A LINEAR MODEL FOR PREDICTING *ENSET* PLANT YIELD

AND

ASSESSMENT OF *KOCHO* PRODUCTION IN ETHIOPIA

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Summary and Background Information

Enset ventricosum is the edible species of the separate genus of the banana family, thus named 'false banana', but the *Enset* fruit is not edible. Variation within the species to altitude, soil and climate has allowed widespread cultivation in the mid- to highlands of western Arsi-Bale, the Southern Peoples Nations Natinalities Regional State (SPNNRS), and western Oromia including West Shewa, Jima, Ilubabor and Welega. Three *Enset* derived foods are popular but the most common is Kocho. The plant is cut before flowering, the pseudostem (see definition below) and leaf midribs are scraped, the pulp is fermented for 10-15 days and finally steam-baked flat-bread is prepared. As many as 7 million people consume the low-protein *Enset* products as staple or co-staple foods, sometimes solely with Vitamin A foods but commonly without the needed protein supplement. Leaf, fibre and plant parts are used for food wrappers, cattle feed, ropes and house construction materials[1].

In December 1993, the FAO/WFP Crop and Food Supply Assessment document provided estimates of *Enset* and root crop production for the past seven years amounting to about 10% of the net cereal and pulse production. However, *Enset*/root crop production was not included in the 1994 FAO/WFP Crop and Food Needs Assessment Mission report. According to the report, although its (i.e. *Enset* and root crops) contribution to nutrition is considerable, a formula for its inclusion in the food balances needs to be determined. The Mission felt that some confusion existed over recent *Enset* yield reports of 4 tons per hectare (in cereal equivalent) compared to Ministry of Agriculture estimates of 5 tons per hectare. Moreover, in the SNNPRS, 1994 estimates show that 300,000 hectares of *Enset* is projected to yield almost 10 tons per hectare. Inclusion of *Enset* production from Oromiya Region (Oromia) and the national root crop production would have placed estimated '*Enset* and root crop production' at more than 1/4 of the total cereal and pulse production of Ethiopia. This would have created, on paper, a food surplus situation in Ethiopia that could endanger the food security of numerous communities, which are in fact food deficit areas.

Anyone who travels in the *Enset* growing area would conclude that *Enset* is a major part of the food production/consumption system of the area but quantification of its complex production mechanism has eluded statistical measurement. Several reports give average plant yields but an 'average plant' varies across agro-ecologies, cultural systems and even households. The number of plants utilized by a household is reluctantly and often incorrectly revealed by the farmer. And furthermore, quantification of land allocated to *Enset* is confounded by the multi-year nature of the crop, harvested throughout the year, and a complicated system of multiple transplantings at ever increasing spacings. This is further complicated by the findings reported herein and elsewhere that immature harvesting occurs during periods of food and a large percentage of plant seedlings succumb to drought and pests.

For this study, the authors hoped to circumvent these problems by constructing a regression relationship between the dimensions of the actual plant size utilized and the yield. This plant yield relationship was then used to multiply by the average number of plants harvested from a random sample of 100 farmers per wereda and then multiplied by the number of farmers in the *Enset* growing kebeles (peasant

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[1] For further general information on culture of *Enset* in Ethiopia, refer to Shank, Robert. 1994 The *"Enset Culture"*: Technical report on *Enset* or the `false banana'. UN- Emergencies Unit for Ethiopia.

associations) in the wereda. Although land area was assessed, ascertaining production per unit land was circumvented by basing yields on households and their utilization.

The average number of plants harvested per household per year varied from below 12 plants in a few weredas to more than 100 in several. If 50-60 plants are needed to fulfill a major staple food requirement, then obviously those harvesting the lower number must be supplementing the Enset foods and those harvesting the higher number are either surplus producers or could be utilizing smaller plants. Wereda per plant yields averaged 19.7 to 84.6 kg with an overall average of 44.2 kg at 50% moisture. This compares to farmers opinion that average yields are 25 kg and researchers reports of 12 to 42 kg at unspecified moisture levels. Annual household production of Kocho varied from around 1 quintal in low producing areas to more than 90 quintals in 3 weredas. Average annual household production varied from 5-15 quintals in subsistence producing weredas to 35-70 quintals in surplus producing weredas.

Assessed total annual Kocho production from 80 weredas and 7 special weredas amounted to 4,381,903 mt (metric tonnes) of which 3,704,698 mt is from the Southern Region and 667,205 mt is from the Oromia Region. This compares to 5,422,935 mt reported by the Ministries of Agriculture of which 5,008,515 mt was estimated to be produced in the Southern Region and 414,420 in the Oromia Region. The previous production figure accepted by the FAO-MoA for crop assessment in 1995 was 2,482,574 mt but was derived by deduction and did not include production in Oromia Region.

Pulse crops, which are annually assessed, account for only about 10% of the grain production in Ethiopia. They are the basis of non-meat national dishes, are a vital protein supplement to the cereal diet but tend to be very low in productivity. Unlike pulses, *Enset* and root crops are simple basic starch crops, quite low in protein, not very adaptable to varying food dishes but very high in productivity, and may account for more than 10% of the cereal equivalent consumption. The implications of heavy dependence on these "poor nutrition" crops may have serious implications on the physical and mental health of the people of the "*Enset* Culture."

Therefore, with the derivation of a formula for assessing Enset production, Enset and root crop production should go back into the food equation. Acceptance of the herein assessed production figure would put the country and certainly the Southern Region in a surplus production situation. While Enset products are not easily transported or stored, other grains produced in the Enset growing area are and should be considered in the national food balance. It may be that balance sheets should be regionalized so that surplus and deficit stocks can be balanced according to traditional foods consumed in that region.

The Enset production assessment does not contradict the current food deficit in the areas currently recieving relief aid. In fact the data supports the concept that, even with Enset, the land shortage in some areas has resulted in immature harvesting and does not allow the most efficient production of this of multi-year crop.

Subsequent assessments, whether on individual farms or in entire affected areas, should show whether relief aid enables the household to recover in terms of allowing Enset plants to grow larger thus more productive.

It is hoped that this report will help stimulate the Food and Agricultural Organisation (FAO) and the Government of Ethiopia to focus attention on this crop and conduct any future assessments as needed.

Definition of Terms

Agro-ecology- a defined group of ecological factors (climate, soil, altitude etc.) that contribute to the classification of distinct agricultural system.

Amicho - the fleshy inner portion of the *Enset* corm which may be cooked and eaten separately, tasting similar to potato.

Bulla - the small amount of water-insoluble starchy product that may be separated from Kocho during processing by squeezing and decanting the liquid. It is eaten as porridge.

Clone or variety - a distinct type or grouping of plants within a species separable from other types by some form of heritable trait, be it visual, chemical or other. New plants of clones are usually reproduced asexually, i.e. without utilizing flowering and seed production.

Corm - an enlarged fleshy structure at the base of the plant from which new shoots emerge following destruction of the dominant shoot.

Cereal equivalent (CE) - conversion of the yield or weight value of a food to the proportion of standard 3,500 calories/kg equivalents of cereals. *Enset* and root crop foods, being high in water, are adjusted by the following factors to give CE (see Table 7).

Kocho	.54	Cassava	.44
Bulla	.57	Yam	.18
White Potato	.21	Taro	.32
Sweet Patato	.32		

Jump- the package of Kocho or Bulla ready for transport and marketing usually wrapped with dried leaf sheaths.

Kocho - the pulp of the *Enset* pseudostem derived by scraping the individual pieces and excluding the fiberous remains. Bulla may or may not be extracted and the Amicho may or may not be included. The raw mash is chopped and fermenting and it is this product at 50% moisture that is being assessed. When steam baked, the flat-bread is also called Kocho.

Leaf sheath- the basal part of the leaf which is wrapped around other leaf sheaths to form a false plant stem

Metric tonne- ten quintals or 1,000 kilograms

Midrib-	the central portion of a leaf which supports and carries nutrients/water to and from the leaf surface
Multi-year crop-	a crop which takes several years to mature or flower as opposed to perennial crops which bear fruit or seeds each year. Annual refers to crops which are replanted and harvested annually.
Plantation-	an area designated for grouping of crop plants such as *Enset*
Pseudostem -	the 'tree trunk' formed by the bases of the leaves or leaf sheaths adhering to one another in concentric fashion
Peasant association or farmer kebele-	an administrative grouping of farmers in a geographic district usually delineated by some natural boundary such as a foot path, a ridge or stream.
Sucker or Seedling-	a new plant shoot that develops at the base of the leaf, in the case of *Enset*, at the juncture of the pseudostem and the corm, more properly called a sucker since it is not developed from a seed.
Wereda-	an administrative group of farmer kebeles usually having a common ethnic background and bounded by common geographic features.

The Importance of Assessing/Reporting *Enset* Production

Governments need to take responsible action to ensure the avaialability of food supplies at all times. To do this, policies that encourage stability and growth of food production must be formulated in order to insure a reliable supply of inputs and provide protection against hazards. This includes a focus on research and extension activities that address those constraints limiting production, as well as a focus on other factors that could lead to increased output. These factors interact in determining the food security and nutritional status leading to the improved health and welfare of the nation's people.

In addition, an accurate account of the vital food supply of a country is important to the food security of any people but especially in areas which have experienced food shortages in the past. To ignore the extensive production of *Enset* and its contribution to the food balance of this area would endanger the credibility of the World Food Programme and the Commission for Disaster Prevention and Preparedness' appeal to donors for food aid. However, to accept the data provided by the Ministry of Agriculture in 1994 would have jeopardized any request for the required food aid (see Table 1). It has become increasingly evident that definite action must be taken to clarify the data utilized for planning food aid.

Table 1. Crop assessment and food aid needs for Ethiopia[2].

[2] Data from 1994 FAO/WFP Crop and Food Supply Assessment and the Southern Ethiopia Peoples Administrative Region Agriculture Bureau.

	Assessment (Metric Tonnes) 1993	1994
Cereal and pulse production	7,151,000	7,203,300
Enset and root crop production	670,000	2,747,635 for SNNPRS + ?? from Oromia
Total food available	7,601,000	10,530,935
Structural food required	8,626,000	8,835,000(1995)
Structural food deficit	1,025,000	-
Structural food surplus	1,695,935**	
Actual food aid requested		882,000
Actual food aid distributed	911,000*	606,980 (1995)

*revised **tentative, pending acceptance of SNNPRS *Enset* and root crop data

Assessment Production Data- Past and Present

A reliable *Enset* production assessment is difficult because plants:

a) are transplanted 1-3 times at varying and increasing spacings,

b) are harvested after 4-7 years depending on rainfall and the altitude conditioned growth rate;

c) are consumed across seasons and years depending on a family's food needs; and

d) vary greatly (agroecologically, in terms of variety, and individually) in yield of Kocho which is "about" 50% water and is not packaged in standard units.

However, this is not reason to abandon estimation and research on the production of *Enset*. It is obvious that a reasonably accurate method of sampling could be used to assess production from the many reported surveys already available.

Evans (1993) states that *Enset* crop production is a necessary parameter that needs to be measured since it is not only used for food security assessment of the *Enset* dependent areas but also for formulating government policy and research/extension resource allocation to the crop. In the words of one 1994 Crop and Food Needs Assessment Mission team member:

> "Everyone agrees that measurement of the *Enset* plantation area is straightforward and we have to rely on the farmer to truthfully report the number of plants he harvested. But that is

where the consensus ends. What mathematical figure to use for the yield per plant and per hectare, no one agrees."

The assessment of *Enset* production for the years 1987 to 1990 was made by the Central Statistical Authority - CSA (Table 2) using enumerators trained in measuring yields from 2x2 meter samples of grain fields. For *Enset* production they had to rely on farmers' and limited research reports of average yield per plant, age of plants harvested, as well as estimated hectarage and plant spacing to calculate an across-the-country, per hectare-per year harvest yield. Following assessment-by-estimate in the early years, incremental increases were added without knowledge of actual changes in hectarage or production for the years 1989-92.

Table 2. Annual national food production in Ethiopia for the crop years 1987 to 1993.

Production 000 mt	1987	1988	1989	1990	1991	1992 est.	1993 fcast
Cereals/Pulses less feed, seed export and postharvest loss	5,703	5,763	5,693	6,231	6,000	6,755	6,322
Enset and Root Crops-**Cereal Eq**	570	570	570	600	620	640	670
Milk and Milk Products-**CE**	249	261	273	285	300	300	330
Meat and Eggs-**CE**	185	190	195	200	200	200	210
Total Production	6,707	6,784	6,731	7,316	7,120	7,895	7,532

Source: 1993 FAO/WFP Crop and Food Aid Assessment Report. FAO. Addis Ababa.

Beginning in 1991, the responsibility for *Enset* assessment was shifted to the Ministry of Agriculture (MoA), first at the national level and recently to the wereda and zonal level. The local MoA staff estimate the hectarage and production of each Peasant Association or farmer kebele from each wereda. Regional decentralization and expanding emphasis on agriculture has resulted in shifting of staff and hiring of new recruits as agricultural extension agents, some of which have had little training and experience in assessment.

