bepaalt in elke zone het grondrythme van het beheer, waarop alle andere omlopen zijn afgestemd. Door zijn anatomie geschikt voor wateropslag en met zijn dichte wortelmat van van 30 tot 60 cm diep, met een soort strooiselomzetting die de bodem op peil houdt, is *ensete* meer dan een gewoon productiegewas. Door zijn vermogen tot waterbeheersing levert hij een organische oplossing voor erosie-problemen in geaccidenteerde hooglanden. Met zijn trechter van bladeren leidt hij regenwater naar het reservoir, gevormd door de bladscheden, en laat het langzaam weer vrij. Hoofdstuk 5 bespreekt ook het systeem van teelt met meervoudige omlopen. Het blijkt dat gebruik van *ensete*, als voorbeeld van zo'n systeem, de boer toestaat om voor tien jaar nuttige biomassa in cohorten levende planten op te slaan.

Ook bespreekt hoofdstuk 5 andere agrosysteemcomponenten. Het landontwerp der Gedeo harmoniseert teelt op en bescherming van het land. Teeltcomponenten zijn daarom òf kern-, òf bijkomende componenten. De eersten zijn zowel *pacemakers* van het agro-ecosysteem rythme, als *spacemakers* voor kunstmatig vergrote biotopen voor andere gewassen, als tenslotte *placemakers* van biotopen voor wilde flora en fauna. *Ensete* en allerlei houtige meerjarigen zijn kerncomponenten. Deze zijn als het ware de hoekstenen van het intacte systeem. Bijkomende componenten zijn "opvullers" die nog ongebruikte biologische mogelijkheden voor zichzelf en de boer nuttig maken. Zo zijn er koffie, eenjarige gewassen, tuinbouwgewassen, en huisdieren.

Hoofdstuk 6 betreft principes en praktijk van beheer van natuurlijke hulpbronnen door boeren, en de wijze waarop zij duurzaam producten en diensten uit agrobos verkrijgen. De boeren richten zich vooral op optimalisatie van de interactie tussen componenten. Aantal en massa van te oogsten en te planten agro-bos componenten zijn in evenwicht. Dit vindt men net zo in het principe van Midden-Europese duurzame bosbouw. Slechts oogstrijpe componenten worden weggenomen, volgens het tijdschema in het ontwerp. De omlopen, perioden tussen zaaien of planten en oogsten of kappen, zijn enkelvoudig of meervoudig. Maar in het Gedeo landgebruik horen beiden bij menging van gewassen.

Enkelvoudige omlopen combineren de een- of meerjarige gewassen groepsgewijs per soort. Elk krijgt een deel van het land van de boer, en elk deel wordt totaal geoogst en herplant of ingezaaid op zijn eigen tijdstip. Er is dus een enkele omloop per perceel. Dat wordt uitgedrukt in landschappen met velden met diverse landrassen van diverse gewassen, afgewisseld met gelijkjarige *ensete*- percelen en bomenrijen, vooral in het hoogland en ook wel in het laagland. Meervoudige omlopen in hetzelfde perceel kenmerken de middelhoogten. Elk perceel omvat gemengde, ongelijkjarige plantages met een basistructuur van meerjarige gewassen en selectieve oogst van rijpe exemplaren. Slechts consumeerbare biomassa wordt geoogst, alle oogstafval blijft in het veld, zeer veel bij *ensete*. Na vertering door micro-organismen wordt deze geabsorbeerd door plantenwortels en in levende planten opgeslagen en blijft de bodemproductiviteit op peil.

Oogst van slechts van een klein, in kleine stukjes verspreid, deel van het boerenland, voorkomt schade aan de groeiplaats door bodemerosie of zonnebrand, die mycorrhizen-schimmels doodt. Dit vergt beheer van hoge precisie. Een boer die per ongeluk een seizoen overslaat of fout invult is gelijk een Marathon-loper die door luttele seconden nalatigheid zeer moeilijk kan bijblijven en zelfs de wedstrijd verliest. Daar de boeren veel van hun producten opslaan in levende organismen is opslagruimte geen probleem.

Hoofdstuk 6 behandelt ook ziekten en plagen, alsook marketing en andere problemen. De boeren vinden geen enkel organisme echt schadelijk, het wordt slechts schadelijk gemaakt bij fout beheer. “Onkruid” dekt eerst de komende oogst beschermend af, en verzamelt in zijn biomassa voedingsstoffen, die na mulchen weer naar het gewas gaan.

Hoofdstuk 7 gaat over bodems en hun beheer door Gedeo boeren. Het is kleileem met een pH (H_2O) tussen 5 en 6, tekort aan beschikbare P (2 tot 5 ppm), een organische stof-gehalte tussen 4 en 5%, totale stikstof tussen 0,3 en 0,5% en CEC van 20,0 tot 25,6 meq. per 100 g bodem. Gedeo bodembeheer is organisch, met behulp van gewas-bijproducten zoals strooisel van bomen voor meervoudig gebruik, “onkruid”-biomassa, organisch huishoudelijk afval, verrijkte bodems vrijkomend door verhuizing, en dierlijke mest. De boeren kennen nauwelijks minerale meststoffen. Hun gebruik zou in de zeer complexe Gedeo-percelen ongewis en riskant zijn.

Hoofdstuk 8 evalueert de ecologische draagkracht van Gedeo agro-bossen. Die is zeer hoog door de hoge *ensete*-productiviteit en slim gebruik van begeleidende gewassen. Zes rijpe *ensete*-planten (*ganticho* varieteit) kunnen een volwassene een jaar lang voeden. Een boerenhuishouden van 7 personen heeft dan slechts 0,2 ha nodig om te voorzien in 42 *ensete* planten van het cultivar ganticho. Er is dan extra land over voor andere doelen.

Synthese

Hoofdstuk 9 geeft de synthese van resultaten en gevolgtrekkingen. Gedeo landgebruik bevat elementen van zwerflandbouw. Dit is ingebouwd in beheer op het niveau van het agro-silvatische mozaiek, waarin een deel van het land braak ligt zoals bij zwerfbouw. Evenals zwerfbouwers gebruiken de Gedeo eco-eenheden in verschillende stadia van ontwikkeling. Zwerfbouwers branden hele volwassen bospercelen plat en converteren ze naar eenjarige gewassen. De Gedeo, daarentegen, oogsten en herplanten pleksgewijs en gelijktijdig. In de zwerfbouw liggen verbruikte percelen braak, bij de Gedeo nooit, omdat direct hier en daar jonge gewassen worden geplant.

Dit doen de boeren door met zorg componenten te selecteren als *pacemaker*, *spacemaker* en/of *placemaker*, met name *ensete* en ook bomen, voor meer dan louter productie. Dit toont dat het systeem van zwerfbouw komt, en verklaart de duizendjarige duurzaamheid. Diversiteit en complexe rangschikking in ruimte en tijd zijn de pijlers van het ontwerp. Gewasdiversiteit en de organisatie ervan leiden ook tot zeer diverse eco-eenheden en tot diversiteit in die eenheden. Deze opbouw maakt dat destabilisatie wordt gebufferd.

Het ontwerp zelf is zeer vergelijkbaar in de drie agro-ecologische zones. Het is overal gemengde teelt, beheerd op een zeer complex niveau, het agro-silvatisch mozaiek. Twee strategieën leiden daarbij tot het ene doel, duurzaamheid (Hfd. 6). De eerste is de enkelvoudige omloop, vooral in de hooglanden, minder in het laagland. Eco-eenheden, de kleinste ecosystemen, zijn er betrekkelijk grote velden, gelijkjarig, met één omloop, en met veel eenjarige gewassen zoals granen en groenten. Bomen staan in rijen langs wegen of grenzen, of vrij in een veld. Per groeiseizoen en per veld is er een omloop.

Zo wordt een perceel waar vorig jaar gerst stond nu in gewasrotatie voor peulvruchten, groenten of ui gebruikt na bemesting met dierlijke mest. Zulks gebeurt in het laagland met maispercelen,een jaar erna bonen of zoete aardappelen dragend. Hoe lager gelegen, des te meer houtige gewassen, ook omdat lagere gewassen als *ensete* en koffie schaduw vereisen. Enkelvoudige omlopen horen bij flauwe hellingen en vlak landschap, vooral op de bergplateaus waar het erosierisico minder is. Deze strategie is duidelijk aanpassend.

Meervoudige omlopen horen bij het geaccidenteerde middelland met steile hellingen. De gemiddelde groeiomstandigheden combineren er aspecten van hoog- en laagland. Men vindt er het meest complexe teeltsysteem, met een bosachtig uiterlijk. Een rijk mengsel is aanwezig van eenjarige gewassen, culturen met gemiddelde omlopen (*ensete*, koffie) en talrijke houtige soorten met lange omlopen. Voor elke soort geldt een eigen omloop, en oogst op de tijd van rijpheid. Eco-eenheden zijn klein en lijken op de “enkele-boom” eenheden uit natuurbos (Hfd 5 en 6).

Ensete is aantoonbaar de Ethiopische voedselplant met de hoogste opbrengst, nl. 5,6 ton/j/ha in Gedeo agrobossen. Waar er in het land nu geen *ensete* groeit, kan Ethiopië profiteren van invoering ervan als erfgewas voor kwade tijden. Als groente eetbare *ensete*-klonen kunnen in goede tijden het vee voeden en bij droogte de mens. *Ensete* kan ook bodems beschermen en/of restaureren in hoogland met erosiedreiging. De drie functies gaan zeer goed samen, of het nu goed of slecht gaat.

Hoewel *ensete* essentiëel is voor voedselzekerheid van Gedeoboeren en stedelingen, zijn er geen ontwikkelingsprojecten die daarmee rekening houden. Dit zou moeten veranderen. Inspanningen voor veelomvattende ontwikkeling kunnen zonder *ensete* niet. Waarom bij voorbeeld niet *ensete* plantgoed en compost voor boeren subsidiëren, zoals nu gebeurt met koffiezaailingen in het Coffee Improvement Project?

Bezwaren tegen *ensete*-ontwikkeling zitten vooral tussen de oren. Voorlichting aan boeren in streken zonder *ensete* moet dus voorrang krijgen. Problemen zijn bijv. de verwelkingsziekte bij *ensete* (*Xanthomonas musacearum*) in monocultuur. Men gelooft dat deze ziekte van de *ensete* komt en ook bananen aantast. De hoge mengingsgraad van gewassen maakt de ziekte bij de Gedeo onbelangrijk. Echter werken alleen hygiënische maatregelen, zoals het scheiden van zieke en gezonde planten en het schoonmaken van gereedschap alvorens een veld in te gaan. Betere bestrijdingsmethoden zijn onmisbaar alvorens de *ensete*-cultuur over de natie te verbreiden. Ook de verwerkingstechnologie voor *ensete*-producten moet in samenspraak met de boeren verbeterd worden.

Het grootste struikelblok is historisch vooroordeel. Ethiopië kan zich gelukkig prijzen met een oplossing voor de structurele tweeling van problemen, honger en erosie, die namelijk beiden tegelijk met *ensete* kunnen worden aangepakt. Daarom werd de noodzaak van vernieuwing genoemd, in de verwerking van *ensete* voedselproducten, alsmede voor technische verwerking van *ensete* vezels en zetmeel als grondstoffen.

Scholing en opleidingen zouden moeten worden georiënteerd op beter landgebruik. Het niveau van werkgelegenheid in systemen op basis van *ensete* is op geen manier te rechtvaardigen. Het verergert met de bevolkingsgroei. Ook dit vereist ontwikkeling en bouw van met *ensete*-culturen geharmoniseerde industrie. Organisch geteelde *arabica* Gedeo-koffie zou lokaal moeten worden verwerkt en gecertificeerd. Houtverwerkende werkplaatsen in stadjes exploiteren nu de bomen niet duurzaam. Zij zouden moeten worden gestimuleerd om boeren een billijke prijs voor hoge kwaliteit hout te betalen.

Aan de complexe Gedeo teeltsystemen kunnen nog steeds nieuwe gewassen worden toegevoegd in nu “lege” biotopen. Een boom voor meervoudig gebruik zoals *Moringa* sp., die hardhout produceert en bladeren als groente, kan erbij komen, maar ook wilde paddestoelen. Gegeven het hoge productievermogen bij hoge biodiversiteit is het dringend nodig, verbeterde composteringssystemen te bedenken. Algemener zouden wegen moeten worden gezocht om miniatuurgewassen met hoge toegevoegde waarde te verbouwen, zoals geselecteerde stikstofbindende bacteriën, mycorrhizenschimmels of medicinale korstmossen. Dat is beter gebruik van de bodem en het kronendak van de agro-bossen.

De omstandigheden zijn nu gunstig om zulke ontwikkelingen onder de Gedeo in gang te zetten. Het federale regeringssysteem in Ethiopië ondersteunt de ontwikkeling op locaal initiatief. Ondanks deze gunstige situatie hebben de Gedeo de kansen nog niet volledig benut. Er bestaan in Dilla drie hogere opleidingen, nl. het Dilla University College of Teacher Education and Health Sciences, het Dilla junior Agricultural College en het Dilla College of Vocational Training. Hun mensen en middelen kunnen nuttig worden ingezet voor de planning van de ontwikkeling bij de Gedeo. Niets staat de oprichting in de weg van een Gedeo Centrum voor Geavanceerde Ontwikkelingsstudies. *Ensete* is endemisch in Ethiopië, maar de educatieve waarde ervan is grensoverschrijdend en raakt de hele mensheid. De internationale gemeenschap zou aan de ensete een voorbeeldrol kunnen geven, als bij voorbeeld MAB Unesco *in situ* behoud, onderzoek en onderwijs in deze gebieden zou initiëren.

Om het Gedeo systeem volledig te begrijpen is inzicht in de complexe historische, sociaal-economische, culturele en politieke samenhangen en factoren nodig. De huidige brede studie is de eerste van zijn soort over *ensete* landgebruik. Hij verschaft een theoretisch en praktisch raamwerk en basisgegevens voor het ontwerp van ecologisch gezond landgebruik in marginale streken, berggebieden met erosierisico bij voorbeeld. Hij verschaft een theoretisch kader voor de studie van complexe teeltsystemen zoals de andere *ensete*-systemen in Ethiopië. Hij verschaft inzicht in de mogelijkheden van verder versterking van de eigenschappen van *ensete*-systemen op het gebied van hoge productie in combinatie met hoge stabiliteit, dus duurzaamheid. Gedeo systemen zijn zelf-regulerend en zelf-regenererend. Zij vergen van de boer de harmonisatie van productie- en beschermingsfuncties. De huidige studie rechtvaardigt de afkeer van deze boeren tegen hun in het verleden aangeboden, moderne, doch hierbij niet passende "ontwikkelings-alternatieven".

Gedeo boeren produceren inderdaad ook nu al voor de markt. Zij gebruiken geld voor de meeste transacties. Zij betalen belasting, kopen artikelen die ze niet zelf maken, dragen bij aan locale onderlinge verzekeringen (*olla'a* of *iqqub*), ofwel investeren op de lange termijn, bij voorbeeld in de bouw van een huis.

De Riftvallei en zijn bewoners waren sedert millennia een bron van ontwikkeling van de menselijke beschaving. De huidige studie toont aan dat de principes van duurzaamheid door hen succesvol verweven zijn in minstens enkele van hun samenlevingen. Daarom bepleit dit boek om voort te bouwen op die basis door studie aan en onderwijs over deze principes, als fundament van innoverend ontwerpen van duurzaam landgebruik voor de eenentwintigste eeuw.

Glossary of technical terms

Archtecture**:** the spatial distribution of the interacting components and their forms in a system, expressing its organizination . Viewed on the level of a tree, architecture considers the spatial distribution of the organs and the form. Viewed on the level of an eco-unit, it considers the spatial distribution of trees and their form. Viewed on the level of a field, it considewrs the spatial distribution and form of eco-units within the mosaic in the field. Viewed on the level of a territory, it considers the spatial distribution and forms of mosaics in the territory (see Van der Wal, 1999, p9).

Agro-ecosystem an ecological system modified by man to produce food, feed, fuel, fibre and other products desired by man.

Adaptive strategy changes in the "normal" behaviour of agro-ecosystem components to fit into environmental and/or interrelational pressures.

Agroforestry a form of modern polyvalent land use accommodating aspects of forestry and agriculture but falling short to accommodate Gedeo "agroforests" which is an indirect common progenitor of modern forestry and agriculture.

Biomass refers to the total crop/plant mass (including the roots). But the term is also used here to refer to either the above-ground or below-ground mass.

Biodiversity: epiphenomenon of biocomplexity expressed as diversity of biological instruction carriers at one moment in biological time and at one biological scale level (Rossignol et al., 1998); the degree to which variation in properties exceeds the average in a structural way.

Biome: ecosystem uniting all interacting ecosystems at all levels in one large biogeographic region (Rossignol et al., 1998).

Biospher*e*: ecosystem uniting all interacting ecosystems at all levels on a planet (Rossignol & al., 1998).

Corm a short swollen underground stem that serves as an organ of perenation and vegetative propagation. The foliage and flower leaves form one or more axillary buds and grow at the expense of food reserves in the corm (Toothill, 1984). Cf. Rhizome, rootstock.

Crop performance: the character of the growth and development in the course of a biological cycle of a population of cultivated plants on a field (often expressed using such structural parameters as biomass yield). In *ensete*-based Gedeo systems farmers use the term to explain the pattern of crop development.

Eco-unit: one ecosystem developing on one surface, cleared by one impact, from one specific moment on , and one development process (see Rossignol, 1998, p152).

Endurance capacity to retain the original integrity in the face of destabilising forces through undergoing a cyclic change (adapted from Oldeman (1983)).

Ensete A genus of consisting of *Ensete edulis* and *Ensete* spp. div. (MUSACEAE): musaceous giant herbs akin to the common banana but in contrast to the latter their parenchymatous tissue, the pseudo-stem, together with the root (corm) can be decorticated and fermented into edible products.

Field*:* patch of land which has been subjected to at least some homogenizing action of man, intended to make possible its use for agriculture and which has the same use history over its whole surface.

Kebele: The lowest leagal administrave unit (in Ethiopia) into which a woreda is subdivided.

Land evaluation refers to assessing the potentials of a land for using it for a given purpose on a sustainable basis (FAO, 1976).

Multipurpose tree species are tree species purposely grown to provide more than one significant products and/or service function in the land use system they occupy (MacDicken, 1990.).

Neolithic relating to the latest period in the Stone Age characterised by polished stone implements. Generally referring to 10, 000 years ago (Fortey, 1998).

Of future use: refers to part of biomass meant for recycling, i.e., for the maintenance of the agro-ecosystem.

Of immediate use: refers to biomass meant for the present use, i.e., as opposed to the part meant for recycling.

Of the future: crop component that has not attained its maximal expansion potential and hence must be maintained in the field.

Of the Present: crop component that has attained maximal potential of its expansion and meant for harvest, e.g., *daggicho* in *ensete* plants which lose value if left in the field.

Pacemaker ecosystem components (e.g., trees in forests) that set and/or maintain rhythms of growth and development of ecosystems (Neugebauer & al. 1996).

Parameter a variable, generally easy to observe and measure, that changes in parallel to another variable.

Placemaker ecosystem components (e.g., trees in forests) that establish or maintain places for living beings or biotopes or ecological niches or habitats (Neugebauer & al. 1996).

Productivity the aggregated productive capacity of all the agro-ecosystem components exceeding the sum of average productive capacities of separately grown components.

Region: Any one of the eleven administrate units into which Ethiopia is currently subdivided. Also see table 1.1.

Rhizome an underground stem that grows horizontally and, through branching, acts as an agent of vegetative propagation and as an organ of perenation (Toothill, 1984). Cf. Corm, rootstock.

Rootstock a short erect underground stem, as seen in various angiospers, e.g., plantains (plantago); an equivalent of vertical rhizome (Toothill, 1984).

Spacemaker ecosystem component (e.g., trees in forests) that efficiently organise production space for living beings (Neugebauer & al. 1996).

Special woreda: an administrative unit (particularly in the Southern Nations, Nationalities and Peoples'Region) inhabited by one ethnic group, but because of its smaller geographical area short of a zone. See also *zone* and *woreda*.

Stability agrosystem capacity maintained by collective agro-ecosystem characteristics and minimising the negative effect of abrupt and unexpected change.

Sustainability continuity in time of collective agro-ecosystem characteristics, including agro-ecosystem properties like yield, maintained by the diverse interactions among agro-ecosystem components.

Land use pattern spatial and temporal regularity in the distribution of the use of fields by human community in their territory. In ensete-based systems the term is used in the context of land allocation to diverse crops.

Minimum tillage in this book refers to minimal level of soil working using the traditional African hoe and related impliments.

Pioneer plant species that is adapted to grow in empty biotopes, often linked to early development phases of eco-mosaics (Rossignol & al., 1998).

Plants of the future represents the younger class in the perennial components of ensete-based Gedeo systems. For example,younger class in ensete include simaa (seedling stage), kaassa (newly field-planted seedlinds).

Potential plants plants with a potential for growth (general). In forest trees, the term refers to trees with a potential for crown expansion (Oldeman, 1990, p167).

Shifting cultivation a general form of land use, confined to the tropics, in which fields are prepared for cropping by clearing tracts of forests, usually by slashing and burning.

Fields are cropped for one or more seasons and then left fallow for longer periods than that of cropping.

Species composition the distribution of plants and animals to a certain area taxonomic species, rated for their abuandance.

Surface yield yield referring to the real surface on which a crop is grown.

Sustainable agriculture (wide sense) agriculture in which the social, cultural, economical and natural contexts are reproduced and/or maintained (See Van der Wal, 1999). In a strict sense, the term refers to agriculture in which the level of productivity is maintained in the course of time.

Temperament the package of reactions of a plant towards its environmental stimuli (Rossignol & al., 1998).

Transfer of function transfer of a biological function within a living system from one subsystem or organisation level to another, ensuring a minimum cost-benefit ratio in terms of matter and energy and information (Rossignol & al., 1998).

Tree of the past (Oldeman, 1990, p167): a tree with a decaying or damaged crown, destined to run down to its death.

Tree of the present (Oldeman, 1990, p167): a tree with a crown that has reached its maximal expansion.

Woody perennial is any woody species purpusely grown as a crop. The term is used to refer to shrubs and trees together. Cf. Multipurpose tree species.

Woreda an adminstrative unit in Southern Nations, Nationalities and Peoples' Region, below a zone. See zone. A woreda in turn is subdivided into kebeles, the lowest official administrative unit.

Yield structural parameter indicating the weight of the harvested product of a crop either on individual plant basis or on the basis of the area over which the crop is cultivated. Farmers measure yield of their *ensete*-based systems on individual plant basis.

Zone an administrative unit, usually inhabited by one ethnic group, below the Region of Southern Nations, Nationalities and Peoples' Region.

Glossary of Gedeo words used

Adooleessa: A season with intermittent rains and sunshine, following *Haarsso*.

Baallee: A social-political system based on age grades, duties and responsibilities of a person changing hands every eight year.

Bakarro: One of the seven Gedeo tribes.

Baxxe: Foreyard of a residential area.

Badda'a: A general name for undomesticated plants.

Beyaa: Development stage of *ensete* below *idago* but above *guume*, of about ten years of age.

Ba'leessa: A dry season, following *Bonoo*.

Bu'laa: unfermented *ensete* foodstuff obtained by squeezing freshly processed but unfermented *ensete* biomass.

Cimaaleeyye: crop plants that have fully realized their growth potential. Applied to perennial crops such as trees.

Ceekoo: Tool used by women to pulverize *ensete* corm.

Cege'o: Sheep manure.

Bidiro: A wooden table on which women process *ensete* food.

Daamma: a grinding stone.

Dagama: A rack constructed immediately above the fireplace. Used to dry firewood, particularly in the rainy seasons. It is also used for storing seed or for smoking meat.

Daggicho: Development stage of *ensete* plants at which it flowers and dies.

Diboo: A kind of *ensete* bread prepared.

Dikko: a market place.

Dhiibata: Midlands, a dweller of the midlands

Dogodo: A shelter constructed over *hassuwwa*.

Dookko: Song played by women when working in a group, as in preparing food for a party.

Doobba'a: One of the seven Gedeo tribes.

Doobbala: A type of *waasaa* coming from *ensete* with decayed corm.

Doonee: A spherical container made from bamboo, used to store sun-dried coffee.

Gadda: A song sung during nights, after the burial of adults (those dying after marriage).

Gada: A name given to the traditional leader of the Gedeo people elected according to the *Baallee* tradition.

Gaamaa: Part of the corm reserved to be fermented, for use as a *gamama* or *a* starter in the future.

Gamama: Fermented corm used as a starter or yeast in fermenting *ensete* biomass.

Gatee: Backyard, used to grow vegetables and also for raising *ensete* suckers.

Gishsha: A cable used in climbing trees and also in directing falling trees by pulling it with the cable.

Golqqo: Refers to a seedling, mostly applied for seedlings of tree species.

Googgore: A group pray song played by women, during thanks-giving or pleading with *Mageno*. While women sing *googore*, men play *qeexala*.

Goottale: Refers to work group and to pooling labor at peak times, particularly in picking coffee or house construction.

Gorggorshsha: One of the seven Gedeo tribes.

Gorora: a fluid that oozes from plant part cut or damaged.

Guumee: Development of *ensete*, which is below *beyaa* but above *saxa*.

Haarsso: a rainy season, following the dry season, *Ba'leessa*.

Haanxxa: *ensete* fiber, one of the products of *ensete* harvest.

Hachcho: Live *ensete* leaf sheath used as a container, e.g., for a placenta in the ceremony of adopting a child.

Hanuma: One of the seven Gedeo tribes.

Ha'micho: *Ensete* corm, the stem of *ensete* plant.

Henbba'a: One of the seven Gedeo tribes.

Hiiloo: Pole-sized woody from shrubs and younger trees or branches from of older trees.

Hochcho: Live *ensete* leaf.

Hocoqo: *Ensete* dish prepared from *waasa* or *bu'la* by boiling it together with cabbage and/or meat.

Hofa: Surface released by crop plant harvest.

Hookko: Hook used to reach for distant plant parts such as coffee branches or *ensete* leaves.

Huuffee: *Ensete* sucker separated from the mother corm and planted in a line in the nursery. See *simaa*.

Idago: *Ensete* development stage in which it starts initiating flower, below *daggicho* but above *beyaa*.

Kaassa: Development of *ensete* which is above *simaa* but below *saxa*, about 2 to 4 years of age.

Ka'umaa: crop plants with unrealized development potential. Applied to perennial crop plants.

Kebbo: A kind of *ensete* bread among the Gedeo.

Ma'a: *Ensete* leaf sheath prepared for scraping.

Mageno: The Gedeo term for the God Almighty.

Maxarabaa: a small axe used by men in working wood or pruning small tree branches.

Ma'ne: Place in a tree for hanging a beehive. Such a place becomes ma'ne when bees are accustomed to it and arrive predictable periods of time. It is a production niche and named after the person who establishes it, by hanging a beehive first.

Meessanoo: an axe used in felling trees, and splitting wood for fire.

Meetaa: A wooden board used as a tool in *ensete* processing.

Meella: A song played by men when husking coffee using a mortar and pestle.

Mine: A residential place, the home.

Moocaa: *Ensete* foodstuff obtained by squeezing fermented *ensete* biomass (*waasaa*).

Moona; Livestock enclosure, for keeping animals usually cattle at night so as to collect their droppings.

Murgga gosallo: The aboriginal people whom the Gedeo regard as their ancestors.

Oncce: young bract leaves of bamboo, used to cover beehives.

Oki'a: Livestock fodder.

Oofee: Dried leaf sheath of *ensete*.

Okolee: Drum used in songs.

Olkka: Group song played in celebrations.

Oosee: the Gedeo term for an immature crop plant.

Oxa: Dish of *ensete* specially prepared to be carried on a journey.

Qaaqee: Gregarious edible fungi.