In the 1993 MoA report compiled by CSA[3], 2,831,000 metric tons of *Enset* (1,529,000 mt-CE) were reported harvested from 137,000 hectares, giving an average yield of 206 quintal per hectare (11.1 mt-CE). This is almost three times the national yield reported by the 1992 WFP/FAO crop assessment for ***Enset* AND root crops**. In the Southern Region (Gedio, Hadiya, North Omo, Sidamo and Kembata), produced 2,417,000 tons on 102,000 hectares at 237 quintals per hectare. In contrast, in the Oromiya Region (Borena, Jima and Bale zones) produced 414,000 tons on 35,000 hectares at 117 quintals per hectare.

[3] MoA/CSA Crop Assessment: 1993/94 Report on area, production and yield of crops - private holdings (Meher Season). September, 1994. Addis Ababa.

Climatic, edaphic (soil), cultural or varietal differences for the more than double difference in yield levels between the two regions are not known. However, administrative emphasis on the crop may have entered into the assessment since in the Southern Nations Nationalities Peoples' Regional State *Enset* is reported to be the major crop, accounting for 65% of the 37 million quintals of crop production, whereas in Oromiya Region *Enset* production amounts to 9% of the 46 million quintals of produced. Nevertheless, at the time it was felt that these figures must be incorrect, so an incremental increase (about 4.7%) was again used to estimate the 1993 production.

For the 1994 crop assessment, data provided by SNNPRS MoA (Table 3) reported 5,008,000 tons of Kocho and Bulla production (2,299,000 mt-CE) on 300,000 hectares giving 166 quintals per hectare (8.96 mt/ha-CE). Sidamo moved from fourth to first in production changing from 227,000 mt on 23,000 hectares (82 qunitals per hectare) to 1,026,000 mt on 43,000 ha (240 qunitals per hectare). Gurage zone moved from seventh to second changing from 53,000 mt on an unspecified area to 864,000 mt on 52,000 hectares (166 quintals per hectare). Gedio zone moved from first to fourth in production changing from 889,000 mt harvested from 8,900 hectares (1000 quintals per hectare) to 186,000 mt on 18,800 hectares (100 quintals per hectare).

The 1994 SNNPRS reported root crop production (white and sweet potato, taro, yam and cassava) of 825,173 mt on 80,181 hectares (103 quintals per hectare) gives a cereal equivalent of 248,435 mt for a total *Enset* and root crop yield of 2,747,000 mt-CE from SNNPRS alone as compared to the forecasted estimate of 670,000 mt production in the whole country. Production data on *Enset* and root crops in Oromiya Region was not collected. It became evident that a realistic assessment of production needs to be made before entering into the picture for the national food availability report. Including these crop figures would have significantly raised the caloric balance 30-50 calories per day for all Ethiopia. It was concluded that accepting the *Enset* and root crop data may be more misleading than no data at all, so only cereal and pulse production data were used in the determination of food aid needs at the time of the 1994 assessment (Table 1).

Some of the descrepancies noted in the SNNPRS Agricultural Bureau *Enset* estimates can be attributed to the zonal and wereda staff of the MoA in their inexperience at estimation of hectares and yields. However MoA staff justified the hectarages in that past villagization programmes had discouraged planting of the multi-year crop whereas now people were moving back to their holdings and expanding their normal planting for food security. In addition new reports of higher per plant production, lesser spacing and earlier harvest were proclaiming higher yields potentials. During this time even expatriots were joining the ranks of those propounding *Enset* as a 'wonder' or 'miracle' plant with perhaps the highest food production potential of any crop.

Table 3. Hectarage and Production of *Enset* products in the Southern Ethiopia Peoples Administrative Region in 1994

Zone	Hectares	Kocho (mt)	Bulla (mt)	Fiber (Qtl)
Gurage	52,400	786,000	78,600	366,800
Hadiya	18,013	210,752	25,218	108,078

N. Omo	55,609	706,234	72,292	389,263
Kembata Alaba Tembaro	11,689	136,843	19,883	93,568
Gedeo	18,844	186,048	NA	NA
Shekacho	3,279	19,346	NA	NA
Kaficho	22,273	133,638	NA	NA
Sidamo	43,334	940,347	86,668	476,674
Bench	750	6,000	NA	NA
Maji	150	1,005	NA	NA
S/Omo	210	2,100	NA	NA
Yem	5,020	62,750	2,008	10,040
Amare	4,000	32,000	NA	16,000
Buggi	385	3,080	NA	1,150
Derashe	373	2,984	186	1,119
Konso	80	480	NA	NA
Min Tea & Coffee	70,584	1,023,468	70,584	282,336
TOTAL	300,000	4,653,076	355,439	1,745,028
Cereal Eq(mt)		2,296,600	202,600	

Source: Southern Ethiopia Peoples Regional Administration Ministry of Agriculture.

Attempts to measure *Enset* yield

In published studies on *Enset* production in sample areas, attempts to assess the exact production level have been numerous. Teketel (1975) processed a large number of plants of each of three varieties and found the average yield to vary from 27 to 34 kg/plant. In a 1985 extension cirrular, Dereje proposed from his studies that a family of five using *Enset* as the major staple food would consume 60 plants (4 to 8 years old) per year. Furthermore, at 2 X 2.5 meter spacing and 25 kg of product per plant, he estimates production from harvesting six year old plants would be 83 quintals per hectare. At 1900 calories per kilogram of Kocho, this would amount to a somewhat high estimated consumption of 1560 calories per day of *Enset* for each family member.

In a study of 60 households in six villages nearby Attat Hospital in Gurage zone (Pijls et.al. 1994), 46 plants per year were harvested per household of 6.1 persons averaging 34 kg of Kocho per plant. The household average of 0.16 hectare of *Enset* divided into the number and yield of plants was found to give 95 quintals per hectare per year assuming 6 year-old plants were harvested. Average consumption of 0.55 kg per person per day amounts to 852 calories per day which was reported to be 78% of the carbohydrate intake. The high yield per plant in this study was thought to be influenced by the presence of cattle and the use of manure. Although it was known that sale of *Enset* occurrs, which would further reduce caloric consumption, no measurement of sales was attempted.

In extensive descriptive characterizations of *Enset* culture collected from various sources including their own, Kefale and Sandford (1991) found North Omo *Enset* cultivation to average 78 square meters per household member or .69% of cultivated land. From Wolayita Agricultural Development Unit (WADU. 1977/78) data, the reported 78 plants harvested and processed averaged 27kg of Kocho per plant. Spacing of 18 plants within a plot gave Kocho+Amicho yields of 18-42 kg/plant which can be translated into yields of 33-70 quintals per hectare.

However Sandford (personal communication) feels that drought, diseases, animal pests and harvest by choice or due to food shortage are reducing the number of plants at each age, the number of plants reaching maturity, and therefore the per plant as well as plantation yield. All these factors, if true on a widespread basis, would tend to reduce assessed yields. Therefore use of any figure for an area wide average mature plant yield would upwardly bias *Enset* yield assessment.

Production assessment methods and survey techniques

In 1993 FAO project ETH/86/013 (Evans, 1993) attempted to formulate a questionnaire to determine design and survey techniques for future measurement of *Enset* production, consumption, sales and contribution to diet. In this pilot survey, five households in each of two peasant associations in four weredas in each of five zones (195 samples) were selected for data collection. Although field size of each crop including *Enset* was enumerated, summarized results were not reported "because fallow and pasture land was not measured and would have biased size and proportion of landholding". Furthermore, data was taken in local land units (timad) and packages (jump) which were not standard and varied even within a community. (NOTE: Central Statistical Authority apparently has the raw data but plans to summarize or release are undecided).

In the 195 households, number and age of *Enset* plants was taken. Total number of plants per holder varied from 87 in Illababor to 1191 in Sidamo. In the *Enset* plantation across all regions, 30% of the plants were new transplants whereas only 15% (85 plants per landholder) were over 5 years old.

When trying to measure production of *Enset* products, it was found that "local unit names for measuring Kocho are varied" as is "the weight of the *bundle* for a particular unit, sometimes from 1 to 15 kg within the same community." Even after purchasing, harvesting, fermenting and weighing the produce of 163 mature plants individually, yield of Kocho varied from 8.5 kg per plant from 6 year-old plants from Sidamo to 92.5 kg for 5 year-old plants from Illubabor (Table 4). For the 163 plants yield tested, the average production was 30.8 but the standard deviation of yield from plants of the same age across the 5 regions averaged 9.3 kg. Although other extensive data was taken such as storage and preservation, livestock and poultry ownership, and foods consumed, the use of the criteria `age of plants' and `region grown' was found to be statictically unreliable for quantification of *Enset* assessment.

Table 4. Kocho yield statistics for individually measured plants by age and region.[1]

Region	Plants Sampled	Plant Age	Kocho yield	Standard deviation(kg)	Coefficient of variation(%)
West Shoa					
	1	6	23	-	-
	8	7	24	9.45	39
	5	8	23	8.32	35
	3	9	34	2.39	9
	2	10	17	.99	5
	3	12	34	6.56	19
	1	13	20	-	-
	3	14	18	2.05	11
	3	15	33	6.95	21
	2	16	35	7.07	20
	1	17	35	-	-
South Shoa					
	5	4	46	14.08	30
	10	5	56	15.81	28
	12	6	36	24.88	69
	5	7	31	6.02	19
	5	8	37	11.99	32
	1	10	12	-	-
Ilubabor					
	2	2	31	3.54	11
	10	3	47	23.66	50
	6	4	47	10.39	22
	2	5	93	10.61	11
	5	6	29	14.17	49
North Omo					

1

	4	3	11	5.64	52
	13	4	26	11.28	43
	12	5	29	11.21	38
	4	6	31	11.34	36
	2	7	34	.64	1
Sidamo					
	16	4	11	5.26	49
	5	5	22	11.02	49
	6	6	9	1.82	21
	6	7	33	14.89	54
	163		30.8	9.33	30.48

The study concludes that in determining *Enset* production, instead of trying to ascertain the age, spacing, area, number of mature plants or questioning producers on the number of bundles (jump) produced in a particular area or region, the best result is obtained by simply measuring the plantation, asking the number of plants harvested in a given year and multiply this by an average expected plant yield for an area or region. Still the basic deficiencies of this assessment method would be:

1) mainly the determination of a basic plant yield considering the large variation in individual plant yield due to varietal, agroecological, husbandry and cultural differences as well as household processing,

2) differences in age of harvest among households and during the crop year due to the current food supply and the plantation space available and

3) basing the assessment on production per hectare, whether the area is measured or estimated, still involves the complex factors of plant spacing and number of times transplanted which varies widely across households and administrative areas.

Hiebsch (personal communication) used the data from several sources to calculate estimated yield per hectare of different transplanting systems. In one method, the yield of a mature harvested plant is divided by the area and time that it occupied that space. In another method, when the system is assumed to be in equalibrium, the total annual yield is divided by the area occupied by that system. From reported plant yields and theoretical plant spacings over time, he estimates possible dry weight yields of 32 to 69 quintals/hectare/year (44.8 to 86.6 quintals @ 50% moisture).

Recently, Yeshi (1995) compiled yield estimates of *Enset* production by accepting regional figures on *Enset* hectarage but not production. Instead for the calculation of production, she used an average of the per plant yields reported by 6 different researchers studies. This average of 27 kg/plant was multiplied by an estimated 1/4 of the *Enset* plantation area harvested per year and a calculated 400 plants (2.5 X 2.5 meter spacing) occupying that space. Finally that estimated production of 108Qt per hectare was multiplied by the reported 287,334 hectares of *Enset* in the Southern Ethiopia Peoples Administrative Region.

The assessed production was given to be 2,482,574 mt per year but did not include production from Oromiya Region (Oromiya). An additional 15,487 hectares has been reported by Oromiya Region excluding Borena which is estimated by MoA to have 11,334 hectares. So this additional 26,821 hectares, at the same yield level, would have added an additional 289,667 mt bringing the total Ethiopian *Enset* production to 2,772,241 mt or 1,646,018 mt cereal equivalents.

Using this method of assessment, the accuracy of the three factors, average plant yield, mature plants per hectare and hectarage, would continually be questioned and need costly re-evaluation. For instance if a farmers decided to increase planting of *Enset*, hectarage would immediately go up raising assessed production. However in fact the actual increase in production would not happen until years later. On the other hand, if some factor caused farmers to increase their harvest of *Enset*, hectarage would be reduced, assessed production would be reduced when in fact production/consumption has increased.

Assessment of *Enset* production, in order to increase accuracy and reflect reality, needs to be uncoupled from the usual methods of annual crop assessment i.e. production/hectare X hectares grown. Annual crop production is uncomplicated by the fact that a defined area is planted, harvested and the produce consumed, sold or held in reserve within the specified season. *Enset*, however being a multi-year crop with the intermediate stages being edible, allows for flexible harvest timing and consumption. For this reason assessment could be based alternatively on utilization.

Household utilization multiplied by number of households per administrative area is a valid assessment of production. Recent population census should assure reasonably accurate data on rural households. The remaining factor of household utilization should be assessable by sampling within the defined administrative area. In fact Yeshi (1995) suggests a nested design of sampling to insure greater randomness of sampling. A nested design would mean a certain percentage of households within a percentage of PA's within a percentage of weredas. The number of plants and the product for each size plant processed by households over time would need to be readily assessed. The number and size of plants by household can be enumerated by interview and verified by the number of plants presently being readied for future use. The processed yield per plant should be a function of the size of plant being utilized by the household.

Non-destructive measurement of plant characters contributing to yield would appear to be the most logical means of assessing *Enset* plant yield. Kefale and Sandford (1991) while trying to use plant characters to distinguish varieties, report a reasonable 22 and 23% coefficient of variation for pseudostem girth and height respectively within plants of the same age/variety with sample size being only 3 plants. WADU (1979/80) report Kocho yields of 48 plants (24 each treatment) after measurements of pseudostem girth and height (Table 5). In this test the differences in measurable plant size were proportionately reflected in the Kocho yield. Furthermore many researchers continue to use these measurements to indicate growth response to a treatment and to characterize clones/varieties. This indicates not only measurable response to environment but also a heritable relationship.

Table 5. Effect of transplanting on growth and yield of Kocho.

Transplanting treatment	Once	Twice

Plant base Circumference (cm)	170	191
Pseudostem Height (cm)	218	236
Kocho Yield (kg/plant)	20.7	25.9

In summary this method of assessment would be similar to that utilized to estimate lumber yield from standing trees or meat yield of live animals. Simple, multiple or curvilinear regression relationships for product yield have been developed using diameter and length of a sample of trees in a forest or chest circumference of live animals.

Succession of cropping systems determined by land economy

Before going directly into the assessment study, it would be informative to understand the food security and land economy that interact to produce cropping systems and nutritional vulnerability in the *Enset* growing areas.

Westphal (1975) describes the agricultural systems of the *Enset* growing Southwest Ethiopia as

1. Staple food cropping i.e. *Enset* as a primary food crop (Gedio, Sidamo, Gurage, Hadiya, and Kembata zones)

2. Co-staple food cropping i.e. *Enset* and cereals as primary food crops (Wolayita, Gofa, Keffa, Amaro and Yem zones)

3. Grain Cropping i.e. cereals as the staple food with supplementation especially in off-saeasons with *Enset* foods (Welega, Jima, West Shoa, Illubabor and parts of Kefecho zone)

4. Shifting cultivation i.e. rotational utilization of cleared forest areas with a variety of crops including *Enset* (Bench, Shakicho and forested Kefecho zones)

In the *Enset* growing areas, these cropping systems are adapted to the land availability and the food production economy. In the far western part, where forest and grassland is not so limited, cattle herders grow *Enset* as food insurance. Plants as old as 17 years are reported and occasionally plants mature, form seeds, die and dry up without being harvested. In these areas, plants grow naturally `in the wild' having started from seeds dispersed from the maturing ones. Shifting cultivation and livestock products provide self-sufficient food supplies and distance from markets discourage cash cropping. These areas are seldom needing supplementary or drought-caused food aid.

Also there are areas where the forest soils support either naturally occuring or cultivated coffee trees. Coffee prices were up recently (though coming down rapidly) and the income per unit land cultivated is good. Chat, banana, pineapple and other fruits are also common, along with livestock so desired cereals can be purchased from cash sales. Once land is cleared and where topography allows cultivation, along with *Enset*, cereal and pulse cropping is popular - wheat, barley and horse beans at the higher altitudes and maize, sorghum and hariocot beans at the mid-to lower elevations. These crops also produce residual fodder that support livestock in a supplementary role as draft power. However, in land short areas, cultivation of *Enset* and annual crops is by hand hoeing. Cattle, where affordable in these land short areas, are often staked in the small grazing areas and are slaughtered at maturity for meat consumption or sale.

Nevertheless as size of holdings in the *Enset* growing areas decrease, as much as possible, farmers maintain cereal production but switch from low-yielding pulse cropping to high yielding root crop culture. Sweet potato and/or white potato are the main substitutes with taro, cassava, and yam being common to a lesser degree, probably for food variety and food security. The white potato is adapted to loose soils and higher elevations but very susceptible to the devestating late blight disease. Sweet potato is better adapted to the mid-altitude clay soils but can often be limited by shortened rainy seasons or drought.

Vegetables and fruits, although still not large cash cropping systems for self-sustaining farmers, are beginning to occupy ever larger farming areas. Onions, cabbage, carrots and beet root patches are increasingly common and are supported by the Orthodox tradition of animal product fasting. Avocado, mango, koke (peach), ghesho (hop) and zatu (guava) seedlings are in high demand and MoA tree nurseries are beginning to supply the farmers. In some areas growing of Eucalyptus poles has become a common cash crop.

Crops requiring high labour, but which have high production or value are the economic factors that would allow the densly populated areas to survive on small landholdings by generating cash for purchase of needed additional energy foods. However, these crops too are dependent upon market development, climatic dangers, high seed costs and expensive chemicals to control diseases and pests. These are among the reasons households increasingly depend on *Enset* for food security. In summary, the succession components in the farming systems as related to rural poverty, decreasing land holdings and increasing dependence on cropping technology can be summarized as follows:

Livestock < Coffee < Pulses < Cereals < *Enset* < Root Crops< Vegetables < Fruit

It may appear fatalistic to forecast that if Ethiopia's rural population and poverty continues to grow with limited land availability, the trend will be in the direction of more high yielding crops, poorer balance in terms of nutritional quality and quantity and higher risk of dependence on these few crops.

Cropping systems and current food security/nutritional situation in four *Enset* dependent areas

When considering the problems and solutions to the problems of the *Enset* growing area, it is important to consider the agro-ecology of the entire crop/livestock system and its means of supporting the family food security. However soil, climate, elevation and other factors effect the production potential and the solution of constraints in each area. The following is a preview of some agro-ecologies growing *Enset* and information sharing between them could be helpful in finding common solutions. From interviews with representative families, it is clear that by utilizing *Enset*, large families can derive a large quantity of foor from a small proportion of their land holdings (Table 6).

Table 6. *Enset* cropping data from sample farms of the Southern Ethiopia Peoples Administrative Region in March,1995.

Town Zone	Farm size ha	*Enset* area ha	Plants/yr consumed	Plant Yield Kg	Family size	Plant spacing	Plant Daime cm	other foods		Income generation
								grow	buy	
Dilla Gedio	1.5	.5	25	10-15	4	2.0	190	maize s.pot fruit		Coffee Kocho
Bule Gedio		.08	14	40-60	12	1.25	250	cereals lentil meat		Cereals livestock
H.Selam Sidamo	1.5	.07	100	6-10	8	1.0	50	wheat onion milk		wheat onion
Geneto D Sidamo	.5	.04	12	50	7	.75	175	maize pulses fruit onion S. cane		tobacco coffee Euca trees chat
Durame Kembata	1.0	.16	100	70	12	2.0	160	maize maize s.pot wheat w.pot		coffee chat euca trees
Boditi	1.25	.04	24	75	9	.8-1.0	145	maize s.pot h.bean		teff s.cane
Wajakero Wolayita	.75	.12	20-25	100	24	1-4	100	maize wheat s.pot barley w.pot pulse		coffee teff maize
D.Wogane Wolayita	1.0	.05	40-50	65	12	1.5	125	wheat maize s.pot s.pot w.pot taro milk		wheat horsebean
Waka	1.25	.38	18	100	7	1.0	225	meat maize F.bean		
Angacha Kembata	1.25	.35	24	35	8	1.5	180	wheat F.bean		wheat F.bean
Average	1.10	.17	39.2	58	10.3	1.6	160			

1. The *Enset*/coffee/maize culture of Sidamo-Dilla

This area is an intensive coffee growing area as a result of development work by the Ministry of Tea and Coffee. Fertilizer and pesticides have been made available for coffee growing, especially in the latter case for control of the Coffee Berry Disease to the extent that there are no honeybees in the area. With the current price of coffee being good, farmers can buy cereals and pulses as needed and there are no signs of food insecurity in the majority of the population. However, having experienced past fluctuations in coffee prices and production, farmers have become accustomed to growing their own *Enset* as insurance of food supply.

2. The *Enset*/maize culture of Jima-Mizan Teferi

Adequate and reliable levels of rainfall and length of the Krempt season have been benificial for this area and it has become well-known for high maize yields and surplus production. However oxen used to cultivate the maize fields, have consistently been plagued by Trypanosomiasis. Also because of the high rainfall, weeds and crop diseases restrict the use of small grain crops under these conditions. *Enset* is utilized during the cropping season food gap, is the source of the high energy foods needed by the farmer and is without the risk of disease or crop loss.

3. The *Enset*/root crop/maize culture of Wolayita-Sodo

Due to land pressures, livestock production has decreased and the area devoted to low yielding pulse production is also diminishing. Not only is the population dependent on these high yielding crops but they are grown and eaten successively within the same year. Maize can be planted in February and in July for two harvests in July (June for fresh maize) and November whereas sweet potato can be planted in October and February for harvest in January and May. Therefore, from late February until the end of May, *Enset* (Kocho) is the only available high energy food usually eaten with a little `Ubasha cabbage' as a source Vitamin A. White potato is planted at the higher altitudes in April to be eaten after June because late blight disease becomes severe with the heavy rains. Taro is harvested in November and Cassava is ready to eat in September.

4. The *Enset*/Livestock culture of Dawro-Waka

When traversing the river from Wolayita, the Omo valley is dry and stony with pockets of maize/sorghum and cotton until returning to the *Enset* cultivating highlands of Gofa, about 30km before Waka, the wereda center. These highland hills are steeply sloping and not suitable for cultivation. Although the soils are deep and rainfall percolation is rapid, erosion would be serious. The growing season is short, supporting only early maturing barley varieties and cabbage. For the three months of July-September it is reported to be only a little lighter in the daytime fog than at night. Pastures are green throughout the year though growth is not luxurious. Meat and milk products supplement the heavy consumption of *Enset* with no cereals or pulses except those purchased for holidays or by the wealthy. Although pneumonia and TB are present here, people choose to live here and take their cattle to work in the surrounding lowland because of the presence of malaria and trypanosomiasis there.

Food Nutritional Comparisons for the *Enset*/Root Crop systems and the interacting factors of nutritional status

During the food shortage of early 1994, it was reported that starving children from the lowland maize/sorghum cropping areas would recover much faster than those from *Enset* dependent areas. This is thought to be related to the higher incidence of Kwashiorkor related malnutrition cases. Unlike marasmus, the energy intake deficiency which is corrected by willing intake of caloric foods, Kwashiorkor is first symptomized by loss of appetite and apathetic unresponsiveness. Accompanying these symptoms, loss of immune response is followed by death from illness, usually diarrhea or malaria, unless protein intake is forceably administered.

Table 7 lists the caloric and protein content of foods eaten in the *Enset* growing areas. The cause for protein deficiency during the food shortage-high *Enset* consumption period of February to May can be seen from the very low protein content of *Enset* and the root crops. The greatest risk is to children under the age of five who are weaned from their mothers milk. This is why vigilant and targeted supplementary food programmes are needed for poor and/or food insecure families in the *Enset* dependent areas. Areas which have cereal based consumption will probably recover with cereal relief supplies, but *Enset*/root crop-dependent populations will show high child mortality unless supplementary food programmes are carefully administered.

Table 7. Nutrient value of some common foods consumed in the *Enset* growing areas.

Food Source	% Moisture	Value of 100gm edible portion	
		Calories	% Protein
Cereals			
Maize	12	363	10.0
Wheat	13	344	11.5
Teff	11	345	8.5
Pulses			
Horicot bean	10	339	24.0
Horse bean	9	342	25.9
Oil crops			
Noug (Niger)	6	513	17.0
Fleshy plants			
Enset	50	190	1.5
White potato	80	75	2.0
Sweet potato	70	114	1.5
Yam	73	41	1.0
Cassava	60	153	0.7
Taro	70	113	2.0
Vegetables			
Beetroot	87	45	1.8
Carrot	90	33	1.0
Leaf cabbage	90	28	2.0
Fruits			
Avocado	75	165	1.5
Banana	70	116	1.0
Papaya	89	39	0.6
Animal Products			
Beef	66	202	19.0
Fish	78	95	18.0
Eggs	74	158	13.0
Milk (cow)	88	64	3.3

Source: World Food Programme manuel on food nutritional contents; 1991, WFP, Rome.