Qallee: A sport played by two teams like in foot ball with a hockey-like sticks and ball.

Qalo: immature, applied to trees.

Qaarxxa: mat made from bamboo splints, used for spreading fresh coffee beans in sun-drying it.

Qeexala: A popular group prayer or war song, played by both men and women, the latter sing *googore* while the men sing *qeexala,* beating rhino shields with a wooden hammer or jinffo, shaft of a spear.

Qocee: A small axe, similar to *meessano,* used for pruning tree branches and in working with wood.

Qotto: A tool used in digging the soil, the main planting and harvesting tool (see fig. 6.2).

Quncisa: A pancake of *ensete,*a popular dish among the Gedeo.

Rubbanaa: a groove of coffee trees planted on a private property by a farmer short of land.

Riiqata: Lowlands, a dweller of lowlands.

Saddeeqaa: A game played by two persons as in chess using *ensete* seeds as stones over a a wooden or stone board with goals or "houses"

Salaxo: A long slashing knife, also used in warfare.

Saxa: Development stage of *ensete* above *kaassa* but below *guumee*, between 4 and 6 years of age.

Sheffile: gleaning coffee, after the owners have harvested the main crop.

Shopha: A solitary edible fungus, a mushroom.

Simaa: Suckers of *ensete* intact on the mother corm. See *huuffee*.

Sirbba: A group song played by a group of women or girls on one side and a group of men or boys on the other.

Sissa: Tool used by women in scraping the parenchyamateous tissue from the *ma'a*.

Sonee: Messenger of honeybees. Swarms of honeybees take refuge on tree branches and send these messengers to look for appropriate beehives to be occupied.

Songgo: A village ritual, recreational place with a hut and sport place and items such as saddeeqa

Soro: Verandah of a house.

Suubbo: Cold highlands, a dweller of the highlands.

Tutume: firewood derived from old tree stumps.

Uranee: Farmhouse.

Waasa: Major fermented *ensete* product used as staple.

Were'o: A group song played by the Gedeo in respect of bravery of someone who succeeds in killing a lion or a leopard.

Weeddoo: A group song played in celebrations.

Wel'o: A wilt disease of *ensete*.

Weesee: Refers to *ensete* plants in general.

Wi'lishsha: A group song sung by the gedeo during day-time, after the burial ceremony of a deceased adult, see. *Gadda*.

Wobbisa: replacement planting, applied to harvest and replacement on a single plant eco-unit basis.

Xeeroo: An offering given to *Mageno*.

Xudee: Petiole from dried *ensete* leaves, used as fiber or firewood when dry.

Xetee: Root disease of *ensete* and other perennial crops including the trees.

Xibilliisa: Pods from *Milletia ferruginea* PAPILIONOIDEAE trees used as firewood during the dry season of *Ba'leessa*.

Xuxee: Termites feeding on roots of garden vegetables.

Xude: a fiber derived from a dried midrib of an *ensete* leaf.

Color plates

Wageningen University

The investigations reported in this text were carried out in the context of a sandwich scholarship provided by the Wageningen University. The Agricultural Bureau for the Gedeo Zone, provided employment for the investigator as well as office space and its human resources.

The project was started at the former Department of Ecological Agriculture, Wageningen Agricultural University and the write-up of the results was carried out in the auspices of the Indonesian-Dutch Hutan Lestari Project International.

The fieldwork was sponsored jointly by the Fred Foundation and the Agricultural Bureau for the Gedeo Zone. The mapping was sponsored by the Thurkow Foundation, Stichting Pro Natura, Treemail and Privateers N.V. Stichting Het Kronendak guaranteed and raised the funds for printing this work.

Privateers N.V. and Treemail made maps of the study area. Stereo radar images (S2/S7 beam) were procured from the Canadian RADARSAT satellite. The raw data were processed by Privateers N.V. into a digital elevation model with accuracy within 25m (x,y and z) and several derived products, including a contour map and an anaglyph. These maps proved to be of sufficient precision for planning and executing of the fieldwork.

Plate 4.1. Gedeo "agroforests": a general overview from the midlands (Qongga area). Note emergent tree species, particularly *Erythrina abyssinica* PAPILIONOIDAE (*weleenna*) trees conspicuous due to its red flowers and the ubiquitous *ensete* plants below. The building with corrugated iron sheets is the store of the Qongga and surrounding farmers' co-operative. (Photo taken by the author, 1999).

Plate 4.2. Gedeo "agroforests": a general overview from the midlands (Michchille-Shaakko'a area). Note the coffee below the shade trees. Photo taken by the author, in the dry season (*Ba'leessa*).

Plate 4.3. Gedeo "agroforests": a general overview from the lowlands (Tumaata-Cirrachcha area). Note the ficus (*Ficus* sp. MORACEAE (*xillo qilxxa*)) tree, overshading other perennial crops, *ensete (Ensete ventricosum (Welw.) Cheesman* MUSACEAE, coffee *Coffea arabica* L. RUBIACEAE and bananas (*Musa paradisiaca* L. MUSACEAE). Photo by the author (1998).

Plate 4.4. Gedeo "agroforests": a general overview from the highlands (Michchille-Uddo area). Note in the emergent trees *Erythrina abyssinica* PAPILIONOIDAE (*weleenna*).

Plate 4.5. Gedeo "agroforests": an overview from the midlands (the root floor, *Mokkeenssa* area). Note the seedling zone, used as a nursery of coffee.

Plate 4.6. Gedeo "agroforests"(midlands, Dodoro area): a mixed species, uneven-aged plantation. Note the diverse components *ensete*, of diverse ages and coffee, grown together. The leaf petiole of the *ensete* plant depicted in reddish blue (*kakke*) is used as a medicine for dry coughs (*qufa'a*).

Plate 5.1. Using e*nsete* (*Ensete ventricosum* (Welw.) Cheesman MUSACEAE) architecture for rainwater "harvesting". Note the giant leaf of *ensete* to the right of the plant. A mature *ensete* plant (at *daggicho* or *idago* stages, see glossary) can have from 8 to 12 functioning leaves, on the average. These leaves start from the corm, at the basal part where their base is serially inserted. The pseudo-stem is made up of the collection of these leaf-sheaths. These end at the whorl. Photosynthesizing leaves start just above the whorl. The leaf-sheaths act as a funnel, directing rainwater into the compartments. The latter are used as water storage tanks. Note how the pseudo-stem bulges towards the base and tapers towards the top. Also note the wide-opened basal leaf- sheaths, due to the weight of the rainwater inside them. Their opening in turn allows entrance of leaf litter (from the emergent trees, not shown), throughfall and animals such as insects and other arthropods, earthworms, frogs, snakes and/or rats. These animals are attracted by the space and food provided by the compartments. *Ensete* compartments are indeed biotopes. Note mulch of dried *ensete* leaves and leaf-sheaths (*oofee*) and "weedy" herbaceous vegetation in the root floor. Roots of *ensete* can attain a length of 5m , on the average, and a single mature *ensete* plant (at *daggicho* or *idagoo* stage) can have 350 roots, on the average. Roots from several *ensete* plants make a mat-like structure, protecting the soil from erosion, and on

decomposition, providing organic matter and improving soil aeration. The epidermis of roots however remains intact, acting in the soil like earthworm tunnels (White, 1997). The resulting hollow traps air. Note a coffee seedling planted just beneath the *ensete* plant so as to benefit from the water store. Each compartment can store from 0.25 up to 1liter of rainwater. Farmers use the water stored (*oo'yoo*) for washing after farm work. Photo taken by the author (2000), from the Tumaata-Cirrachcha area, about 1680m asl, a lowland zone.

Plate 5.2. *Ensete (Ensete ventricosum* (Welw.) Cheesman MUSACEAE*)* architecture responsible for rainwater capture. Several leaves of *ensete* intercept quite a large area so that very little rainwater that falls over them escapes. Note the giant petiole of the leaves, capable of directing huge amounts of rainwater towards the storage organs, i.e., compartments of leaf-sheaths. That small part of the rainwater that escapes is also trapped by the excessive mulch in the root floor of the dried *ensete* leaves (*hashupha*) and dried *ensete* leaf-sheaths (*oofee*) as well as the "weedy' herbaceous vegetation (plate 5.1). This shows the suitability of *ensete* for erosion-prone highlands. Photo taken by the author (1999), from the Gora-Dibaanddibbee area about 2680m asl, a highland zone.

Plate 5.3. *Ensete (Ensete ventricosum* (Welw.) Cheesman MUSACEAE*)* architecture responsible for soil conservation. Note the dried leaves (*hashupha*) and dried leaf-sheaths (*oofee*) protecting the rainwater stored within the compartments. Also note the largely emerged corm of the plant, showing the mature stage of the *ensete* plant. The *ensete* plant depicted is *toorachcho*, particularly used for soil maintenance. Its height from ground surface to the whorl was 4.5 m. Photo taken by the author (1993) from the Dodoro area about 2000m asl, a midland zone.

Plate 5.4. An example of a mixed species uneven-aged Gedeo "agroforest" from the lowlands (Tumaata-Cirrachcha area). Note the emergent and majestic *Ficus sp.* MORACEAE *(xillo qilxxa) tree*, shading an area of about 0.2ha. Photo by the author (2000), from the Tumaata-Cirrachcha area abut 1680m asl, a lowland zone.

Plate 6.1. *Ensete* (*Ensete ventricosum* (Welw.) Cheesman MUSACEAE) nursery, an example from the Daroo area (highlands zone, 2800m asl). Photo by the author (2000).

Plate 6.2. Block management of *ensete* (*Ensete ventricosum* (Welw.) Cheesman MUSACEAE) plantations, an example from the Daroo area (highland zone, 2800m asl). Photo by the author (2000).

Plate 6.3a A mixed species, uneven-aged Gedeo "agroforest", an example from the Jaanjaamoo area (midland zone, about 1850m as,). Photo by the author (2000).

Plate 6.3b. A mixed species, uneven-aged Gedeo "agroforest", an example from the Jaanjaamoo area (midland zone, about 1850m asl). Photo by the author (2000).

Plate 6.3c. An *ensete* seedling raised from botanical seed.

Plate 6.4a. Reiteration in coffee (*Coffea arabica* L RUBIACEAE), an example from the Banqqo-Okkoto area (midland zone, about 2100m asl). Photo by the author (2000).

Plate 6.4b. Litter on the root floor, an example from the Dodoro area (midland zone, about 2000m asl). Photo by the author (2000).

Plate 6.5. Crop management on the basis of one – plant *eco-unit.* An example from the Bilooyaa area (midlands zone, 1800m asl). Photo by the author (2000).

Plate 6.6. Use of the root floor for shade-tolerant crops, an example from the Ciicuu area (lowland zone, about 1680m asl). The plant depicted is taro or *godarre* (*Collocasia esculenta*). Photo by the author (2000).

Plate 6.7. Honey production in the tree canopy, an example from the Arraammo area (midland zone, about 1850m asl). Beehives in *Albizzia gummifera* (MIMOSACEAE) tree. Such trees are seen as producing ecosystems and not mutilated. According to farmers, honeybees are peace-loving creatures and do not occupy hives in mutilated trees. (Photo by the author, 1999).

Plate 7.1. *Moonaa*: from the Daroo area, highland zone (about 2800m asl). This is an enclosure with a view to the collection of cattle manure during nighttimes. Cattle are kept in the *moonaa* during the night and their droppings are collected, on the spot. Trampled and mixed with the soil, the droppings replenish the soil for one or more growing seasons, depending on the amount of the manure collected. On land meant for perennial cropping, such as growing *ensete*, the enclosure is kept longer than in annual croplands. Farmers rotate the enclosure and in this way, avoid the need for transporting cattle manure. (Photo taken by the author (2000).

Plate 7.2. An example of mismanaged coffee field from Bilooyaa area (midland zone, 1860m asl). The major factor is lack of shade trees. (Photo by the author, 1998).

Plate 8.1. Use of *ensete* (*Ensete ventricosum* (Welw.) Cheesman MUSACEAE) leaves and leaf-sheaths for thatching. Note the thatching of the two huts, the right hut thatched with dried leaf-sheaths (*oofee*) and left hut thatched with leaves (*hochcho*). Photo taken by the author , 1999, from Michchille Uddo area, highland zone.

Plate 8.2. *Quncisa*, a favorite dish of ensete among the Gedeo.

Plate 8.3. A three-dimensional map of the Gedeo country and its surroundings derived from radar satellite images.