In a study carried out by USAID in Kenya (Neumann et.al. 1993) on the effects of food intake on toddlers and schoolers, limited quantity and quality of diet was found to cause growth retardation, reduced resistance to illnesses and impared cognitive function. In rural African areas, where large amounts of energy requiring work exist, no resting energy adaptations were found and stunting without recovery was prevalent. While mild illness was found to be related to household sanitation, parental literacy and illness exposure; low levels of food intake, particularly protein and fat, predicated serious illness. Apart from duration of schooling, diet quality (protein composition) was the second most important determinative of cognative performance in school. Students with good diet quality were also found to show more spontaneous social and leadership behaviors than their peers.

Enset production reliability and improvements needed

Effects of drought and rainfall on productivity of the system

Enset grows best at altitudes above 1600 meters above sea level, not because it cannot withstand heat, but because it needs adequate soil moisture. Irrigation studies in hot climates show that it stores large amounts of water but wilts severely during long periods without rain. The fact that transplanting is done in the dry season, usually just before the start of the Belg rain, and that growth resumes but at a reduced rate throughout the dry season, has earned the crop the misnamed reputation as being drought tolerant. The fact is that in the higher elevations, ample soil moisture reserves are being depleted by this deep rooted plant. On the other hand, at lower elevations and on tight clay soils where soil moisture stress occur, severe leaf pruning is practiced to conserve plant water use. The practice of manuring, natural mulching by leaf and stem residues, and the high inception of rainfall by plant leaves all contribute to rainfall capture, soil moisture conservation and reduction of run-off as compared to bare-earth farming. *Enset* is therefore a reliable crop during seasonal rainfall shortages but would succomb to prolonged droughts.

The effect of the dry period on carbohydrate reserves and caloric content of the Kocho has not been studied. Especially in the lower altitude and dryer climates, it would be expected that plant reserves would be depleted when growth rates decline. Under these circumstances advantage may be taken by harvesting and storing the Kocho supply for the dry period rather than harvesting month-by-month.

Soil fertility and *Enset* crop improvement prospects

Because of the practice of manuring, household waste composting and *Enset* residue mulching, soil fertility in the *Enset* plantation is much higher than adjacent fields and pastures. However, with decreasing pasture and forage resources, declining cattle numbers and available manure, *Enset* growth and fertility requirements are becoming apparent.

The SNNPRS-MoA *Enset* team has decided to undertake fertilizer, spacing and variety yield trials. These will be quite difficult to interpret considering the 5-7 year length of the cropping season and the variance in plant yield even before treatments are imposed. Plot size of 4 plants with 3 replications could have above 20% inherent variation.

Based on the limited data of the Institute of Agriculture Research, 6 *Enset* nursery sites have been selected for increasing certain 'selected improved clones' for distribution to farmers. These clones are reputed to be less susceptable to bacterial wilt and better adapted.

Other agronomic practices should be critically examined for contributions to yield. For instance, transplanting is practiced to conserve land area but is known to delay growth to maturity by 1-2 years. The size of the trade-off between time and space in the two cropping systems is not known.

Transplanting loss occurs (individual farmers transplant 2-3 plants per space) and some selection is probably practiced for better appearing plants. Grouping of transplants is probably practiced to fully utilize the limited supply of manure. Intercropping with competitive species such as maize, sorghum and climbing beans or already established coffee, hops or tree fruits may allow more efficient land utilization.

<u>Constraints to production from diseases and pests</u>

Bacterial wilt (*Xanthomonas musacearum*) appears to be the only major disease of *Enset*. While the disease is present and `of concern' in most *Enset* growing areas, farmers are not alarmed and appear to be living with the disease though asking for `medicine'. Extensive experiments were conducted by Dereje (1984) to explore the mode of transmission. One hundred percent infection occurred from cutting leaves with contaminated knives or injecting the bacteria onto the cut surface. Thirty to 60% infection was achived by dipping transplants or watering the soil surface with bacterial solutions. But no infection occurred when transplants replaced dead infected plants (time between replacement not specified). Bacteria were found to survive on the surface of contaminated knives for up to 3 days under humid conditions and up to 4 days under dry conditions.

MoA pathologists and extentionists are instructing farmers in removal and burying of diseased plants and sterilization of knives with fire but many farmers believe other means of spread occur and do not cooperate. Presently it appears that most farmers simply grow additional plants and do not concern themselves with diseased plants.

Other means of disease spread are still possible and the real means of spread should be elucidated. It is known that bacterial infection of plants occurs by contamination through wounds, breaks in the epidermis or through the stomates (natural ventilation pores). So being able to manually transmit the disease does not mean the same as how the disease is transmitted under farmers conditions. The as yet unanswered questions about Bacterial Wilt of *Enset* are:

1. In many areas apart from the Gurage zone, successive transplanting and knife prunning are not practiced. So what is the means of infection of *Enset* plants in these areas? (Up to 10% infection was observed in these cases). Possible sources of Xanthomonas spread to new plants are

    a. Splashing rain
    b. Birds, bees/wasps, flies(fruit)
    c. Wind blown leaves of infected plants
    d. Lizards, snakes, etc

e. soil inhabiting organisms (mole rats, insects, nematodes)
f. rainfall runoff to newly planted corms or plants

2. Is the farmers' practice of tying down the leaves, allowing the diseased plant to dry and then burning a sanitary control practice? It does prevent contanimation of adjacent plants that could occur during the recommended practice of removal of diseased plants.

3. Wilt occurs most commonly in 3-4 year old plants. If wounding is the means of pathogen entry, then why are small plants not similarly affected?

4. What is the threshold of bacteria necessary to incite the disease i.e. could small amounts of inoculum from the above listed natural sources be sufficient to cause disease? One milliliter of concentrated inoculum will incite symptom development within 2 weeks, however what is the effect of sub-threshold levels of inoculum over the long term.

Another threatening pest, which can be more devastating to an individual household is the mole rat. These animals, the size of large rats, tunnel and move from plant to plant eating the roots and corm, inciting variable damage including immediate decline and death of the plant. Cases were observed where serious infestation had caused 10-20 plants/week to be salvaged for what little pulp was possible to extract. Control consists of flooding the tunnel and killing the emerging animals. A large fish-hook type snare trap with a string trigger through the tunnel is being introduced by the MoA.

Area of *Enset* cropping

The area utilized for *Enset* cropping encompasses vast areas of the Southwest quarter of Ethiopia (Figures 2 & 3). Although *Enset* is utilized throughout the area, population density is lower in the western part and *Enset* cultivation is not as extensive.

The mid-highlands are termed *Woina Dega* and the highlands are called *Dega*. The area of *Enset* cropping correlates well with these altitudinal delineations (Figure 4). The lowlands or *Kolla* of the Rift valley, the Omo-Gibe River, the intermountain area of North and South Omo and the Southwest Ethiopian perimeter are too dry for this consumptive water-using crop.

Enset is adapted to deep fertile soils and ample rainfall areas throughout Ethiopia but the derived foods are utilized mainly from Addis Ababa south and west. *Enset* plants occur in Hararge and Gojam but the large leaves are used there, here in Addis Ababa, as well as in the southwest as wrappers for baking flat breads.

METHODOLOGY OF THE *ENSET* PLANT YIELD REGRESSION STUDY

Following the lead of the WADU Study (1980) which indicated a correlation between plant size measurements (pseudostem base circumference and pseudostem height) and Kocho yield, a regression study of these variables was undertaken for the following reasons:

1. These two parameters could easily be measured in the field both now and for future assessments by development agents as a non-destructive quantification of Kocho yield per plant regardless of size of plant utilized.

2. The predicted yield of varying size plants multiplied by the number of each size harvested would lead directly to *Enset* production per household .

3. Utilization of *Enset* at the household level could be related to food security and reflect fluctuations in annual crop harvested by the household.

4.The problems currently encountered in trying to establish production per hectare over time would be avoided. These problems include documenting number, age and spacing of plants at each of up to 4 transplantings, number/size and time of harvest, and finally average plant production over highly variable agroecologies.

5. Variations in zonal, ethnic and household husbandry result in variations in plant growth rate and ultimately yield per unit time and space.

6. Due to the 3-7 year growth cycle and the flexibility of harvest time, changes in household food economy and land holdings which may affect *Enset* plantation size and Kocho production would be measured as area expansion/ contraction per se / poor yields / high yields, respectively.

Using the predictive equation with the following parameters

Standard Error of an Estimate $= \dfrac{\text{variance}}{\text{sum of observations - mean}}$ or $SE_e =$

and assuming an 80% correlation between plant size and Kocho yield, then

further assuming a range in harvested plant circumference from 150 to 300 centimeters and a range on Kocho yield from 10 to 70 kg/plant then

Now choosing a 90% confidence interval of predicting yield, the 't' value on a two tailed graph would be 1.645 and solving for the number of plants tested would give

Consequently it was decided that data on size and yield of 70 plants would be collected to form the model with an attempt to sample an equal number of plants throughout the expected range of yields. In addition, it was recognized that Kocho production from a certain size plant could also be influenced by variety or clone of plants, agroecological factors and household processing practices. For these reasons plants were sampled throughout the *Enset* growing area in order to get a random sampling of plant Kocho yield.

After weighing the Kocho (Bulla and Amicho were included if present), a sample was taken for moisture correction and the woman indicated the size of plant and height of pseudostem included in the Kocho. Circumference was measured about 20 cm above the corm and did not include pruned or partial leaf sheaths. Pseudostem height was measured from the corm juncture to the cut-off point indicated by the woman. Cases sampled which had excessive fiber were not included in the analysis. Also cases removed from the analysis were those in which the plant had already flowered because extension of the pseudostem during the flowering process resulted in skewed expectation of Kocho production and high residual deviations from regression. In the final analysis data from 60 plants were used in deriving the model.

RESULTS AND DISCUSSION OF *ENSET* PLANT YIELD REGRESSION STUDY

As shown below (Table 8), even after purposefully measuring a few small and a few large plants, the majority of plants sampled yielded in the 10 to 60 kg/plant range. The actual plant measurements and moisture-

Table 8. Distribution of Kocho plant samples by weight categories.

	Number of plants in each of the sub-classes sampled							
Yield of Kocho (kg)	<10	10-20	20-30	30-40	40-50	50-60	60-70	>70
No of plants sampled	5	13	15	9	7	7	1	10

adjusted yields of the sampled plants is given in Table 9. As a result of the diverse area sampled, the plant yield and size, both circumference and psuedostem height, varied widely. There should be no attempt to correlate size of plant with any place or agro-ecology since random households were simply asked whether they have Kocho under fermentation. Also no attempt should be made to correlate altitude with any plant character for the same reason. Some processing structures were contaminated with flies, maggots and ants.

Table 9. Data on *Enset* plants measured and weight of Kocho derived used in formulating the regression model.

Zone	Wereda/ Village	Kocho Weight (kg)	Plant Circum (cm)	P'stem Height (cm)	Altitude (m)	Comments
*Gedeo	Wanago	116.02	225	180	2500	chopped
Arsi	Kofele	114.72	298	303	2320	
"	"	112.59	252	270	"	
*Gedeo	Bule	106.10	225	252		flowered
"	"	100.00	237	234		
N. Omo	Chencha	94.28	346	286	2500	
"	Bidessa	92.65	206	214	1980	
Gedeo	Bule	91.60	304	300		
Jimma	Goma	87.99	156.6	177		flowered
Gurage	Goro	73.26	157	207		chopped
N. Omo	Bidessa	62.45	218	181	1980	moggots
Jimma	Saka	57.68	160	243	1750	flowered
W. Shewa	B Girama	53.47	155	234		pair-6
Keficho	Chena	53.38	226	187	2120	
Sidama	W Genet	52.06	189	232	1800	
Hadiya	Konteb	51.43	232	202	2300	
N. Omo	Boditi	50.61	150	143	1960	pair-5
W. Shewa	B Girama	50.28	158	208		pair-6
Jimma	Deedoo	49.80	182	162		
N. Omo	Boditi	49.39	173	196	1960	pair-5
Keficho	Chena	43.99	169	165	2120	
Shekecho	Masha	43.85	171	205	2200	
Jimma	Goma	43.56	132	209		flowered
W. Shewa	M Derra	43.26	209	259		
Shekecho	Yeki	42.27	180	245	1700	
Yem	Sekora	38.76	167	210		
W. Shewa	Wonchi	37.71	214	280		
Gurage	Goro	37.14	157	153	1800	pair-3
W. Shewa	M Derra	36.14	148	230		
Keficho	T Gesha	35.11	144	127	1860	
Sidama	A/Tulu	34.98	104	147		
Gurage	Gumer	33.67	172	176	1900	
Shekecho	Masha	32.24	195	228	2200	

Kefecho	T Gesha	31.67	237	152	1860	
Gedeo	Adame	29.20	142	185	2400	pair-1
Shekecho	Masha	29.23	119	170	2200	
N. Omo	Soddo	26.94	156	187	2280	pair-4
Gedeo	Adame	26.72	125	210	2400	pair-1
Hadiya	Konteb	26.45	152	175	2340	
Jimma	Deedoo	25.65	167	183		
Sidama	A Selam	24.88	218	190	2750	pair-2
"	W Genet	23.66	163	211	1800	
Yem	Sekora	22.93	207	197		
N. Omo	Soddo	21.84	161	166	2280	pair-4
Gurage	Goro	21.63	153	174	1800	pair-3
Keficho	T.Gesha	21.50	204	197	1860	
Shekecho	Masha	21.50	131	183	2200	
Sidama	A/Tulu	20.91	124	122		
N. Omo	Soddo	20.73	160	153	2280	pair-4
Gurage	Goro	19.18	137	160	1900	maggots
W. Shewa	Gura	18.77	171	123		flies/ants
Jimma	Gimbo	18.77	176	252	1700	
Sidama	A Selam	17.30	142	195	2750	pair-2
"	A/Tulu	16.14	140	154		pair-7
"	"	15.76	151	153		pair-7
"	"	14.61	142	144		pair-7
Arsi	Kofele	13.97	86	120	2320	
Sidama	A/Tulu	12.30	73	123		
"	A/Wondo	11.60	99	139	1800	
Shekecho	Masha	10.75	94	157	2200	
W. Shewa	Gura	10.61	145	177		
Sidama	A/Tulu	10.45	74	112		
"	"	8.84	71	139		
"	"	7.30	107	140		
"	"	6.07	98	109		
"	"	3.00	58	93		
W. Shewa	Gura	2.45	136	100		

In Table 9 several plants are labeled as paired plants meaning that the sample plants were the same size, age and variety from neighboring plantations. These would be expected to yield equally except for household variations in husbandry and processing. Paired t-test analysis of these pairs of samples, as well as paired data from the calculated yield using the model, was conducted with the conclusion that the yields for paired plants from both sets of data were not significantly different. This indicates not only that same size/variety of plants yield similarly but also that processing, at least by neighboring households, is likely to result in similar Kocho yields from same age/size plants.

In developing the model, the analysis of variance due to regression was highly significant. Testing for curvilinear and interaction (circumference and height) effects, these factors were not significant or useful in explaining yield response. However simple linear effects of both pseudostem circumference and height were highly significant in predicting Kocho yield. The correlations are given in Table 10 and the model is sufficient to explain 82% of the observed sample variations in Kocho yield.

Table 10. The correlation matrix for plant Kocho yield with the plant characters pseudostem circumference and height over the 60 sample cases.

variable 1. plant yield (kg)	1.0		
2. circumference (cm)	.87	1.0	
3. height (cm)	.83	.77	1.0
	var 1.	var 2.	var 3.

Correlation of Kocho yield with pseudostem circumference was 87% and with pseudostem height was 68%. Correlation of circumference with height was 72%. The following equation thus describes the relationship of Kocho yield as a function of plant pseudostem circumference and height.

Kocho Yield (kg/plant) = -32.1 + .26 X circum (cm) + .13 X height (cm)

The response surface graph of this function is given in Graph 1 and a table for field conversion of the two variables to Kocho yield is given (Table 11). It should be noted that there is apparently some non-linearity in the real yield of the very small and the very big plants since the model predicts no yield of the very small plants which actually yielded 2-5 kg/plant. Also the model predicts less than the 100+kg/plant of the very big plants. This indicates additional sampling needed for those wishing to predict accurately these plant sizes in particular.

Table 11. Estimation of Kocho yield per plant from various pseudostem circumferences and heights by application of the regression equation- Kocho yield (kg/plant) = -36.5 + .23 X Plant Base Circumference in cm + .19 X Pseudostem Height in cm.

ht cir	90	110	130	150	170	190	210	230	250	270	290	310
60	-	-	2.0	5.8	9.6	-						
80	-	2.8	6.6	10.4	14.2	18.0	-	-				
100	3.6	7.4	11.2	15.0	18.8	22.6	26.4	30.2	-	-		
120	8.2	12.0	15.8	19.6	23.4	27.2	31.0	34.8	38.6	42.4	-	-
140	12.8	16.6	20.4	24.2	28.0	31.8	35.6	39.4	43.2	47.0	50.8	54.6
160	17.4	21.2	25.0	28.8	32.6	36.4	40.2	44.0	47.8	51.6	55.4	59.2
180	22.0	25.8	29.6	33.4	37.2	41.0	44.8	48.6	52.4	56.2	60.0	63.8
200	26.6	30.4	34.2	38.0	41.8	45.6	49.4	53.2	57.0	60.8	64.6	68.4
220	-	35.0	38.8	42.6	46.4	50.2	54.0	57.8	61.6	65.4	69.2	73.0
240	-	39.6	43.4	47.2	51.0	54.8	58.6	62.4	66.2	70.0	73.8	77.6
260		-	48.0	51.8	55.6	59.4	63.2	67.0	70.8	74.6	78.4	82.2
280			-	56.4	60.2	64.0	67.8	71.6	75.4	79.2	83.0	86.8
300			-	61.0	64.8	68.6	72.4	76.2	80.0	83.8	87.6	91.4
320				-	69.4	73.2	77.0	80.8	84.6	88.4	92.2	96.0
340					-	77.8	81.6	85.4	89.2	93.0	96.8	100.6

Graph 1

Factors that could bias the regression relationship

In an attempt to make the regression function applicable to the entire *Enset* growing area, samples were taken in as many weredas as possible and households were randomly selected within the wereda. The only qualifications for taking a sample were `Did they have Kocho of edible age in which all edible parts were intact?' i.e. had not been partially consumed. The use of this model was intended to be useful to predict, with relative accuracy, the per plant yield anywhere in the *Enset* growing area and under any cultural conditions.

1.Bias caused by plant architecture

There is variation in plant architecture affecting pseudostem measurements caused by climatic and cultural conditions interacting with expressions of the genetic variety. In warm climates with rainfall patterns and soil characteristics that result in low soil moisture availability, the pseudostem morphology tends to be short and squatty especially if plants are not crowded. This morphology is characteristic of the vertisol areas of Welisso and Shoa Region approaching the Awash basin. In moist humid areas with good soil moisture and longer growing seasons, plants tend to be more tall and slender especially if crowded. The tall slender plant type is commonly found in Sidama-Gedeo-Borena environs where plant placing is dense. Even here plants utilized vary from surplus seedlings of 80-100 cm circumference and 60-80 cm pseudostem height up to mature, well spaced and fertilized plants of 2.5-3 meter diameter and 3-4 meter pseudostem height.

Altitude and the corresponding temperature/insolation conditions also affect plant architecture. High light intensity contributes to photosynthetic carbohydrate accumulation and, combined with good rainfall, causes lush growth and in general, greater pseudostem circumference. However the lower temperatures present delay maturity and draws out the age to harvest.

Therefore it would be expected that the data from the samples collected in this study would apply with greater accuracy to the area in which those size samples were taken. For example the yield of very large plants for the model were largely determined at places of high altitude where large plants commonly occur. Conversely it was found that large numbers of small plants are often utilized in one area near Awassa and most of the small plant yield data was taken there. It is recommended that other researchers establish their own model if they need highly accurate data for a particular place of study. However considering the diversity of samples used in the present study, the authors consider the model sufficient to predict present and future yield assessments throughout the *Enset* growing area.

It was pointed out by some *Enset* researchers that certain varieties tend to be more bulbous i.e. having greater circumference at or approaching the base. Certainly some varieties appear to have tall and straight or gently tapering pseudostems while others tend to show swelling at or above the junction of the corm. However since regression takes into account variations both in circumference and height, bulbous variations would not affect the model in the way one would expect from a model based on volume calculations.

2. Variations caused from seasonal plant moisture content.

The pseudostem of the *Enset* plant and more specifically the leaf sheaths that compose the pseudostem are composed of multitudinous, somewhat large mesophyll air/water spaces uniformly arranged between the upper and lower fiberous surfaces. It is not known to what extent the thickness of these spaces contract under soil moisture stress affecting the plant base circumference. While most of the *Enset* growing area does not experience drought, the normal period of absence of rainfall could affect soil moisture availability and plant water relationships. It is common practice in Gurage and adjacent areas to prune, even completely decapitate, plants during the 'dry season' to 'prevent dehydration' of plants but it is not known whether this is necessary or interrelated to the need for livestock forage. Certainly these conditions could affect the basal circumference of the plant.

All measurements for this study, both the regression study and the survey, were made during the period from mid-September to the end of November, at which time plant moisture relations should have been stable. Normally crop assessments are made at this time of cereal crop maturing and so the model was designed to correlate with the timing of the need for this information. If yield assessments are needed for other times of the year, it would be necessary to check the effect of soil/plant moisture relationships on the plant circumference and therefore the equation.

3. Variations caused by Kocho processing methodology

Household processing undoubtedly affects kocho yields. Size of plant utilized would not bias model yield estimates since size is the basis of measurement but what is done or not done with any particular size plant varies tremendously among households. First the outer leaf sheaths which contain quantities of chlorophyll and anthocyanin pigments may or most likely would not be included in the Kocho. Secondly the inner leaf sheaths may be scraped hardily, including more fiber, or gingerly, giving better quality Kocho. Also the inner shoot apex which eventually becomes a flower primordia may or may not be included. Bulla may or may not be extracted and finally whether the corm is processed with the Kocho, wholly, partially or not at all. For the model, Kocho, Bulla and Amicho or corm were complete for each plant sampled and weighted as one. Obviously the moisture content of the Bulla and Amicho fractions, where present, differed from that of the Kocho subsample taken for adjustment. These fractions were present in about 20% of the 60 samples used for the model and it is hoped that by random sampling the processing variations were a random sample of the actual household processed yields.

Out of concern for differences in plant yield being attributable to processing variations, several times where neighbors were sampled with similar sized plants, notation was made. Correlation between observed plant yields of these 'paired neighbors' was 87%. It can be extrapolated that variations in household culture and processing could contribute approximately 10% to variation in plant Kocho yield. Therefore, if particular ethnic groups are being assessed who utilize particular processing methodologies, their yield may differ slightly from the overall population.

4. Variation caused by maturity of the plant.

Since the model considers size and not maturity of the plant, changes in dry matter content at different stages of maturity could affect estimated plant yields. As the plant approaches maturity, larger amounts of starch are accumulated in the plant prior to flowering. It is commonly known that plants nearing maturity make the best quality Kocho and the highest yield of the highly prized Bulla. According to the model, large plants, whether approaching maturity or not would yield the same. It is not known how much difference in yield this would make except to say that yield of Bulla per plant is small, averaging 6% (Pjils et. al.).

METHODOLOGY OF ASSESSMENT OF FARMER *ENSET* HECTARAGE AND KOCHO PRODUCTION IN ETHIOPIA

During the process of Kocho sampling for construction of the model, farmer survey forms were distributed at the zonal and, as much as possible, directly to wereda level extension or crop production personnel (Figure 6). Seventy four weredas which were thought to be major *Enset* growing weredas were solicited to participate in the survey and meter tapes were provided to facilitate conducting the surveys. Instructions were given on how to approach the farmers and how to insure random sampling of 100 farmers per wereda. Obviously some weredas which were lesser producers in the major growing areas were omitted. Also some weredas were inadvertently omitted due to their being under the Ministry of Tea and Coffee. Segmo and Satema weredas were omitted because they were being transferred from Illibabor zone to Jimma zone. Other weredas were omitted either by the MoA or the authors due to their inaccessibility.

Farmer reported number of plants harvested was expected to be biased in some cases so the number of plants available for harvest was also assessed by the enumerator. In cases where there was extreme discrepancy between these two, harvested number was adjusted. Measurement of mature plant pseudostem diameter and height was done on 2-3 plants per farmer. Farmer *Enset* plantation size was either asked, estimated, or actually measured. Since total household production rather than per hectare production was considered to be the aim of this survey, accurate measurement of the plantation was not considered to be critical.

Plant measurements for each household were inserted in the model formula and multiplied by the number of plants harvested by that household. Average production as well as hectarage of the 100 surveyed households was multiplied by the total number of farm households in the wereda. In some cases, as noted in the tables, wereda production data was not recieved by the survey. For these cases adjacent weredas average production was multiplied by the number of farm households. Also in some weredas which do not grow *Enset* in greater than 90% of the households, only the number of farmers in *Enset* growing farmer kebeles or peasant associations was used to calculate wereda production.