Plate 4.1

Plate 4.2

Plate 4.3

Plate 4.4

Plate 4.5

Plate 4.6

Plate 5.1

Plate 5.2

Plate 5.3

Plate 5.4

Plate 6.1

Plate 6.2

Plate 6.3a

Plate 6.3b

Plate 6.3c

Plate 6.4a

Plate 6.4b

Plate 6.5

Plate 6.6

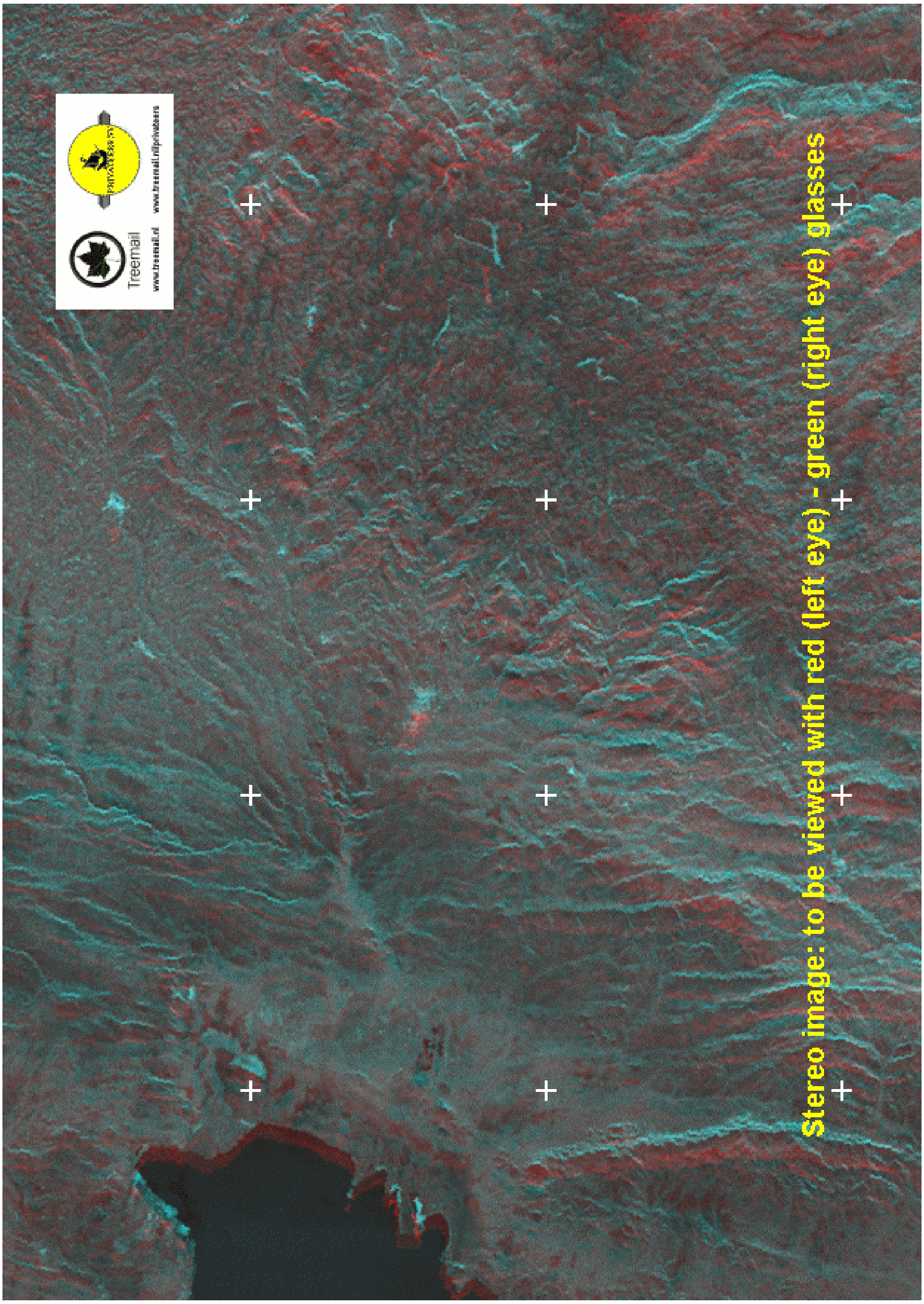
Plate 6.7

Plate 7.1

Plate 7.2

Plate 8.1

Plate 8.2


Stereo image: to be viewed with red (left eye) - green (right eye) glasses
Treemail
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Appendices

Appendix 1. Checklist of Questions used in data collection

Enset-based Gedeo "agroforests": questionnaire and research questions

Part I. A checklist of questions to be administered to farming families

Name (including grandfather's) ....…………..**sex** (M/F) **woreda**...................**Kebele**............

Age of your first born ………...off-farm occupation (if any) …………**Marital status** .... …………

married/divorced/widowed............... **Number of children living**……**Male**…… **Female**……..…

Number of children deceased……**Male**………**Female**…… …. **Number of children married**

Off (male)……… (Female)…..**Number of household members**……..…

1.1. Constraints to *ensete* production (for both sexes)

1. What problems do you have in growing *ensete*?
2. How do you judge the rate of *ensete* growth? a) Faster/ Why?
3. Slower? Why?
4. Not changed? Why?
5. How long does it take a *ganttichcho* to flower starting from field planting?
6. What do you think is the source of the problem?
7. What do you think is the solution to the problem?
8. What *ensete* diseases have you observed in your neighbor's farm? When?
9. In your own farm? When?
10. Do you think *badda'a* are generally harmful to *ensete*? Why?
11. What kinds of *badda'a* grow in your farm? Would you name them?
12. Which of these are useful for livestock?
13. Which are not eaten by livestock? Why?
14. Which are useful as medicine? For which ailment(s)?
15. Which are good for soil? How and why?
16. Which are not good for soil? Why?

17. Which *ensete* disease is the worst? Why?
18. What do you think is the solution? Why?
19. Have you ever observed *ensete* types resistant to the disease? Why?
20. What *ensete* pests have you observed in your neighbor's farm? When?
21. What *ensete* pests have you observed in your own farm? When?
22. How do you see the problem of *badda'a in ensete* plantations in general? Why
23. In your neighbor's farm?
24. In your own farm?
25. Which *badda'a* is the worst for *ensete* plantations? Why?
26. How do you control *badda'a* ?
27. In your neighbor's farm? In your own farm?
28. How do you compare *ensete* pests and diseases with pests of other crops? Why?
29. What measures do you use to avoid the pest and/or disease?
30. How do you see resistance of *ensete* types to the pest and /or disease?
31. Why do you think it was not affected by disease and/or pest?
32. Which *ensete* types are more frequent in your farm? Why?
33. Which *ensete* types are least frequent? Why?
34. How do you see the role of *ensete* plants in soil improvement? Why?
35. How do you rate *ensete* types for their effects on the soil?
36. Which *ensete* type(s) do you think are best for soil improvement? Why?
37. How do you judge the effect of *badda'a* on soil conservation and/or development? Why?
38. How many times are your *ensete* plantations weeded within a year? Why?
39. What effect do you think *badda'a* have on the growth of *ensete* Why?
40. How do you estimate the time you spend in your farms? Why?
41. How many times do you slash your fields? Why?
42. How long (months in a year) does it take you? Why?
43. In what season (s) do you field plant *simaa* (*ensete* suckers)? Why?
44. How many plants do you plant within the year? Why?

45. In what seasons(s) do you cultivate the newly plated *ensete* plants? Why?
46. How long does it take you to cultivate your soil? Why?
47. How do you field-plant your *huuffe:* block by block or enrichment planting ?Why?
48. Which type of planting is more common in your area- block-field planting or enrichment planting? Why?
49. Which trees do you think are good for *ensete*? Why?
50. Which trees do you think are not good for *ensete*? Why?
51. Which do you think is better, planting *ensete* alone or intercropping it with coffee and/or other crops? Why?
52. How do you raise *simaa* (*ensete* suckers)? Why?
53. When do you plant *ensete* plants in to the field? Why?
54. How do you compare the present rate of *ensete* growth to a previous one, say when you were only a small child? Why?
55. How many years does a *ganttichcho* plant in your farm, from field-planting to flower initiation, take? Why?
56. How do you see this duration of time? What would you do to solve the problem?
57. Other questions.

1.2.Questions on *ensete* harvest and processing

1. At what development stage do you harvest *ensete*? Why?
2. What tools do you use for harvesting *ensete*?
3. How do you select the plants for harvest?
4. How many *daggichos* do you have?
5. How many *idagoos* do you have?
6. How many *beyaas* do you have?
7. How many *ensete* farms do you have?
8. How do you see the adequacy of your *ensete* supply? Why?
9. How many *ensete* plants do you harvest at a time? Why?
10. Where do you process your *ensete* plants? Why?
11. Why do you rotate the processing site (*hassuwwa*)?

12. Would you tell me step by step how you uproot the plant and prepare the parts for *hooggoo* (processing)?

13. Would you tell me step by step how you would proceed with hooggoo (*ensete* processing)?

14. How long would it take you to scrape the pseudo-stem of a single *daggichcho*?

15. Pulverization of the corm of a single *daggicho*?

16. What products do you get from scraping (the pseudo-stem) and pulverization (corm) of a single *idagoo*?

17. A single *dagicho*?

18. A single *beyaa*?

19. A single *guumee*?

20. Which one do you prefer to harvest *daggicho* or *idagoo*? Why?

21. Which one gives you more *bu'la, daggicho* or *idagoo*? Why?

22. Which one gives you more fiber (*haanxxa)*, *daggichcho* or *idago*? Why?

23. How long would it take you to process (*hooggoo*) one *daggicho*? Why?

24. How long would it take you to process (*hooggoo*) one *idagoo*? Why?

25. What is the best season for processing (*hooggoo*) *ensete* plants? Why?

26. What stage of *ensete* is best for harvest? Why?

27. Which *ensete* type(s) gives higher biomass (unfermented) per plant?

28. Which *ensete* type is best for guume (*ha'michcho*)? Why?

29. How many *ensete* types do you know?

30. Would you list or name them?

31. How many types of these do you have in your farm?

32. Would you tell me how you proceed in assisting good fermentation?

33. What items do you need for this task and what precautions do you take?

34. How many *usurras* of *waasaa* do you expect from a single *daggicho*?

35. How many *usurraas* of *waasa* do you expect from a single *idagoo*?

36. From a single *beyaa*?

37. One *idagoo*? Why?

38. From a single *guumee*?

39. How long does it take to ferment a *daggicho*? *idagoo*? *beyaa*? *guumee*?
40. What do you think determines the rate of fermentation?
41. Which ferments faster, *beyaa*? *idagoo* or *daggicho*? Why?
42. How fast? Why?
43. Which *ensete* types normally ferment faster? Why?
44. How fast is it?
45. Which *ensete* types ferment slowly? Why?
46. How slow is it? Why?
47. Would you tell me ways of shortening it, if any?
48. How do you see problems in fermenting *ensete*?
49. What do you think are the source(s) of the problems? Why?
50. What do you think determines the quality of *waasaa* (fermented *ensete* food)?
51. Which one gives you more *waasa, daggicho* or *idagoo*? Why?
52. Which *ensete* type(s) give(s) *waasaa* of highest quality?
53. Where do you store *waasa*? for how long?
54. How long would *waasaa* be stored without loss of quality?
55. Other questions.

1.3. *Ensete* products (from *Gantticho ensete* type)

1. What products do you get from this *ensete* type?
2. What for do you use these? Why?
3. Would you tell me the amount obtained from a single *daggicho*?
4. A single *idagoo*?
5. A single *beyaa*?
6. Which *ensete* type do you think is better in the amount of *waasa* obtained? Why?
7. Which *ensete* type(s) do you think is/are good for the quality of *waasa*? Why?
8. In terms of the quantity of *waasaa*? Why?
9. Which *ensete* type(s) is/are predominant in your farm? Why?
10. Would you tell me the types of *ensete* whose corm is boiled and eaten?

11. Which type(s) is/are best for this purpose?

12. How many of these do you have in your farm?

13. How many *usurras* of *waasa* do you get from a single *daggicho* of this *ensete* type?

14. How many *usurras* of *bu'la*?

15. How many *usurras* of *waasaa* from a single *idagoo*?

16. A single *beyaa*?

17. Which *ensete* product is the most important to you? Why?

18. How long would food from a single *daggicho* feed you and your family without other foodstuffs purchased from markets?

19. With a minimum of other foodstuffs bought in markets?

20. Food from a single *idagoo*?

21. Food from a single *beyaa*?

22. Other questions.

1.4.The carrying capacity of land planted to *ensete* (for both sexes)

1. Would you tell me how many *ensete* plants you harvest at a time? Why?

2. Would you tell me the number of *ensete* plants you harvested last week?

3. Which *ensete* types were they?

4. How many plants did you harvest within the last two weeks?

5. How many *daggichcho*?

6. How many *idagoo*?

7. How many *beyaa*?

8. How many *guumee*?

9. How many plants did you harvest within last month?
   Within the last two months? Within the last three months?
   Within the last six months?

10. How many *daggicho*?

11. How many *idagoo*?

12. How many *beyaa*?

13. What *ensete* types were these?

14. Do you think there is a shortage of mature *ensete* plants in your farm? Why?

15. What do you think are the reasons for the shortage of *ensee* plants in your field?

16. How do you rank the quality of present *ensete* plants with earlier ones? Why?

17. What do you think made the quality better? Lower? Why?

18. What do you think made the quality lower than previous ones? Why?

19. How do you judge the time taken by the fermentation process? Why?

20. Has it increased, shortened or unchanged? Why?

21. How do you see the need to buy *ensete* food (*waasaa*) from markets? Why?

22. How do you see the need to buy food items like bread, wheat grain, maize grain, *teff* grain, barley or others from markets, as a supplement to *waasaa*? Why?

23. What else to you buy from markets? Why?

24. How often do you eat food other than *ensete* (*injera*, bread, roots like sweet potato, *boyina, ha'micho* (*ensete* stem)?

25. Other questions.

1.5. Preparation of an *ensete* dish (for ladies only)

1. How many different dishes could be prepared from *waasaa*?

2. Please name these and the occasions when they are frequently prepared?

3. How long does it take to prepare each? Why?

4. Which dish is most frequented? Why?

5. How long will it take to prepare this dish?

6. Which dish is the most prestigious? Why?

7. How long does it take to prepare it? Why?

8. Which dish is regarded lowly? Why?

9. How long does it take to prepare it? Why?

10. Which dish took longer to prepare? Why?

11. Which dish was easiest to prepare? Why?

12. How long does it take to prepare it? Why?

13. Which dish is very difficult to prepare? Why?

14. How long does it take to prepare it? Why?

15. What dishes are commonly prepared in your surrounding? Why?

16. At what occasion are these prepared? Why?

17. What are the *ensete* types in your surrounding the corms
Of which are boiled and eaten?

18. Which of these are regarded the best? Why?

19. How long does it take till each reaches the harvestable stage? Why?

20. How many of these do you have in your farm? Why?

21. Other questions.

1.6. Marketing farm products (for both sexes)

1. What markets are there in your vicinity?

2. Which one(s) do you visit most often? Why?

3. Which one(s) do you attend only sometimes?

4. Why do you go to markets most of the time, to sell or to buy?

5. What items do you sell in markets? Why?

6. Where do you get these items?

7. What items do you buy from markets?

8. For how much do you sell an *usurra of waasa*? Why?

9. Of *moocaa*? Why?

10. Of *bu'la*? Why?

11. Do you sometimes buy or sell live *ensete* plants? Why?

12. A single *idagoo of gantticho?*

13. A single *beyaa of ganticho?*

14. What do you think of the price of *ensete* food, constant?

15. Increasing? Why?

16. Decreasing? Why?

17. Varying with times? Why?

18. What do you think of the buying power of money you
obtain by selling *ensete* or its products? Why?

19. What else do you sell in markets? Why?

20. Do you sell coffee? Where do you get it?

21. Do you sell pulses (horse beans (*Vicia faba* L.), pea (*Pisum sativum* L.))? Where do you get these?

22. Do you sell maize, cabbage, sweet potato, pumpkin (*Cucurbita* sp.)? *Godarre* (*Colocassia esculenta*)? *Boyina (Dioscorea abyssinica)*? Where do you get these?