Figure 6. Sample survey form used to assess *Enset* production in 74 weredas

Zone___Hadiya_________ Wereda__Soro_______________
PA ___1st Otoro________ Farmers in PA__2401___________
Farmers in the Wereda_40,335__ Hectares *Enset* in PA___387_______
Hectares *Enset* in Wereda_4,281__ Hectares Cropland in Wereda_63,426___

Farmer Number	*Enset* Plants Harvested /Year	Mature *Enset* Plants Available to Harvest	*Enset* Base Circum-ference centimeter	*Enset* Edible Stem Height cm	Farmer *Enset* Area Hectares	Comments
1	30	21	170	220	.08	
2	54	18	199	204	.21	
3	15	64	203	250	.17	
4	35	49	187	200	.20	
5	-	20	-	-	.10	immature
6	200	300	190	205	1.80	commercial
7	-	-	-	-	-	no *Enset*
8	19	200	150	185	.95	expanding
9	40	10	125	142	.06	poor farmer
10	37	46	228	203	.24	
11						
12						
13						

RESULTS OF THE ENSET PRODUCTION ASSESSMENT SURVEY

Of the 81 weredas in the Enset growing area of the Oromia and Southern Regions, 74 were asked to participate in the assessment survey. From these 74, 58 weredas responded by returning completed survey forms. Some important Enset producing weredas were missed because of the zonal MoA's failure to include the survey of weredas under the Ministry of Tea and Coffee Development. Other weredas were temporarily under transition from one zone/region to another.

Assessment data on number/size of plants harvested

The number and size of plants harvested by the household varied both among and within the weredas (Table 12). It is likely that harvest parameters reflect the household food supply and the harvest of annual crops. Number of plants harvested annually per household varied from below 12 in 4 weredas to more than 100 in 13 weredas. Also evident is the many weredas with large standard deviation of plants harvested, indicating there is considerable spread among households in the wereda in terms of above and below average number of plants harvested. Obviously, in the case of extensive harvest, above 50-60 plants per year, the family may not consume the entire product but are likely to be commercial producers as well, selling varying amounts through local, urban and Addis markets.

Variation in the size of plant harvested is not as extensive as could be expected. Standard deviation of circumference and pseudostem height could have been high as this measure is expected to reflect not only age of plants harvested per se, but also varietal, cultural, and agroecological differences as well as household food economy differences. Field observations by the authors indicate that there are often a few large plants in reserve at some household for special purposes; it is possible that enumerators may have measured those few largest plants not yet harvested rather than the average plant harvested by the household.

Several weredas which are known to be extensive Enset growers reported low numbers of plants harvested. This cannot be accounted for by accusing the farmers of minimizing their food production because the enumerator/development agent also counted and reported standing plants available for next year harvest. Rather the enumerator is likely to have minimized both the harvest reported by the farmer and the remaining mature plants. This is evident in 2 cases in Sidama zone (Awassa and Bensa), and in several cases of N. Omo zone (Chencha, Damot Gale, Kindo Koshia and Soddo) and Kefecho zone (Decha, Gawata, Gimbo and Tineshu Gesha). In these weredas, the reason why the number of plants harvested should be up to 5 times less than other weredas in the same zone with similar reported hectrarages is not logical.

Again the size of plant harvested is reported to be dimensionally small in some weredas and therefore the resulting yield per plant and household production in these weredas is lower than would be expected. Two weredas in Sidama zone, Aleta Wondo and Arbegona, reported very small size plants being harvested even though harvest numbers were similar to that of the other weredas of the zone. Harvest of plants this size is not uncommon, especially for the corm food, Amicho, but not expected for the majority of the household Kocho consumption. It may be that enumerators should be instructed to differentiate between harvest for the corm food `Amicho' and that of the more mature pseudostem foods, Kocho and Bulla. In both the cases of unreasonably low numbers and size, the average of the other zonal weredas is proposed for the assessment (in parenthesis) until more extensive data can be obtained in these particular weredas.

Assessment data on hectarage of Enset

Although Enset hectarage was not used directly in calculating the assessment the data was taken to give indicative relationships. The small household plantation size reported emphasizes the productivity of Enset. It appears that 1/6th to 1/8th of a hectare is common among households. Even among what appears to be commercial producers, plantation size above 1/3 hectare is not common. In 5 weredas (Arodessa of Sidama, Yerga Chefe of Gedio, Telo of Kefecho, Agere Maryam of Borena and Welisso of West Shoa) unusually large areas were given for the Enset hectarage. While enumerators were not specifically instructed to measure the Enset area, they were asked to give estimates since crop area was used for assessment in the past. It is likely in these 5 cases, as may well be true for the other enumerators also, that estimating Enset area is more difficult and therefore less acurate than for cropland. It would be helpful in future assessments to have the hectarage reported in consistent units rather than as fractions, decimals or square meters, i.e. 1/4, .25 or 2500.

General considerations in assessment data collection

In general the three parameters needed for the assessment, i.e. plant numbers and harvest dimensions, were reported to be easily obtained by the enumerators-- usually development agents, MoA specialists or a combination of both. It is likely that specific enumerator instructions by survey experts would lead to better standardized and more accurate assessment. In this first assessment the authors directly contacted wereda experts, who were not necessarily the enumerators, in about half of the weredas.

Verifying the availability of the 10-100 plants indicated by the household to be harvested annually took the enumerator a matter of a few minutes. Further, measurement of the pseudostem circumference and height of a few of those plants also required only a few minutes. The only materials needed was a 3 meter tape measure and the assessment could be accomplished by a single person without assistance and without harvest or destruction of any plants.

While it was specified that the 100 households were to be a random sample, it was evident in a few cases that households with larger Enset production were enumerated first and the last few enumerated were notably smaller than the first. Another enumerator pattern that was evidebt was that of reporting plant numbers in multiples of 12, indicating that plants harvested per month was extrapolated for the year. This may have exagerated either the maximizing or the minimizing farmer and would not have included harvest for holidays and celebrations.

Calculation of Kocho production per plant, per household and per wereda

The regression equation for Kocho yield of varying size plants was included in the computerized data base to give production per plant (Table 13). The wereda average was weighted by the number of plants of each size. Apart from the two Sidama weredas, average plant yields varied from 19.7 kg in Bonke wereda of N. Omo zone to 84.6 in Yirga Chefe wereda of Gedio zone. Most commonly, assessed plant yields ranged from the high 20's to the mid 40's.

The overall average of the wereda averages gave plant production of 44.2 kg. However this is not weighted by the extent of Enset plants harvested by the respective wereda. Those weredas where commercial interests allow plants to reach larger size are averaged equally with those weredas where large numbers of households consume plants of smaller size. Therefore it is misleading to use this figure for generalizing household production.

Per household production was also calculated from the data base by multiplication of respective plant production for each household by the number of plants harvested for each of the 100 households sampled. Household Kocho production varied from a low of 78 kg in Seka wereda of Jimma zone to 9829 kg in Bule wereda and 9716 kg in Wanago wereda of Gedio. Several weredas had household production of 5-7000 kg but most commonly weredas using Kocho as a staple food on a subsistance level produced 600 to 1500 kg per household.

Recent census data provided up to date figures on rural households which were used for calculation of wereda production from the household production. The average of the 100 households sampled in the wereda was multiplied by the number of rural households. In a few cases, where the wereda is on the edge of the Enset growing area, the proportion of the rural households using Enset was used instead of the total number. And in a few weredas that were not surveyed, the household production of adjacent weredas was used to estimate the wereda production (figures given in [ ] brackets).

Assessed total annual Kocho production in the 80 weredas and 7 special weredas amounted to 4,381,903 mt (metric tonnes) of which 3,704,698 mt is from the Southern Region and 667,205 is from the Oromia Region (Table 14). This compares to 5,422,935 mt reported by the Regional Ministries of Agriculture of which 5,008,515 mt was estimated to be produced in the Southern Region and 414,420 in the Oromia Region. The previous production figure accepted by the FAO and National MoA for the crop assessment in 1995 was 2,482,574 mt but was derived by deduction and did not include production in Oromia Region.

Since wereda populations are so large especially in the Enset growing area, small errors of the sample, in this case 100 households per wereda, are magnified thousands of times. Sample standard deviations could be used to calculate wereda variability in household Enset production and to project future sample size needed to assure desired survey accureacy.

DISCUSSION OF THE ENSET PRODUCTION ASSESSMENT SURVEY

Despite the great variability in plant age, size, and time of Enset harvest as well as household variability in culture and processing, the survey was successful in establishing a `formula' for assessing Enset contribution to the food balance in Ethiopia. Furthermore when conducted on an annual basis, as is the crops harvested annually, the Enset assessment proceedure utilized herein would reflect the household food situation in the wereda in relationship to other food crops as well as food shortages. From this aspect, this proposed assessment process would be useful to both the agriculturalist interested in production responses as well as the humanitarian interested in food security.

Acceptance of the herein assessed Enset production figure would add considerably to the food balance sheet for Ethiopia. Enset/root crops, as well as livestock products, are deliberately left out of the equation because of the difficulty in getting a handle on production/consumption. However now that a `formula' for assessing Enset production has been devised, production of a crop that contributes 20% of the national carbohydrate and is the staple food of 18% of the population should be considered in the balance sheet. The country and certainly the Southern Region would be in a surplus production situation. Conversion of the assessed production to cereal equivalents gives 2,366,228 mt-CE which should be added to the 9,435,000 mt of cereal and pulses produced in 1995.

It should be the philosophy of the crop assessment process to monitor the production season for the major crops in the major production areas. Other major food sources should not be ignored just for ease of calculation. Recent missions have avoided the contribution of Enset because it is not easily transferable, i.e. stored, transported and utilized by different cultures. The same could be said for non-users of teff, maize or wheat. The fact is that the other surplus carbohydrate from the Enset area, be it what may, could be `local purchased' and transported to the deficit area. This could support local agriculture similar to the local purchase of sorghum in the Humera area for the Tigre Region. It may be that the balance sheet could now be regionalized to see which food sources are in surplus and would be suitable to the food preferences of local or adjacent deficit area.

The assessed Enset production does not contradict the occurrence of food deficits in Enset growing areas currently recieving relief assistance. In fact the methodology developed herein points to low household production of Enset in the Wolayita area as an indicator of food insecurity further agrevated by declining Enset use as a coping mechanism. Both the smaller plant size and the lower plant numbers harvested are indicators of the failure of Enset to fill the food needs. Whether the Enset plants are being harvested immature, the land area is too small for the household needs, deseases or pests are affecting production or poor soil fertility/ lack of manure is imparing growth needs ground verification. However the methodology developed should also be a useful tool for monitoring Enset production changes that could result from diverting family food consumption from Enset to food aid/employment generated income.

In summary, in vulnerable areas which grow Enset, it is the food security stabilizing crop. Consumption can be adjusted to compensate for fluctuations of annual production. The methodology developed for Enset assessment, as it was intended, could be useful as an indicator, like food prices and terms of trade, both for increasing food insecurity and for recovery of the household. The historic annual record of size and number of Enset plants harvested would be an immediate as well as a trend indicator of vulnerability. The measure of recovery, however, is expected to be delayed due to the rate of Enset plant growth but would be a better indicator since it signals perseverence of the recovery.

Household production parameters

Plant harvest numbers, production per plant and per household reported in this study are consistent with isolated observations reported previously. As mentioned in the literature Dereje (1984) proposed 60 plants @ 25 kg per plant as the `model' Enset production for a household of six using Enset as a major staple food. Also Pjils et. al. (1994) reported family consumption (plus possible sale) to be 46 plants @ 34 kg/plant in Gurage zone, which is an area using Enset as a major staple food. The number of harvested plants recorded herein is similar to these reports for the staple food areas of Gurage and Hadiya zones. However, plants harvested is significantly lower in Kembata and N.Omo zones where food insecurity is known to exist. Plants harvested is also low in Keficho and Bench zones but reliance on other crops in these less densely populated zones probably explains the lack of food shortages. On the other hand, the much greater number of plants harvested in Sidama and Gedeo zones reflects a household surplus of Enset production. Consequently these zones are a known source of supply for the Addis and other urban markets.

Extensive comparisons with plant yields reported in the literature are possible. While plant yields in this survey are uniformly reported at 50% moisture; many reports do not specify moisture content nor do they always include corm and Bulla portions in the Kocho. Yeshi reported the farmers concept of average plant yield to be 25 kg. However from reports of 12 to 42 kg, she uses 27 kg for the average plant yield for her assessment. Mekiso's report of an average 30.6 kg from 173 plants processed does not specify moisture content but is given as refined Kocho after a 25-73% post-fermentation weight loss. Of the 173 plants, 35 were from Sidamo and had `fermented product' yields of 73 kg but `refined Kocho' yields of 27 kg implying that the remainder was water. Evans and Pjils et al do not give moisture information relative to plant yield except the latter states that in a few Kocho samples, moisture ranged from 48-59%. The high plant yields reported here in some weredas is due entirely to plant size enumerated and not to water content of the products since correction for water content was included in the model.