23. How do you see selling barley, wheat, onion or potato? Why?

24. Which source of income is more important to you? Why?

25. What do you spend the money you obtained on? Why?

26. Do you always have enough food at home? or do you sometimes starve? Why?

27. What crop ensures that you and your family are fed well? Why?

28. Did your husband prepare *ensete*"seedlings" last year? This year? Why?

29. What do you think of the adequacy of the mature *ensete* plants in your farm? Why?

30. Other questions.

1.7. Ecological benefits of *ensete* (for both sexes)

1. Which *ensete* type(s) do you think is/are good for the soil? Why?

2. Which *ensete* types are good for rainwater conservation? Why?

3. What *ensete* parts do you leave (as by-product) on the site? Why?

4. How do you compare part of *ensete* regarded as a by-product to that regarded as edible ?

5. What benefits do you see in the part regarded as a by-product? Why?

6. What part of the by-product have you put to use?

7. How do you see the benefits of *ensete* roots? Why?

8. What effects do *ensete* roots have on the soil?

9. How do you see the impact of the cut and carry system of grazing (for livestock feeding) on *ensete* production? Why?

10. How do you see the effect of this practice on *ensete* production? Why?

11. What herbs (*badda'a*) grow together with your *ensete* plants?

12. How do you see growing *ensete*, particularly younger *ensete* plants,

together with herbs (*badda'a*), Why?

13. Which do you think is good, *ensete* grown under shade or in the open? Why?
14. What types of trees do you think are good as *ensete* shade? Why?
15. How do you grow *ensete*, in the homestead? or in the field? Why?
16. How do you compare growing *ensete* alone with growing in a mixture with other crops? Why?
17. What crops do you grow with *ensete*? Why?
18. How do you maintain the age of *ensete* plants grown in a mixture? *Ensete* plants grown alone?
19. Other questions.

1.9. The tree components (for both sexes)

1. What tree types do you have in your farm?
2. How many of these do you think are mature and harvestable, if need be?
3. How do you see the need to plant tree seedlings every year? when and why?
4. Which tree types grow from seedlings planted? Why?
5. Which tree types do self-regenerate? Why?
6. Who plants the tree seedlings? When?
7. For what purpose are these planted?
8. How do you compare number of tree types in your farm that regenerate

   from stem coppice (*kichcho*) and those that grow from seed? Why?
9. Those that regenerate from root suckers (*laakka*)? Why?
10. Which criteria do you apply for planting and/or retaining automatically germinating tree seedlings in your farm?
11. Which tree types do you have in your farm? Why?
12. Which trees grow fast? Why? What do you use this for?
13. Which tree types do you think are best as fuel wood? why?
14. How do you see the problem of wood shortage (both for

    firewood and construction)?
15. When do you feel the shortage? Why?

16. How do you see the adequacy of your farm trees? How do you rate the care you give to trees and other crops? Why?
17. Which tree type is the most frequent in your farm? Why?
18. Which tree type(s) grow slowly?
19. What is the fastest growing tree in your farm?
20. What do you use it for? Why?
21. How would you rank trees in your farm in their rate of growth? Why?
22. How many mature trees have you felled within the last month?
23. What are the methods of harvesting trees and/or their products?
24. Which one of these do you use frequently? Why?
25. Would you tell me how you would have a tree felled?
26. How would you minimize possible damage done to other trees and/or crops?
27. Which method do you think is best? Why?
28. How do you see buying and/or selling live trees? Why?
29. Which tree types were high in demand? Why?
30. How do you see the monetary value of trees? Increasing/decreasing? Why?
31. How do you compare the money obtained from selling the fuel wood trees and the time taken to grow them ? Why?
32. When do you think the buying and selling of timber /lumber/ trees in your area began? Why?
33. How do you see the situation? Why?
34. How do you judge the effect of tree selling to your surrounding? Why?
35. Other questions.

1.10. The Coffee (for both sexes)

1. Would you tell me how many coffee farms do you have?
2. How many sacks of dried beans do you get from it/them each year?
3. Please estimate the money obtained by you and your family by

selling *luu'lo*, fresh berries or fruits of coffee?

4. How do you judge the productivity of your coffee trees? Why?
5. How do you compare the lifespan of your coffee trees with those of your father's time? Why
6. How do you see the sustainability of coffee yield? Why?
7. How do you see the need to plant coffee seedlings every year? Why?
8. Where do you get the seedlings?
9. What kind of planting do you follow: block/enrichment planting or both? Why?
10. Which one, do you think, is larger, the area under *ensete* or that occupied by the coffee? Why?
11. How do you compare the larger area in no.10 above with that in your father's time? Why?
12. What is happening to this area (mentioned under no.11)? Decreasing/increasing? Why?
13. Which one in the past occupied the larger area, *ensete*/coffee? Why?
14. How do you see this situation? Why?
15. Which trees do you think are best for the coffee? Why?
16. Which trees do you think are not good? Why?
17. Which trees do you think are good for *ensete* and which are not good? Why?
18. How do you see the planting of coffee under eucalyptus? Why?
19. How do you see the planting of *ensete* under eucalyptus? Why?
20. How do you see the effect of eucalyptus on the soil?
21. How do you see the effect of eucalyptus on water?
22. What are the problems you have with coffee growing?
23. Which problem is foremost to you? Why?
24. What have you done to solve the problem? Why?
25. What do you say about current coffee prices? Why?
26. What do you say of the price of a kilo of fresh coffee and a kilo of dried coffee? Why?
27. How do you sell your coffee: dried/fresh/both? Why;
28. What do you say of the time you spend in fresh coffee preparation and dry coffee preparation? Which takes more of your time? Why?

29. How do you spend your coffee income?

30. How often do you go to markets?

31. Why do you go to markets?

32. How do you see supplementing your *ensete* food with grains from the market? Why?

33. How do you see the proposition that coffee belongs to husbands while *ensete* belongs to wives? Why?

34. How would you react if your wife sells waasa in markets and your *ensete* plantation was being undermined in this way? Why?

35. How do you react to treating *ensete* more than coffee? Why?

36. How do you see growing coffee with *ensete*? Why?

37. What do you think, the coffee benefits from the *ensete*?

38. What do you think the *ensete* benefits from the coffee?

39. Which tree types do you use as shade? Why?

40. Which of these do you think are best for the better yield of coffee? Why?

41. Which trees are worst to grow with coffee? Why?

42. What do you think the trees give to the coffee?

43. How do you see present mortality of coffee trees: decreasing/increasing? Why?

44. What do you think causes the death of coffee trees?

45. What steps have you taken to solve the problem? Why?

46. How do you see the result?

47. How do you fell trees without damaging the coffee?

48. Other questions.

1.11. The Livestock component (for both sexes)

1. What farm animals do you have?

2. How do you see the importance of your livestock to your family? Why?

3. What do you say about the problems of your livestock?

4. What do you do to solve the problems?

5. How do you see the importance of farm animals for soil maintenance? As source of cash income? As insurance?

6. What are the major problems in keeping animals in your area? Why?

7. Other questions.

1.12. The "weedy"herbaceous plants (*Badda'a*) (for both sexes)

1. What herbs grow in your farm?

2. Which herbs are edible? When?

3. Which herbs are used as medicine? For which ailments?

4. Which herbs are good for soil enrichment? Why?

5. Which herbs do not grow in your farm but do grow in your neighbor's farm? Why?

6. Which of these are edible? When? How?

7. Would you please name *badda'a* you know growing in your locality?

8. How do you see the abundance of these *badda'a* with time? Why?

9. How do you see removing all *bada'a* from fields in order to increase crop growth? Why?

10. How do you see the competition between *bada'a* and crops? Why?

11. Other questions.

1.13.Farm Production and productivity (for both sexes)

1. How do you rate present and past time farmers have to spend on farms ? Why?

2. What do you think is the most pressing problem farmers face in your area now? Why?

3. What do you think is the most important constraint to increase the production? Why?

4. What do you say of the productivity of your farm? Why?

5. How do you relate soil fertility to productivity? Why?

6. What do you think is the solution(s) for decreasing land productivity?

7. How do you see the requirement of tilling /plowing/ your land in a year?

8. How do you compare your situation with that of your father?

9. When do most farmers in your community plow their land: in rainy or dry seasons? Why?

10. When do you plow your land: in dry or rainy seasons? Why?

11. What do you say about working the soil during rainy seasons? Why?

12. What happens do you think to the soil if ploughed during rainy seasons ? Why?
13. What happens to the crop(s)? Why?
14. Which one is easier do you think, working the soil in the dry seasons or in rainy seasons? Why?
15. What do you say about the number of sacks of dried coffee beans you get every year? Why?
16. How many sacks do you get in good years?
17. How many sacks do you get in bad years?
18. What do you say of the yield of *ensete* food per plant?
19. Is the amount per plant increasing? Why?
20. Is the amount per plant decreasing, Why?
21. How do you see the role of trees in helping stabilize production? Why?
22. What types of trees do you think are good for soil? Why?
16. Which tree types do you use for soil improvement? Why?
17. What types of trees do you think are good for shade? Why?
18. What tree types do you use as coffee shade? Why?
19. What tree types do you use as *ensete* shade? Why?
20. What tree types are better for fuel wood? Why?
21. What tree types do you use as fuel wood? Why?
22. How many fuel wood trees in a month? Why?
23. What medicinal *ensete* plants do you have in your farm? For what aliments do you use them?
24. What *ensete* plants in your farm are edible unfermented?
25. How many flowering *ensete* plants do you have in your farm?
26. How do you compare the number of your flowering *ensete* plants and your family's yearly demand for *ensete*? a) just sufficient (b) more than needed? Why?
27. Has your family ever faced shortage of flowering *ensete* plants? Why?
28. How many mature trees did you fell in the last six months?
29. How many would you need for the coming six months?
30. Has your family ever faced shortage of fuel wood? Why?
31. How do you fell trees?

32. How do you prune trees?
33. How do you protect crops underneath the tree being pruned/felled?
34. How many mature trees do you have in your farm?
35. How do you see planting tree seedlings every year? Why?
36. Where do you get the seedlings from?
37. Which trees in your farm grow fast?
38. Which trees in your farm grow very slowly?
39. How do you see tending coppice growth? Why?
40. How do you see tending root suckers? Why?
41. Which do grow faster? root suckers or stem coppices? Why?
42. What trees in your farm produced root suckers? What about stem coppices ?
43. How long does it take you (days in a year) to harvest your field of coffee?
44. How many times do you have to slash your coffee farm within a year? Why?
45. How many months do you spend in your coffee and *ensete* farms in a year? Why
46. When do you think is the best time to cultivate your land? Why?
47. When do most farmers cultivate land ? Why?
48. When do most farmers fell trees in your surrounding? Why?
49. When do most farmers cut *ensete* for coppicing? Why?
50. How do you cut *ensete* for coppicing?
51. Tell me if there are other ways of doing it?
52. Which one do you prefer? Why?
53. What do you say of the time for planting *ensete* suckers?
54. Is there a particular time for planting ensete? Why?
55. What happens, do you think, to *ensete* planted in rainy seasons?
56. If problematic, Why is this?
57. Every year? Why?
58. How do you see the supply of *ensete* "seedlings" at hand? Why?
59. Where do you get the seedlings? Why?

60. When do you cut *ensete* plants for raising seedlings?

61. Why, do you think, is this particular time selected for the job?

62. Are *ensete* seedlings readily available in you community? Why?

63. How many times do you have to slash you coffee farm in a year? Why?

64. How long does slashing *badda'a* take you per year?

65. How many *ensete* plants do you cut per year for sucker production?

66. How long does cutting *ensete* for sucker production take you per year?

67. How long does transplanting the suckers together with the mother corm take you?

68. How much time takes separating the suckers from the mother corms and planting them in a line (*huuffee*)?

69. How many *ensete* suckers (*simaa*) do you plant per year?

70. How long does the work take you?

71. How many trees do you fell for firewood per year?

72. What do you say about the protection of crops beneath the trees?

73. How long does the work take you?

74. How do you go on planting trees?

75. How long does the work take you per year?

76. How long does picking coffee take you per year?

77. What do you say of honey production in your farm?

78. How many hives do you have?

79. Where do you hang these? Why?

80. When do you hang the beehives? Why?

81. When are these occupied? Why?

82. When do you harvest honey? Why?

83. How much honey do you harvest in good years?

84. What do you say about the income from the sale of honey?

85. How do you see the freedom to hang beehives on trees belonging to your neighboring farmers? Why?

86. What do you say about the problems of honey production?

87. How many of these are occupied by bees?

88. How do you see the species/age quality of trees preferred by bees? Why?

89. What do you say about the time of flowering of trees in your surrounding?

90. Which trees do you think have the best flowers for honey production? Why?

91. Which flowers are not good for good honey production? Why?

92. Which trees do you think are good for hanging beehives in? Why?

93. In order to get better yields, what do you add to the soil? Why?

94. How do you prepare the soil for *ensete* planting? Why?

95. What do you add to *ensete* after field planting? Why?

96. How do you see the need to remove *badda'a* from *ensete* plantations? Why?

97. How do you prepare the soil for coffee planting? Why?

98. How do you see the need to remove *badda'a* from the coffee?

99. What do you add to field planted coffee? Why?

100. How do you prepare land for sowing barley? Why?

101. What will you do to avoid *badda'a* from the barley field? Why?

102. How do you prepare the soil for sowing maize? Why?

103. How do you see the need to avoid *badda'a* from a maize field? Why?

104. How do you prepare land for onion planting? Why?

105. How do you see the need to cultivate and avoid weed from the onion field? Why?

106. How do you see the role of *ensete* by-products in soil maintenance? Why?

107. How do you compare by-products of other crops such as maize, barely, with those of *ensete*? Why?

108. How do you control soil erosion?

109. How do you see the role of *ensete* in erosion control? Why?

110. How do you see the function of farm yard manure in soil maintenance? Why?

111. How do you compare manure from different farm animals?

112. How do you see the need to work the soil thoroughly? Why?

113. How do you compare litter from trees with farmyard manure for soil maintenance? Why?

114. Which trees are good for the soil and which trees are not good for the soil? Why?

115. It is commonly said that coffee is for husbands as *ensete* is for wives; how do you see this proposition? Why?

116. How do you see the effect of the foregoing belief on the food availability of your surrounding? Why?

117. How do you see the proposition; *ensete* and coffee are like the right and left hands of a person, helping each other? Why?