As the major staple food, per capita intake of Enset foods may be quite high even though the minimun energy requirements may still not be met. Pijls et al reported an Enset intake of .55 kg per person per day (1045 calories) which amounted to 82% of the total energy even though this is only 60% of the requirement (Which would be 2123 calories by their calculations). Earlier Selinus, as reported by Pijls, had reported Sidama region people consuming .80 kg per person per day which was 90% of total energy intake and would have supplied 1690 calories. At .55kg per person per day and per plant yield of 34 kg, they calculated a need for 36 plants to be harvested annually for the family of 6.1 (1225 kg/household/year). Therefore of the reported 46 plants harvested, they assume 10 were sold. Comparable figures for the reported Sidama consumption rate would have been 52.4 plants @ 34kg/plant or 1781 kg/household/year. The assessed production/consumption per household of subsistense level in this study is well below the Sidama consumption reported in 1971 and closer to the Gurage production/consumption reported in 1994.

It is interesting to note the relationship between Enset hectarage and productivity. Pijls noted that the average hectarage in the Gurage study was .16 hectares and should be enlarged to about .27 to supply the household energy needs. Enset area reported in this survey is also in the .10-.20 hectare range for the weredas producing less than the 1500-1700 calorie per person (1800 kg/household/year) needed as a major staple food. Those weredas/zones producing above this level had Enset hectarages above .20.

Immature harvest, food preferences and food shortages

This suggests that there may be a critical mass for efficieny Enset production. Below .20 hectares per household using Enset as a major staple food, productivity erodes from immmature harvest. There may also be complex interactions with unknown effects in that the surplus producing weredas/zones also utilize the random spacing-mixed maturity method of culture rather than the highly organized arrangement of spacings and maturities. Those studying these factors i.e. Tiebebe and Sandford, (Kefale et.al. 1994) tend to feel that these interacting factors have brought the household to the the point of trying to meet short-term food needs without capability to consider long-term productivity. Land seldom lies uncropped in the Wolayita area which is already using multiple season cropping, relay cropping and intercropping even in the Enset.

No data had previously been given on average plant size measurements for household Enset harvested or yield at different stages of immaturity. Considerable attention has been given recently to the high rate of attrition of plants under cultivation, with particular attention given to family food shortages. Early plant loss, i.e. 0-2 years of age, is often attributed to transplanting failure and disease/wild animal destruction. However extensive immature harvest is thought to indicate the family need for food before the plants have had time to reach the size for maximum yield. Plant size harvested and per plant yields appear to be greatest in the highest producing areas indicating the possible interaction of a number of factors: higher productivity, less food shortage and/or less disruption of the multi-year cropping through villagization, devillagization, migration, civil unrest etc.

Farmers also reported immature harvest to provide a variety of foods (Kefale et.al. 1994) that is for the corm food. It is possible that a corm crop can be derived in the process of eliminating the slower growing transplants, i.e. during thinning. From this report it is also revealed there are certain clones which are cultivated especially for the taste of the corm rather than the productivity of the mature plant even in the food short Wolayita area. If this is true in a wide area of the Enset culture, a separate crop assessment may be needed to separate food shortage immature harvesting from food preferences.

Irrelevance of the term Yield per Hectare in the case of Enset

Because of the above mentioned factors, the complex patterns of Enset cropping and the intermittant use of this multi-year crop, it is of little meaning to know the yield per hectare. The fact that Enset could produce as large or larger quantities of energy food per hectare thatn other crops is established. But the more important fact is that with dwindling family land holdings, reliable production of energy food with flexible consumption potential is of great utility. Energy foods are essential to the daily existence of the family caretakers regardless of the current cropping environment. Annual crops deteorate in storage whereas Enset continues to grow until a few days before need necessitates harvest. No other crop provides the productive potential and the flexibility of consumption as that of Enset. Production per hectare at any one time in the year or across years will depend entirely upon the food status of the family relative to the production level of their other crops.

This survey makes no allowance for urban production. Urban Enset growing for Kocho production is widespread even out of the Enset cropping areas such as Ginchi in West Shewa zone. Considering that with as small as 1/10th of a hectare can produce half of the family energy food is highly significant to urban centers with limited income generating potential. Ordinarily food production assessments do not need to include urban agriculture but Enset may be an exception.

Contradictions between age structures and number of plant harvested

Recent work on crop balance sheets for watersheds have raised new questions on the age structure of *Enset* plantations and the resulting effect on production. Sandford and Kefale

(1994) report 41% plant loss of 1-2 year old plants and 13% loss of 2-3 year old plants. Only 41 plants over 3 years of age remained for consumption. The farmers reported drought and disease as the cause for this reduction. However, the authors suspected food shortage as the cause and conclude that lower wealth groups had lower percentage of the maturing aged plants. On the contrary when percent loss is calculated at each age using their data, even though the 'poor' farmers lost 71% of their 'seedling' aged plants, the 'very rich' also lost 48% of their 'seedlings' which at least in the latter case should not have related to food shortage and early harvest. We proposed that it is caused by drought, disease and land shortage for transplanting.

Evans (1993) also reported a 60% reduction in plant numbers between the first and the fourth years of cultivation over the 5 zones assessed. This includes a 71% loss for Illubabor zone and a 64% loss for Sidamo zone neither of which would have been pressured to harvest early by food shortages. In her study, North Omo zone posted an 80% loss of plants between the first and fourth years.

As mentioned again in the section on household financial security, in addition to the natural and transplant losses, intermediate size plants are harvested by the woman unknown to the man and independent of household food security status. Habte-Wolde et.al. as reported by Hiebsch (1995) reported that in 15 households in the Wolayita area, male and female farmers reported death as the primary cause of loss at first transplanting but harvest and utilization as the primary reason for reduction in plant numbers at the age of second transplanting and following. Hiebsch goes on to calculate a hypothetical *Enset* yield of 54 qt/ha/year, 13qt of which or 25% could be coming from harvest of immature plants. The authors concur on this point since harvest of intermediate-sized plants was often witnessed when interviewing the woman for the Regression study samples. However additional study would be required before the figure of 25% would seem in order.

The additional 25% postulated by Hiebsch was calculated to come from a weighted average of an additional 400 plants harvested before the second transplanting and 120 additional plants harvested sometime before the final 46 plants matured yielding 34kg/plant using Pjils et.al. (1992) yield figures. Considering the number of small plants involved, even if the yield were low it should contribute more than 25% of the total yield.

FACTORS INFLUENCING *ENSET* PRODUCTION AND HECTARAGE IN ETHIOPIA

There are a number of factor influencing *Enset* popularity among farmers in Ethiopia. These factors are geared toward independent household survival in farming systems that have been fraught with pests, surprised by erratic rainfall and scourged by government villagization. *Enset* cultivation has been developed by independent farmer investigation and *Enset* foods have been utilized to provide consistent food availability to smooth over the rough times of household food security.

It is likely that *Enset* culture developed as a result of droughts and insect plagues that destroyed the vegetation of the pastoralist in the lowlands. Bringing their cattle to the highlands, they needed crops providing energy foods that did not require annual culture and constant attention. *Enset* propagation suited them ideally in providing them a flexible food supply, a crop that competed well with present vegetation and was not seriously affected by droughts and pests.

1. *Enset* food utilization and household food security

Enset is basically an energy food that is low in protein and Vitamin A. As long as high protein animal products were available, the only shortage that would prevent a balanced diet was the vitamin A. This is probably why the `ubashaw' cabbage is so popular and highly utilized along with *Enset* foods. Many resource poor households, following exhaustion of their grain supplies, subsist largely by eating *Enset* and cabbage. Although the corm can be cooked and eaten like potatoes, it too is largely an energy food. The starchy Bulla, which can be extracted from the pulp by squeezing, is another low-protein *Enset* food that can be used as porage, giving some variety to the diet.

However it is suspected that *Enset* is most popular because it is a `living refrigerator' from which the family can conveniently take as much food as it likes anytime during the season. During the process of sampling *Enset* plants it became evident that the family who has *Enset* and the woman who has Kocho under fermentation can easily remove a flexible amount of Kocho from the pit and steam it as required. If the men are working hard or unexpected guests arrive, it is a simple matter of going to the pit and taking out the required amount. None is wasted by having extra in the pit and more can be taken out if appetites request. Usually the female head of household can regulate when Kocho supplies are getting low enough to justify processing into a second pit to assure an uninterrupted food supply.

When the authors stopped at a house near Ginchi, a traditional wheat and tef growing area in mid-October, the teff and wheat harvest was still months away. The only other food in the house was some maize nubbins recently harvested. The husband said they were partly of Gurage ancestry and since they usually experienced food shortage just when they needed energy for the harvest, they decided to grow *Enset*. The wife showed us her Kocho in a polypropolene bag in the house. The weather was too hot to store the Kocho in an outdoor pit but she readily made a patty that could have been baked on a fire in minutes.

2. Household financial security provided by *Enset*

Not only does *Enset* function in the picture of daily food supply and bridging the cropping seasons but also in household financial security against crop failures, to pay taxes and even to pay social obligations such as wedding expenses. A farmer likes to 'strut' his massive mature *Enset* plants near the compound as a sign that he is providing for his family and is a successful member of society. One farmer in Kofele wereda, just east of Sheshemene showed us 4 huge plants that he said he is keeping as a 'cash reserve'. His neighbor said that last year when he became sick he sold two plants, one to pay for his month in the hospital and the other for his wife to buy food. The arrangement explained to us was that he announces in the market that he has standing plants for sale at a certain price, after agreeing on a sale, the processing is done at his house with the wife assisting and guarding the Kocho pit. He concluded the discussion by saying that a 40 birr *Enset* plant was easier to replace than a 40 birr shoat.

Another most important consideration in providing routine household financial security, is the frequent sale of small amounts of *Enset* by the housewife to buy family supplies at the market. Similarly to the woman's sale of grains by tins, but not regulated by the husband as is the case with grain, the woman can take small amounts of Kocho from the storage pit to sell for purchase of weekly supplies. One native described this as the woman's 'Sekret' in that the husband does not know the quantity of *Enset* utilized in this manner and she does not have to ask him. To this extent it is inferred that a major source of Kocho production, i.e. utilization of immmature plants, was discovered by the authors and should be assessed.

When the woman, particularly in the non-defined spacing culture of Sidama-Gedeo-Wolayita, was asked to show the size of plant in the Kocho being weighed for the regression model, frequent revelation was made to the inclusion of small to medium sized plants in the Kocho. When the woman was asked why small plants were included, replies included:

a) the plantation is too thick and needs thinning to allow room for others to grow bigger;
b) Some plants were leaning over or damaged and needed to be used;
c) Small plants are sweeter and more juicy which adds to the development of the fermentation process; and
d) smaller plants are not so tough and thus are easier to process.

But one of the major reasons for utilizing intermediate sized plants could be that the farmer is growing surplus numbers of this size and desires to maintain only those well spaced and growing more rapidly. In other words, he'll never miss some intermediate plants as long as plenty big ones are present. It is a silent agreement between the husband and wife that she can harvest as many intermediate size plants to boost Kocho production and pay for routine family expenses as long as she leaves enough big ones to give him a feeling of security. The implications for plant size/number and total household production of Kocho in discussed under the section on factors that could increase assessed production.

3. De-villagization, Land Tenure and Land Resource Allocation

Since the change of government in 1991, significant de-villagization has occurred resulting in establishment of new household plantations. Also land tenure issues while not giving the land to the farmers, assured him of not taking it away. This has created enough confidence on the part of the farmer to stimulate enlargement of the area devoted to the multi-year crop. Since accurate measurement of prior *Enset* hectarage is not known, it would be difficult to document hectarage changes.

4. Free Market Systems and Commercial Production

With governmental touting of a free-market economy, traders have developed Kocho collection and marketing systems. It was noted by the authors that divergent goals and production methods are developing among households and in certain geographic areas where commercial production is diverging from domestic production. It is commonly known that the highest amount of Kocho production per plant occurs just prior to flowering (though not necessarily the most per unit area). Current commercial production centers include Gedio zone and adjacent Borena weredas and Gurage zone with adjacent Shewa weredas of Welisso, Wenchi and Tikur Inchina. In these areas growers allow plants to reach a larger size and may include more plant material (outer leaf sheaths, longer pseudostems and more fiber) into the Kocho and are less likely to segregate Kocho qualities at the time of fermentation. If this practice is or becomes extensive, determination of a separate model with more extensive data from plants yielding 70 to 150 kg/plant should be formulated for commercial producers.

A quick market survey in the Addis Ababa-Merkato was conducted by the authors. About 120 women reported selling 2 *`Jump'* of Bulla and 4 of Kocho each per week. They also said that people commonly buy an entire Jump of Kocho for a family holiday. This amounts to 25,000 Jumps of Kocho (2,000 mt) and 12,500 Jumps of Bulla per year. There are also smaller sattelite markets selling *Enset* products in Addia Ababa.