118. How do you see the income of *ensete* and coffee: which one is more important to your household? Why?

119. How do you see the statement: husbands misuse the income from coffee and wives misuse the income from *ensete*? Why?

120. Other questions.

Part II Questions for Development Personnel

2.1.For Development Extension Agents

1. How do you define the Gedeo land use?

2. How do you compare these to agro-forestry systems? Why?

3. How do you rate the role of agro-forest components, viz., *ensete,* multipurpose trees or coffee for environmental protection?

4. How do you rate the role of agro-forest components, viz., *ensete*, coffee and multi-purpose trees for food security in Gedeo zone? Why?

5. How do you compare the role of cereal crops, viz., maize, barley, pulses (chickpea and horse bean), *teff*, wheat for food security in Gedeo zone?

6. How do you rate the following products as source of cash : coffee, livestock, honey, *ensete* (medium altitudes); pulses (chick pea & horse bean) livestock, barley, honey & vegetables (onion, garlic & leaf cabbage (higher altitudes) and livestock, coffee, honey, maize, wheat, sweet potato (in lower altitudes)?

7. How do you rate the following problems: population pressure, land shortage, soil degradation, deforestation, lack of grazing land, drought, diseases & pests and thieves in Gedeo zone?

8. How do you see the problem of population pressure and land shortage? Why do you think ensete farming is incapable of feeding the population? What do you think is wrong with Gedeo ensete farming?

9. How do you see the problems of pests and diseases in the Gedeo zone? Do you think it really is a serious problem? Why?

10. How do you see drought-resistance of *ensete*? Why do you think *ensete* is relatively resistant to drought? How do you relate this characteristic of *ensete* to soil conservation?

11. Do you see the conflict between the cut-and-carry forage among farmers and the sustainability of farmlands? How do you relate this problem with the balance of biomass exported and that retained on the site?

12. Given the soil rehabilitating characteristics of *ensete* and associated multi-purpose trees, how do you trace the problem of soil degradation?

13. How would you react to the problem of soil degradation? How do you compare use of modern chemical fertilizers and bio-fertilizers like manure and compost? Why?

14. What do you think is the most sustainable and least-cost solution to the problem? Why?

15. If you had the means, which problem of Gedeo farmers: poor saving, failure to use fertilizers to increase production, failure to follow modern ways of farming- would you approach first to solve? Why?

16. How do you see intensification of the farm components as a solution to shortage of agricultural land? What components would you increase?

17. Given appropriate conditions and resources, how would you intervene in the Gedeo way of life?

2.2. Questions for the Supervisors of the Development Extension Agents

1. What could be said of the placement of farm components in relation to homestead? What components are planted in the homestead? Why? What components are planted in the field? Why?

2. What are the principles applied by farmers in their day-to-day AF management?

3. What ecosystem properties do you think farmers utilize in following the principles of management?

4. What could be said of the placement of components in relation to each other? How the even-/uneven-aged plantations of diverse components compare with systems of mono-cropping?

5. What could be said of the arrangement of crops in time and space?

6. What could be said of the maintenance of the mixture? How it could be compared with the maintenance of mono-crops?

7. What could be said of the kinds of inputs and outputs; about the amount, time and way of application?

8. What could be said of the capability for future production or rather its improvement?

9. What is the attitude of Gedeo farmers towards the limitations of their agro-ecosystems?

10. What feasible ways of intervention to assist farmers in their efforts could be designed?

11. How do farm households, other farm components and markets react to produce a balanced working condition?

12. Can the human component go on exerting pressure on the biophysical components to yield to its aspirations or should there be a two-way interaction, biophysical components equally exerting pressure on the human component to adapt? To which category do the Gedeo belong?

13. What are the potentials and constraints of Gedeo land use? How do farmers cope with these?

14. What do you think are the unique ecological attributes of *ensete* in maintaining the production base intact?

15. How does management derive a balanced production and protection from the diverse interactions of the systems and subsystems?

16. What are trends in the adaptive strategies of the biophysical and human components?

Appendix 2a. *List of Farmers formally contacted*

Name Head	Age	Household size
Uraagoo Baddoo Dharroo	75	6
Chabasso Quxxu Badachcho	45	10
Tasfayee Danbbobii Dharro	42	17
Hoxxeessa Dukkalle Borojji	35	14
Bayyanaa Baallii Suubboo	53	8
Worraasso Goobanaa Godaanaa	65	15
Taaddalaa Duubee Ginddaa	34	12
Shifarraa Goobanaa Weddoo	55	12
Diidoo Waaqoo Nushuu	75	8
Alamaayyoo Araarssoo Dharroo	40	11
Ayyalaa Gege'a	65	6
Baggajjoo Bonjjaa Qerroo	71	7
Biishawuu Hijjo	80	7
Dhaqaboo Shotaa	100	7
Elelluu Buudhaa	56	8
Hailee Chollo Chodoro	43	12
Maamoo Biittuu Gurraachcha	46	10
Maariqoosii Koyyo Guyyo	45	14
Mokkee Ossee Bajjulee	65	5
Muluunashii Arffaasoo	45	3
Manggaashaa	39	5
Neenqoo Dukkallee Barisoo	60	5
Nigaatuu Weessii Borojjii	48	9
Raaboo Kiphee Kanshshee	39	15
Raggaasaa Barisoo Daraaree	52	7
Sharoo Dharroo Elddaa	60	3
Taaddasaa Lammaa Nabiiy	69	6
Taaddasaa Xumaroo Mijuu	47	4
Waaqoo Mijuu Shabbee	89	5
Worqinashii Waaqoo Barisoo	60	5
Abaraamii Badhaanee Shotoo	40	9
Abbabaa Hi'no Badachcho	51	10
Biraanuu Doggoma Adula	36	12
Badhaasoo Cinciissa Dharroo	60	13
Dassaalagnii Tuuttoo	57	8
Jaggoo Goobanaa	65	16
Taaddasaa Waataa Bushee	55	17
Taaddasaa Saafo'ii Bushee	49	11
Taaddalaa Mokkonna Barraaqoo	45	12
Zallaqaa Kabbadaa	57	8

Appendix 2b. *Mebers of the Field Group*

1. Mr. Girmma Goochcha/highland zone
2. Mr. Dawit Moges/Kiphee/midland zone
3. Mr. Kebede Shunxxuu/midland zone
4. Mr. Kifle Birhane/midland zone
5. Mr. Mekonnen Roba/lowland zone
6. Mr. Kabada Gammade/lowland zone
7. Mr. Samuel Kekebo/highland zone
8. Mr. Andualem Shifera/highland zone
9. Mrs. Degefech Murtti/supervisor, women’s group
10. Mr. Keffalew Rooba/supervisor, men’s group
11. Mr. Tadesse Kippie/investigator and the field group leader

Appendix 3. *Data on soil sampling*

Management	TEXTURE			pH (H_2O)	Available P (ppm)	Total Nitrogen (%)	Organic Matter (%)	C:N ratio
	sand	silt	clay					
A11 0-30	**22.0**	**42.0**	**36.0**	**5.7**	**5.8**	**0.7**	7.2	**11.0**
A11 030-60	**28.0**	**36.0**	**36.0**	**5.1**	**2.0**	**0.3**	**5.6**	**10.0**
A12 0-30	**34.0**	**36.0**	**26.0**	**5.6**	**5.0**	**0.4**	**3.6**	**9.0**
A12 30-60	**24.0**	**32.0**	**36.0**	**5.9**	**1.0**	**0.3**	**2.6**	**10.0**
E11 0-30	**28**	**36**	**36**	**5.1**	**4.4**	**0.4**	**7.1**	**10.0**
E1130-60	**26**	**22**	**42**	**5.5**	**3.2**	**0.3**	**4.5**	**10.0**
E12 0-30	**36**	**32**	**32**	**7.2**	**17.6**	**0.4**	**6.6**	**10.0**
E12 30-60	**20**	**32**	**48**	**6.3**	**3.4**	**0.2**	**3.9**	**11.0**
E21 0-30	**26.0**	**30.0**	**44.0**	**5.8**	**2.2**	**0.2**	**3.5**	**8.0**
E2130-60	**16.0**	**16.0**	**68.0**	**4.9**	**1.6**	**0.2**	**2.6**	**10.0**
E22 0-30	**30.0**	**32.0**	**38.0**	**6.5**	**3.8**	**0.52**	**6.9**	**13.0**
E22 30-60	**26.0**	**34.0**	**40.0**	**6.6**	**4.2**	**0.27**	**3.2**	**12.0**
MEC1 0-30	**26.0**	**30.0**	**44.0**	**5.2**	**2.8**	**0.3**	**6.9**	**14.0**
MEC130-60	**12.0**	**32.0**	**56.0**	**4.7**	**1.6**	**0.2**	**3.4**	**9.0**
MEC2 0-30	**26.0**	**28.0**	**46.0**	**4.9**	**0.8**	**0.3**	**5.6**	**12.0**
MEC2 30-60	**14.0**	**22.0**	**64.0**	**4.9**	**0.6**	**0.2**	**5.1**	**10.0**
ME1 0-30	**20.0**	**40.0**	**40.0**	**6.3**	**2.0**	**0.2**	**4.4**	**10.0**
ME130-60	**16.0**	**24.0**	**60.0**	**6.4**	**1.8**	**0.2**	**2.6**	**7.0**
ME2 0-30	**24.0**	**30.0**	**46.0**	**6.6**	**5.4**	**0.4**	**4.8**	**9.0**
ME2 30-60	**20.0**	**22.0**	**58.0**	**6.5**	**4.2**	**0.2**	**3.1**	**13.0**
MM1 0-30	**20.0**	**32.0**	**48.0**	**5.6**	**0.8**	**0.3**	**4.6**	**9.0**
MM1 30-60	**16.0**	**32.0**	**52.0**	**5.2**	**1.0**	**0.2**	**3.1**	**8.0**
MM2 0-30	**14.0**	**28.0**	**58.0**	**5.0**	**1.2**	**0.3**	**3.6**	**7.0**
MM2 30-60	**22.0**	**28.0**	**50.0**	**4.7**	**1.0**	**0.2**	**2.8**	**7.0**
MA1 0-30	**32.0**	**32.0**	**36.0**	**5.1**	**1.8**	**0.3**	**4.7**	**9.0**
MA130-60	**20.0**	**24.0**	**56.0**	**5.2**	**1.0**	**0.2**	**3.2**	**9.0**
MA2 0-30	**34.0**	**34.0**	**32.0**	**5.6**	**1.0**	**0.3**	**3.9**	**7.0**
MA230-60	**20.0**	**24.0**	**56.0**	**5.4**	**1.0**	**0.2**	**2.2**	**7.0**
A31 0-30	**44.0**	**26.0**	**30.0**	**5.6**	**1.2**	**0.1**	**1.6**	**9.0**
A3130-60	**36.0**	**28.0**	**36.0**	**6.1**	**1.0**	**0.1**	**1.3**	**10.0**
A32 0-30	**42.0**	**30.0**	**28.0**	**5.4**	**2.0**	**0.1**	**1.7**	**10.0**
A3230-60	**40.0**	**24.0**	**36.0**	**5.2**	**0.2**	**0.2**	**2.2**	**8.0**
M31 0-30	**28.0**	**34.0**	**38.0**	**7.6**	**2.2**	**0.3**	**3.9**	**8.8**
M31 30-60	**24.0**	**22.0**	**54.0**	**7.3**	**0.2**	**0.1**	**1.9**	**8.8**
M32 0-30	**30.0**	**28.0**	**42.0**	**5.9**	**trace**	**0.2**	**2.9**	**8.0**
M32 30-60	**26.0**	**22.0**	**52.0**	**7.0**	**trace**	**0.1**	**2.6**	**11.0**

Depth	**Sand (%)**	**Silt (%)**	**Clay(%)**	**pH (H_2o)**	**P av (ppm)**	**T.N (%)**	**O.M (%)**	**C:N**
0-30, n = 7	**26.6**	**33.0**	**40.1**	**5.8**	**2.4**	**0.4**	**5.3**	**9.9**
95% C.I. ±	**7.8**	**3.2**	**7.1**	**0.5**	**1.6**	**0.1**	**1.0**	**1.6**
30-60, n = 7	**20.0**	**27.1**	**51.6**	**5.5**	**1.5**	**0.2**	**3.4**	**9.5**
95%C.I±	**3.8**	**3.8**	**7.9**	**0.5**	**1.1**	**0.1**	**0.7**	**1.2**

A = Annual crops field

E = *Ensete* field

M = Mixed cropping field

Management	MEQ/100 g soil ppm				PPM						
	CEC	k	Na	Ca	Mg	Fe	Mn	Zn	Cu	BS%	Sum*
A11 0-30	**25.8**	**4.0**	**0.6**	**13.6**	**3.3**	**23.5**	**16.6**	**2.9**	**0.8**	**83**	**21.5**
A11 030-60	**22.6**	**1.2**	**0.5**	**9.3**	**2.1**	**15.2**	**15.4**	**0.7**	**0.5**	**58**	**13.1**
A12 0-30	**22.4**	**0.5**	**0.6**	**14.1**	**2.4**	**24.9**	**17.3**	**3.4**	**0.8**	**78**	**17.5**
A12 30-60	**18.9**	**0.5**	**0.5**	**11.7**	**1.9**	**19.7**	**13.3**	**1.8**	**0.8**	**77**	**14.6**
E11 0-30	**27.6**	**0.6**	**0.2**	**17.5**	**0.2**	**20.3**	**22.2**	**3.9**	**0.9**	**67**	**18.4**
E1130-60	**22.9**	**0.4**	**0.3**	**10.3**	**2.4**	**12.7**	**15.6**	**0.8**	**0.6**	**58**	**13.3**
E12 0-30	**26.6**	**3.1**	**0.4**	**15.8**	**4.0**	**29.3**	**23.7**	**4.6**	**1.7**	**87**	**23.3**
E12 30-60	**25.4**	**2.3**	**0.5**	**8.9**	**3.0**	**7.2**	**12.1**	**0.8**	**0.5**	**57**	**14.6**
E21 0-30	**27.9**	**1.1**	**0.2**	**18.8**	**4.3**	**15.0**	**37.0**	**6.8**	**1.3**	**87**	**24.3**
E2130-60	**24.7**	**0.8**	**0.2**	**16.7**	**3.5**	**7.8**	**29.4**	**2.6**	**0.6**	**86**	**21.2**
E22 0-30	**21.4**	**3.3**	**0.2**	**7.8**	**1.6**	**7.6**	**21.3**	**1.2**	**0.4**	**60**	**12.9**
E22 30-60	**18.9**	**1.8**	**0.5**	**5.1**	**3.2**	**2.3**	**7.2**	**0.2**	**0.1**	**56**	**10.6**
MEC1 0-30	**24.7**	**1.2**	**0.3**	**9.5**	**3.2**	**9.6**	**21.2**	**1.8**	**0.6**	**57**	**14.1**
MEC130-60	**18.9**	**0.8**	**0.5**	**5.5**	**1.9**	**5.9**	**13.4**	**0.4**	**0.3**	**46**	**8.6**
MEC2 0-30	**19.7**	**0.2**	**0.3**	**5.3**	**1.8**	**8.5**	**15.0**	**0.6**	**0.4**	**39**	**7.6**
MEC2 30-60	**18.9**	**0.2**	**0.6**	**4.9**	**1.5**	**3.1**	**8.9**	**0.1**	**0.2**	**38**	**7.2**
ME1 0-30	**27.1**	**1.3**	**0.2**	**13.6**	**3.1**	**11.8**	**29.4**	**2.4**	**0.6**	**67**	**18.1**
ME130-60	**17.4**	**0.7**	**0.9**	**10.6**	**2.6**	**5.6**	**22.7**	**0.8**	**0.3**	**85**	**14.8**
ME2 0-30	**29.3**	**1.3**	**0.2**	**19.4**	**4.6**	**12.2**	**33.0**	**4.6**	**0.9**	**97**	**25.5**
ME2 30-60	**23.5**	**1.0**	**0.3**	**17.6**	**4.0**	**6.0**	**23.6**	**1.5**	**0.5**	**87**	**22.7**
MM1 0-30	**24.1**	**0.3**	**0.2**	**12.0**	**4.2**	**9.6**	**29.8**	**1.7**	**0.6**	**69**	**16.6**
MM1 30-60	**20.5**	**0.5**	**0.2**	**7.6**	**2.8**	**5.0**	**25.7**	**0.9**	**0.4**	**54**	**11.1**
MM2 0-30	**21.8**	**0.8**	**0.3**	**8.9**	**2.6**	**13.6**	**23.9**	**1.6**	**0.6**	**58**	**12.6**
MM2 30-60	**20.3**	**0.4**	**0.3**	**5.1**	**1.9**	**6.1**	**16.6**	**0.4**	**0.3**	**38**	**7.7**
MA1 0-30	**25.6**	**0.4**	**0.1**	**8.5**	**3.0**	**9.5**	**25.6**	**1.4**	**0.6**	**47**	**12.0**
MA130-60	**20.5**	**0.2**	**0.2**	**6.7**	**2.2**	**4.5**	**13.1**	**0.4**	**0.3**	**45**	**9.3**
MA2 0-30	**23.7**	**0.4**	**0.1**	**11.0**	**2.7**	**7.9**	**26.1**	**1.5**	**0.7**	**60**	**14.2**
MA230-60	**21.4**	**0.3**	**0.2**	**8.8**	**4.0**	**4.1**	**15.0**	**0.4**	**0.3**	**62**	**13.2**
A31 0-30	**9.0**	**0.9**	**0.6**	**5.0**	**1.2**	**17.8**	**22.4**	**1.2**	**0.1**	**86**	**7.7**
A3130-60	**17.8**	**1.2**	**1.0**	**8.0**	**2.0**	**9.8**	**17.5**	**0.8**	**0.1**	**68**	**12.2**
A32 0-30	**12.4**	**0.8**	**0.6**	**3.4**	**1.3**	**19.0**	**24.7**	**1.7**	**0.1**	**49**	**6.1**
A3230-60	**10.5**	**1.0**	**0.8**	**3.5**	**1.4**	**10.3**	**25.8**	**0.8**	**0.2**	**63**	**6.6**

Depth	Meq/100 g soil				PPM					%	Sum
	CEC	K	Na	Ca	Mg	Fe	Mn	Zn	Cu	BS	
0-30cm, n = 7	**24.9**	**1.4**	**0.3**	**12.6**	**3.0**	**14.5**	**24.5**	**2.8**	**0.8**	**68.3**	**17.1**
95% C.I. ±	**4.1**	**0.4**	**0.2**	**3.2**	**0.5**	**5.2**	**5.0**	**1.2**	**0.3**	**12.5**	**3.9**
30-60cm, n = 7	**21.1**	**0.8**	**0.4**	**9.2**	**2.7**	**7.5**	**16.6**	**0.9**	**0.4**	**60.5**	**11.9**
95% C.I. ±	**2.3**	**0.4**	**0.1**	**2.8**	**0.6**	**4.4**	**4.1**	**0.6**	**0.2**	**14.2**	**2.6**

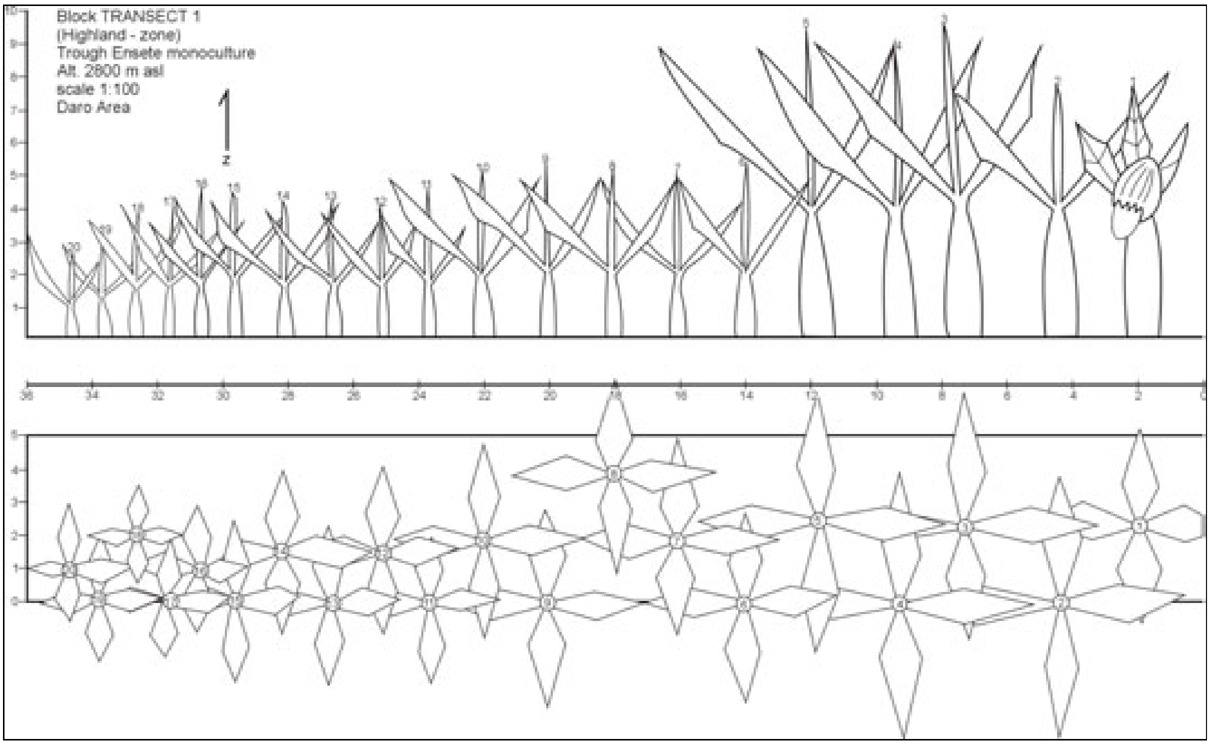
A = Annual crops field

E = *Ensete* field

M = Mixed cropping field

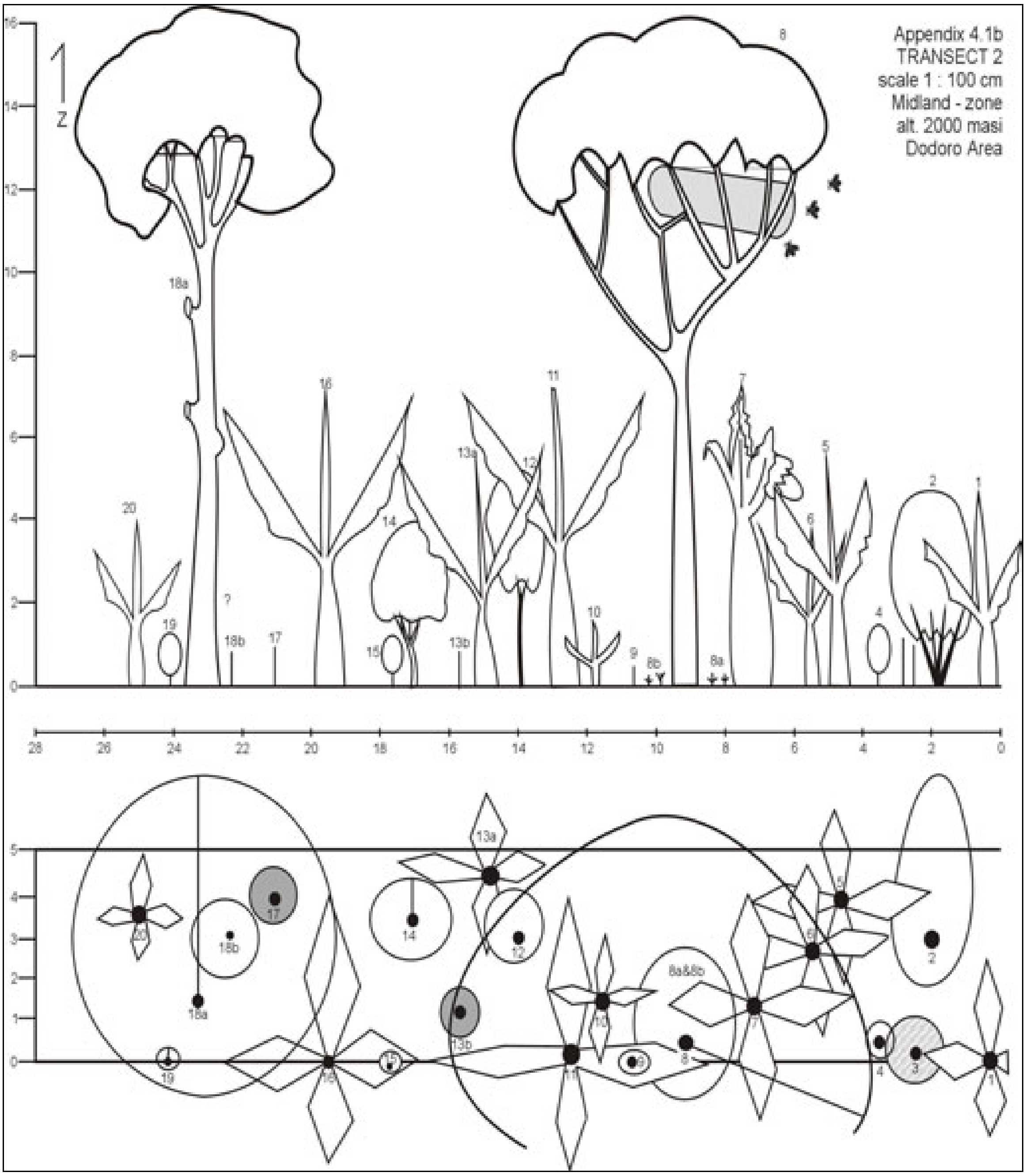
* = Sum of Bases

Appendix **4. B**lock transects through the Gedeo ägroforests”