Jumps of Kocho from Gedeo area were found to weigh an average of 79 kg (ranging from 60-100) and sell locally for 60-75 birr. Contract trucking from Welisso to Addis was reported to cost 10-15 birr per Jump. Bulla purchased wholesale for 4 birr/kg was sold for 6-7 birr and Kocho purchased for 2 birr/kg was sold for 4 birr. Kocho from anthocyanin pigmented plants was sold for 2-3 birr/kg and Kocho or Bulla with excessive fiber was sold for 2 birr less than the normal price. In conclusion, since Kocho can be purchased locally for less than 1 birr/kg and transported to Addis for 1-2 cents/kg, it should be economical to develop competitive markets for Kocho and its uses.

5. Diseases and Pests of *Enset*

The only disease currently threatening *Enset* crop production is *Enset* Bacterial Wilt caused by *Xanthomonas musacearum*. The wilt causes complete death of the plant within weeks of the first symptom, i.e. yellowing and drying of the emerging shoot. Individual plant infection and loss is common but 'hot spot' losses can amount to half of the harvestable plants. One farmer claimed that wilt consumes 3 times as much as his family. Pathologists and extensionists recommend uprooting and burrying of diseased plants as well as fire sterilization of knives, machetes and tools.

Farmers believe that other means of spreading occur; in fact they have pointed out that in the process of removal from the plantation, brushing against other plants may contaminate them and spread the disease. Common practice of the farmer is to allow infected plants to dry in place and then burn them. It is likely that from the copious amounts of bacteria produced in infected plants, spread could occur naturally by splashing rain or passively by birds, insects and mole rats (gophers).

Although the bacteria is highly pathogenic (a few drops of inoculum can infect and kill a large plant), at this point it does not appear to be highly infectious (spreading). This indicates that vectors or means of spreading are not extensive but does not assure that one will not develop. Care needs to be exercised in terms of vigilence for the development of vectors especially since the disease also affects banana. Screening of clones or varieties by researchers has not identified sources of resistance but rather differences in levels of susceptability have been noticed.

FUTURE DEVELOPMENTS IN *ENSET* UTILIZATION AND INFLUENCE ON HECTARAGE

1. Overpopulation, Rural Poverty and Cereal Price Parity

Portions of the *Enset* growing area are among the densest populated rural areas in Ethiopia. Large family size has brought about farm subdivision until present land holdings in many zones amount to less than 1 hectare. While land holdings have decreased, proportion allocated to *Enset* and root crops production has increased. Even prior to subdivision and toukel construction, one can often see new plantings of the multi-year crop.

Unlike other areas of Ethiopia which experience risks of rainfall failure and definitive growing seasons, soil moisture levels in the *Enset* growing area often allow for year-round annual cropping and even then, relay cropping is becoming common. The *Enset* growing area already is dependent on successive cropping of as many as three crops per year. Limited land resources must increasingly be devoted to highly productive, low protein quality *Enset* and root crops. Pulse crops, teff and even wheat are increasingly utilized for cash generation. Only maize and sorghum remain competitively priced with *Enset* and root crops. Families with low land resources are forced to grow and consume the most reliable and productive food crops. *Enset* is perceived to be among these crops and is often eaten 2-3 times per day throughout the year. A family with 50-60 mature *Enset* plants, which requires less than 1/10 hectare is thought to be food secure. It is no wonder that almost every household has a full complement of *Enset* plants at each stage of development.

2. Spread of *Enset* growing to adjacent areas-historic records

The *Enset* growing area is slowly enlarging into adjacent areas and has the potential for spread to other land short areas. Although the Gurage to Wolayita to Sidamo area has been considered the *Enset* growing area in the past, vast areas of Borena, West Shewa, Kefitcho-Sheketcho-Bench, and even Jima-Illubabor are now growing *Enset*. When the authors asked cereal growers of Jima and Shewa zones why they grow *Enset*, they replied that usually they had a shortage of food during the 'hungry gap' of June and July when grain stocks were exhausted and new crops were not yet mature. Now they can use *Enset* to fill in for whatever shortage of annual crops they encounter.

Enset could be grown for food in many other parts of Ethiopia. *Enset* is found in scattered areas of East/West Hararge where it has been used for baking wrappers. Recently farmers in these areas have become interested in food consumption as well. Large areas of the mid-to highlands of northern Ethiopia could grow *Enset* also. Historical records of 16th century Portuguese priests accompanying the Orthodox in retreat from the Gran Mohammed show *Enset* cultivation as far north as Asmara (Dr. Steve Brandt, personal communication).

3. Urban poverty, escalating food prices and traditions

While rural overpopulation, land shortage and poverty encourage migration to urban areas, urban food prices are higher which forces the poor to seek the lowest priced foods. As grain prices rise, especially in periods of shortages, cheaper *Enset* foods could become available.

Considering the productivity of *Enset*, increasing commercialization of growing, processing and marketing could decrease prices for Kocho below that of maize and sorghum. While non-fertilized maize and sorghum commonly yield 15-20 qt/ha, *Enset* yields of 40-70 qt/ha on an equal area-time basis are possible.

Urban use of *Enset* foods is becomming increasingly popular. While Kocho used to be popular only for the Gurage and `southerner', it is now eaten, though to a more limited extent, by all ethnic groups. It is becoming traditional to serve Kitfo (raw meat) with Kocho at holidays, weddings and specialty restaurants. Some urban restaurants now serve wheat bread, injera and Kocho with meals. Merchants in the Merkato report individual customers buy an entire 'Jump' of 60-100 kg of Kocho for the Meskel holiday season.

4. *Enset* in mixed flours for injera and other products

Already in the Dembidolo area *Enset* is dried, ground and mixed with teff and other flours to make injera. Tests of *Enset* flour mixed with other cereals have produced consumer acceptable products with tef, maize, sorghum and wheat flours. Although commercial drying may add to the cost, *Enset* flours should be economical to develop.

5. Soil fertility, cost of fertilizer and land degradation

Because of the high rainfall and the slope of the fields in the mid- to highlands areas, continuous cultivation leads to depletion of soil organic matter, loss of rainfall percolation, erosion and land degradation. Even if farmers are careful to avoid erosion with conservation measures, the soil fertility has depleted over time and yields are low unless fertilizer is applied. Fertilizer costs have gone up substantially and are of questionable use for farmers and crops which are not market oriented. That is, unless product is brought to market to pay for fertilizer costs, use is not sustainable.

Enset however is a soil building crop. Since *Enset* is a multi-year crop, tilling the soil is not necessary, the extensive plant canopy intercepts the rainfall and erosion is minimized. Even though manure is applied in some areas, *Enset* culture builds soil organic matter and soil fertility. Asnakech (personal communication) reports that soil structure, organic matter and fertility differ greatly in the *Enset* plantation as compared to adjacent fields or even pastures. In many cases plant residue from weeding and thinning/pruning of *Enset* are used as plantation mulch further raising organic matter and reducing erosion. In conclusion, *Enset* culture is more beneficial for long term sustainable, subsistence farming. Therefore land degradation and high fertilizer prices may favorably influence *Enset* production and hectarage.

6. Land shortage and livestock feed

As farmland is subdivided and cropland is needed, land available for livestock grazing becomes limited. Even common grazing pastures are being broken where suitable for cropland. As forage becomes limiting farmers are increasingly looking to crop residues for livestock feed. *Enset* as a crop produces high tonnage of forage along with the human food products. Already in most *Enset* growing areas, pruned leaves, thinned plants and harvested plant tops are utilized for livestock forage. Also in areas where dry season forage becomes limiting, successive pruning of *Enset* leaves to the point of complete defoliation of the plant is practiced to provide forage.

Since the technology of producing livestock silage is similar to that of fermenting Kocho, additional forage could be stored from the growing seasons. Parts of the *Enset* growing area experience a rainy season with surplus vegetation followed by a dry season with a shortage of forage. In these areas *Enset* plant material not used for Kocho could be chopped into old fermentation pits and stored for dry season livestock utilization. Silage production does not increase nutritive value but simply stores and maintains its value for later use. In conclusion overpopulation and land shortages are forcing reduction of livestock numbers at a time when the beneficial effects in terms of *Enset* supplementing protein foods are most needed. Increasing the efficiency of seasonal surplus forage utilization by storing in earthen silos would enable greater production of the urgently needed livestock proteins.

7. Intercropping *Enset* with legumes and cereals

Although *Enset* is a very competitive and densely canopied crop, there are periods of time after transplanting and pruning when large amounts of space are under-utilized at the beginning of the growing season. Short season crops like pulses could be cultivated at this time, adding nitrogen to the soil, before *Enset* growth closes the canopy. Tall crops like maize and sorghum, which can become competitively established, are already intercropped with *Enset* in Wolayita-Hadiya-Kembata. Climbing annual and perennial legume crops are also a possible contribution to soil nitrogen and protein foods. Winged beans, climbing cowpeas and beans and local forage legumes could be adapted to benefit *Enset* plantation fertility without reducing but hopefully increasing *Enset* growth and production.

References

Dereje Ashagari. 1984. studies on the bacterial wilt of *Enset* and prospects for its control. Ethiopian Agricultural Research Conference. April. Addis Ababa.

Evans, Valerie. 1993. Consultants report for *Enset* pilot survey. FAO. Addis Ababa.

Hiebsch, Clifton. (personal communication) Professor of Agronomy. University of Florida.

Kefale Alemu and Stephen Sandford. 1991. *Enset* in North Omo Region. Farm Africa. Addis Ababa.

Kefale Alemu et. al. 1994. Gender, structure and landraces in peasant *Enset* Plantations in North Omo. Farm Africa. Addis Ababa.

Neumann, Charlotte, et. al. 1993. Diet quantity and quality: Functional effects on rural Kenya families. Human nutrition CRSP. US/AID.

Pijls, Loek, Arnold Timmer, Zewdie W/Gebriel and Clive West. 1994. Cultivation, preparation and consumption of *Enset* in Ethiopia. J.Sci.Food Agric. July 16.

Shank, Robert. 1994. The *Enset* culture: Technical report on *Enset* or the `false banana'. Unithe Nations-Emergencies Unit for Ethiopia.

Taye Bezuneh. 1983. Evaluation of some *Enset* clones for food yield with emphasis on the effect of length of fermentation on carbohydrate and calcium content. Tropical Agriculture 61:111.

Teketel Makiso. 1975. A study on the yield of *Enset*. Proc. 6th IAR research seminar. Addis Ababa.

WADU. 1979/80. Crops and pasture section agronomic report. Wolayita, Soddo.

Westphal, E. 1975. Agricultural systems in Ethiopia. Ag Research Report 826.

Yeshi Chiche. 1995. Assessment of *Enset* and root crops contribution to food supply in Ethiopia. FAO. Addis Ababa.

Plate 1. *Enset* Cropping is usually near the house for convenience of processing by the women and manure appli- cation. Right: *Enset* between the house and the cereal fields near Ambo, West Shewa zone of Oromia. Center: *Enset* behind the house but after the garden and seedling nursery near Wendo, Sidama zone of SNNPRS. Bottom: *Enset* completely surrounding the house near Bule, Gedeo zone of SNNPRS.

Plate 2. *Enset* seedlings come from suckers produced on corms. Top: First year seedlings are transplanted close together, while 2nd and 3rd year trans-plants are spaced increasingly wider (background) Gumer of Gurage zone, SNNPRS. Center:In other cultural methods which minimize transplanting, seed-lings may be periodically thinned and consumed, fed to livestock or used for mulch and weed control. Agere Selam, Sidama zone of SNNPRS. Bottom: Seedlings are grown commer-cially in highland areas of Sidama and Gedeo zones of SNNPRS.

Plate 3. Processing is labour intensive for household and village women. Top: The pseudo-stem pieces are separated and halved longitudinally. Bottom right: Holding one piece with her foot, the inner surface is scraped with a half of a bamboo stick. Bottom left: The pulp is hand and/or foot packed into a leaf linedsurface of earthen pit for fermentation.

Plate 4. *Enset* products can be stored and eaten as needed or bundled in dry leaf sheaths for

transport to market. Top: A surface fermentation pit is uncovered showing a packet of starchy Bulla on top, more fresh leaves and then the Kocho - here darkened by the purple-red anthocyanin plant pigment evident in the plant variety behind the lady. Bottom: Packages of Kocho called `Jump' weighing 60-100kg are collected by a `middle man' awaiting transport to retail sale markets.

Plate 6. Top left: Mole rats or gophers tunnel to the succulent corms especially in the dry

season. Top right: Damaged by mole rat feeding, corm rot may set in, seriously retarding corm and top growth. Bottom: In systems that utilize successive transplanting into the same hole, pest build-up results in serious plantation space under-utilization and food crop loss.

Plate 5. Pests affecting *Enset* are few but can be devastating to household food supplies. Top: A

woman stands in front of a bacterial wilt infected plant, first evident from the yellowed and drying new leaves. (Brown leaf tips and margins in the background are caused by frost.) Bottom left: Pseudostem leaf sheaths, normally clean and white, are filled with putrid bacterial slime plugging the vascular water flow to leaves. Bottom right: Dying plants may be uprooted leaving blank spaces in the plantation or they may be left to dry and burned in place.

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