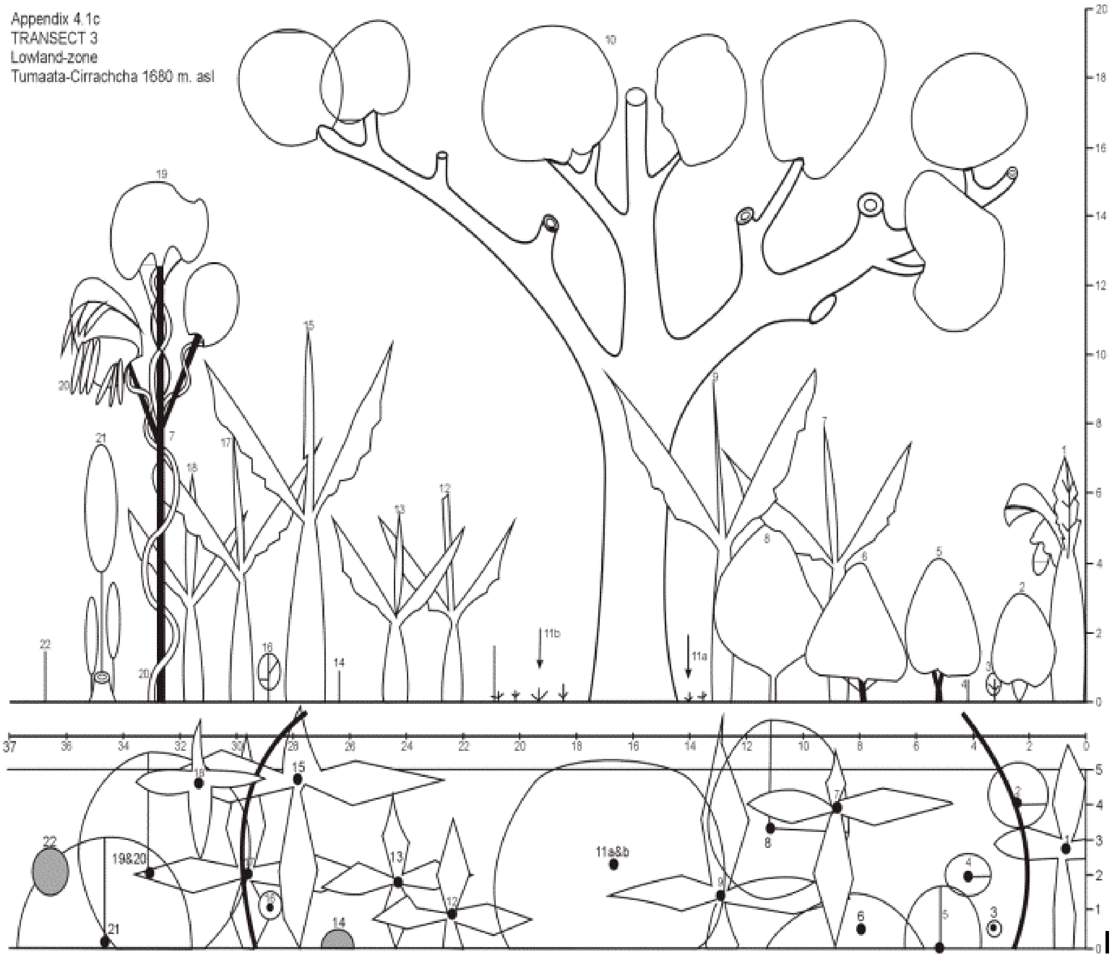
Key to block transect I (highland zone)

No.	Development stage	Remark
1	daggicho	Mature (harvestable)
2	idago	Mature (harvestable)
3	idago	Mature (harvestable)
4	beyaa	Mature (harvestable)
5	beyaa	Mature (harvestable)
6	guumee	Immature (harvestable if)
7	guumee	Immature (harvestable if)
8	guumee	Immature (harvestable if)
9	guumee	Immature (harvestable if)
10	guumee	Immature (harvestable if)
11	saxa	Immature (root vegetable)
12	saxa	Immature (root vegetable)
13	saxa	Immature (root vegetable)
14	saxa	Immature (root vegetable)
15	saxa	Immature (root vegetable)
16	kaassa	Immature (root vegetable)
17	kaassa	Immature (root vegetable)
18	kaassa	Immature (root vegetable)
19	kaassa	Immature (root vegetable)
20	kaassa	Immature (root vegetable)


Appendix 4.1b
TRANSECT 2
scale 1 : 100 cm
Midland - zone
alt. 2000 masi
Dodoro Area

Key to block transect 2 (midland zone)

No.	Development stage	Remark
1. *Ensete ventricosum, ganticho*	*kaassa*	immature
2. *E. ventricosum, ganticho*	*kaassa*	immature
3. *Coffea arabica*	*amaatto*	mature
4. *C. arabica*	*gurbbe*	immature
5. *E. ventricosum, ganticho*	*guumee*	immature
6. *E. ventricosum, ganticho*	*kaassa*	immature
7. *E. ventricosum, ganticho*	*daggichjo*	mature
8. *Cordia africana*	*darggageessa*	mature
8a. Seedling zone	-	-
8b. Beehive and bees	-	-
9. *Hofaa* (open space) of *ensete*	-	-
10.*E. ventricosum, ganticho*	*kaassa*	immature
11. *E. ventricosum, gantticho*	*beyaa*	mature
12. *Milletial ferruginea*	*qalo*	immature
13a.*E. ventricosum, tooracho*	*guumee*	immature
13b. *Hoffa* (open spce), of coffee)	-	-
14. C. arabica	*gurbbe*	immature
15. *Persea americana* (avocado)	*gurbbe*	immature
16. *E. ventricosm, gantticho*	*beyya*	mature
17. *Hofaa* (open space) of *ensete*	-	-
18. *Croton macrostachys*	*cimeessa*	mature
19. *Pygeum africanum*	*golqqo*	immature
20.*E. ventricosum, qarasse*	*saxxa*	immature



Key to block transect 3 (lowland zone)

No.	Species	Development stage
1	*Ensete ventricosum*	M (mature, harvestable)
2	*Coffea arabica*	M (mature)
3	*Dregeana sp. (onoono)*	IM (immature, seedling)
4	*Hofa (E. ventricosum)*	- (open space to be replanted)
5	*C. arabica*	M (mature, producing)
6	*C. arabica*	M (mature)
7	*E.ventricosum*	M (beya , harvestable)
8	*C. arabica*	M (mature, producing)
9	*E. ventricosum*	M (beyaa, harvestable)
10	*Ficus* sp.	M (reported to be more than 300 years old)
11a &b	Semi-natural nursery under (10)	- used to produce seedlings and other planting materials
12	*E. ventricosum*	IM (guumee, not harvestable yet)
13	*E. ventricosum*	IM (guumee, not harvestable yet)
14	*Hofa* (of *E. ventricosum)*	- (open space to be replanted)
15	*E. ventricosum*	IM (guumee, not harvestable yet)
16	*Cordia abyssinica*	IM (seedling)
17	*E. ventricosum*	M (beyaa, harvestable)
18	*E. ventricosum*	IM (guumee, not harvestable yet)
19	*Fagaropsis* sp. Rutaceae	M (harvestable)
20	*Phaseolus lunatus* (qoqee)	M (Lianascent sp. climbing the tree (no 19).
21	*Milletial ferruginea* (coppices)	IM (young)
22	*Hofa* (of *E.ventricosum*)	- (to be replanted) , harvestable)

Appendix 4.4. **Use value of the "weedy" herbaceous vegetation**

Gedeo name	Vegetable	Fodder	Soil maint.	Medicine	Decoration
Abbuyyo	X	X	X		
Adamme		X			
Annannotto		X	X		
Buuyyichcho		X	X		
Balliqne		X	X	X	
Budhe	X		X		
Be'laa					
Budde			X		
Banddaleessa					
Bookichcha		X		X	
Ballatto				X	
Cirqqe	X	X	X		
Ceekata				X	
Commaekana		X	X		
Doobbe			X		
Ddorree		X	X		
Darigu		X			
Facaatoo		X	X		
Faawwa		X		X	
Gutichchamme		X	X	X	
Gotigole					
Guurree				X	
Gorbbisanne		X	X	X	
Gorraasanjjo		X	X	X	
Gammada		X	X		
Harashshanne	X	X	X		
Hancculle			X	X	
Haarre		X	X		
Hinccinne		X	X		
Henshishalle			X		X
Hanqissa					
Haranjja		X	X	X	
Hanqaqalitto	X	X	X		
Kisha'me				X	
Konshishalle			X		X
Kalalla, golalooxxa		X	X	X	
Kidhe		X	X		
Kallachcha		X	X	X	
Kisha		X	X		
Laalunxxe		X	X	X	
Lacee		X	X		
Leedde		X	X	X	
Luquce			X		
Luxxaa			X		
Miqe					
Mujja		X	X		
Marraca					
Nuxa		X	X		
Qanqqaltto		X	X		
Qeecee	X	X	X		
Qobbo'o		X	X	X	
Qancartto		X			
Ramuca		X			

Gedeo name	Vegetable	Fodder	Soil maint.	Medicine	Decoration
Shokotto	X	X	X		
Soyame		X	X	X	
Shaagoda		X	X		
Seesiqo		X	X	X	
Siibbee	X	X	X		
Simma					
Toore		X	X		
Umogoshe		X		X	
Xu'naayyee	X	X	X	X	
Xuggeno		X			
Lowland Zone					
Ananotto		X	X		
Axefaaris	X		X	X	
Arike					X
Adama					X
Balliqane	X	X		X	
Budhe	X			X	
Buqqee faradinxxa		X			
Busho		X	X		
Bekkekotixxa weesee		X		X	
Buliyye		X	X		
Baalddo					X
Bushootu					X
Cirqqe	X	X	X		
Cooshiqqa		X	X		
Doobbe xilloxxa		X	X		
Doobbe golalooxxa			X		
Doobbe gishshinxxa			X		
Dunbbee'la				X	
Duu'me		X	X		
Doobbe qunxxixo		X	X		
Duke-barbare	X	X			
Daa'nikoolaa					X
Dhangago					X
Facaatoo		X	X		
Fawwa		X	X		
Fiitte		X		X	
Gaayyole		X	X		
Gorraasanjjo		X	X		
Gora		X			
Geeshi'le		X		X	
Guudhdhe				X	
Ggatimura					X
Harashshanne	X	X	X		
Hancculle			X	X	
Ha'nasho	X	X	X		
Hanxxaxe	X	X	X	X	
Honshishille		X	X	X	X
Hajiijja		X	X	X	
Haranjja		X		X	
Hinccinne		X	X	X	
Hinexcon golalooxxa		X		X	
Haarre		X			
Hukukube					X
Hixichcha					X
Irbbo		X	X	X	
Ilqabate					X
Jimala					X
Kidhe		X	X	X	
Ko'molchcha		X	X		
Koshole		X			
Kalala		X	X	X	

Gedeo name	Vegetable	Fodder	Soil maint.	Medicine	Decoration
Kalaate					X
Laalunxxe		X	X	X	
Leeddee		X	X		
Lacee		X	X		
Luquce		X	X		
Luculucu					X
Maadhdha		X	X		
Maracci		X	X		
Mujja		X	X		
Maxiichcha	X	X	X	X	
Nuxaa		X	X		
Qorcciisa		X	X		
Qixal shawe	X	X	X		
Qobbo'o	X	X	X		
Qodhaasanjjo		X	X		
Qu'ne		X			
Qeecee				X	
Qunxxuxxo					X
Quudhee					X
Qosorro					X
Qullubbe					
Raafoo	X	X	X		
Rooriqo				X	
Shiishe	X	X	X		
Seesiqo		X	X		
Shokotto	X	X	X		
Shaallo		X	X		
Shekkitte		X			
Tarcca					X
Tonttona		X	X	X	
Ukeette		X		X	
Ukukuba		X		X	
Umigoshe		X	X	X	
Xu'naayye	X	X	X	X	
Xuggeno		X	X		
Xadho					X
Yasho					X

Appendix 5. Research sites

List of farmers' associations containing research sites

1. Harooreessa (W1)
2. Goolaa (W2)
3. Jaanjamoo(W27)
4. Dodoro(W29)
5. Mokkeenssa(W30)
6. Chiicuu(W10)
7. Galalchcho (W20)
8. Baasuraa (B5)
9. Daroo (B6)
10. Suqqo (B11)
11. Menddo-Wolegee (B18)
12. Haroo-Wolaabuu (B20)
13. Raphphe-Tooraa (B24)
14. Laabaa-Reejii (28)
15. Caqasaa-Liishaa (B29)
16. Garbboota Lak.1(C7)
17. Tuulisee (C10)
18. Cirriquu (C13)
19. Dakoo (C1)
20. Baatii-Gootoo (C28)
21. Qongga (C31)
22. Qooqqe (C20)
23. Wogida (C23)
24. Bilooyya (K4)
25. Dabbo (K7)
26. Bunoo (K20)
27. Boojjii (K23)
28. Rakko (K25)
29. Abbeli (K26)
30. Gora-Dibaanddibbe (K27)
31. Harmmuufoo(K28)
32. Worqqa-Calbbeessa(K33)
33. Gadabe-Gubata (K30)
34. Haloo-Barrittii (K37)
35. Banqqo-Gootitti (K36)
36. Gadabe-Galchcha (K39)

Curriculum Vitae

Tadesse Kippie Kanshie was born on 19 September 1966 in former Sidamo province and former Darassa Awuraja, now Gedeo Zone, Wonago woreda, Dodoro village (Ethiopia). He obtained his elementary education in the Kale-Hiywot Church temporary village schools and at Wonago Elementary and Junior Secondary School. After passing the entrance examination in 1980, he got access to Dilla Comprehensive High School where he studied four years. Successfully completing the program, he sat for the University entrance examination. On passing the examination, the Ethiopian Government awarded him a four-year scholarship in 1985, in any one of the few institutions of higher learning in the country. He joined the then Haile Sellassie I University, College of Agriculture Alemaya. He graduated with the B.Sc. in 1988, specializing in Plant Sciences. The Alemaya University employed him, at capacities of Assistant Graduate and Assistant Lecturer, till 1991 when he was awarded an MSc Scholarship by the Netherlands Government. Tadesse studied in the Departments of Forestry and Ecological Agriculture, Wageningen Agricultural University, and followed specialization Silviculture and Forest Ecology. His M.Sc. research theme was an ecological analysis of age-old Gedeo land use. He graduated in 1994. Before returning home, he worked for four months in the Department of Ecological Agriculture, on his soil and herbarium samples and developed his theme for his further studies. In returning to Ethiopia in 1995, he was offered a job, as Deputy Head, of the Bureau for the Conservation and Development of Natural Resources, of the Southern Nations, Nationalities and Peoples' Region. When the Bureau was dissolved at the end of 1996, Tadesse went to his native town, Dilla, to become director of the Agricultural Bureau for the Gedeo zone. In 1998, the Wageningen Agricultural University awarded him a sandwich scholarship. In September of the same year, he came to Wageningen for a six-month stay, and prepared his Ph.D. research proposal. From September 1999 up to September 2001, he carried out the fieldwork in the Gedeo highlands. On the application of Tadesse Kippie, the Wageningen University activated the last part of the sandwich scholarship in September 2001, and he came to the Netherlands to write up his findings.