PREFACE AND ACKNOWLEDGEMENTS.

Finally I express the hope that this report will contribute something
positive to the work of the Government of Kenya and to the well-being of
the Kenyan people.

SUMMARY.

A random sample of 61 households from 3 villages of Mbiuni Location in
Northern Machakos District, Kenya, has been surveyed.
Although the research area cannot be considered as semi-arid, climatic
conditions are sub-optimal for agriculture.

The composition and use of the vegetation have been inventoried and the
characteristics of the households, farming and collecting surveyed.

In one third of the households the head of the household is employed outside
the area. Eighty percent of the households receive cash from off farm
activities, usually this money is used for consumptive purposes.

The average farm consists of 1.23 ha cultivated land and 2 ha grazing/
wood land; actual sizes of the cultivated area varying between 0.23 and
3.8 ha.

The major annual crops grown are maize, pigeon pea, cowpea and beans.
Major perennial crops are cassava, bananas, mango, pawpaw - grown by more
than half of the households - and guava, lemon, orange - grown by about one
third of the households.

These crops are grown for subsistence purposes with incidental sales of
surplus. Less than half of the households do grow some cotton and/or
sunflower for commercial purposes.
Few inputs are irregularly bought, one third of the households use some
fertilizer on part of their crops. Half of the households only use manure.
More than half of the households experiency occasional food
shortages.

Animal husbandry has become subsidiary to cultivation, especially through
draught animals and manure. Besides, livestock perform a variety of functions
such as supplementary source of protein, accumulated wealth to be cashed
in cases of emergency, etc.
On the average, households possess seven heads of cattle and seven goats.
Almost 90 percent of the households own cattle; one third does not possess a
pair of working oxen.

Half of the households report that their grazing area is not sufficient
to feed their livestock. Use of supplementary sources like crop residues
and the forest across the river does alleviate this feeding problem to some
extent, but in many cases these supplements are not sufficient.
Sharing of the grazing area is common practice, i.e. in 50 percent of the
cases.

The condition of the grazing varies considerably, from overgrazed treeless
grasslands with patches of bare and sometimes eroded soil to dense forest
like woodlands. At present hardly any management of the grazing area is
practised.

60 percent of the households reported problems with firewood gathering.
Only a fraction of these problems are directly related to the supply;
shortages are reported by 20 percent of the households. Other problems
are related to labour problems and the drudgery of the work.
Charcoal is made by almost half of the households, but only 10 percent
do produce charcoal for commercial purposes, often as part of deforestation
for agriculture.

The increasing pressure on the land leads to degradation of the natural
environment especially through erosion. Gullies in roads and grazing areas
become wider and deeper and even in the well terraced cultivated areas run
off often causes problems.

Occasional tree planting does take place, however, on a very small scale
and mainly for construction and amenity purposes. The attitude towards tree
planting is well expressed by the frequently encountered opinion that "trees
grow by themselves".

Half of the households are members of self help groups, these groups are
important not only as a supplementary source of labour for specific
activities, but also as initiators of new developments.

It is concluded that agroforestry could play an important role in alleviating
the identified constraints.

CONTENTS

1 INTRODUCTION.

Investigations of the possibilities for and potential of agroforestry were
carried out in three villages of Mbiuni Location in the Northern Division
of Machakos District, Kenya, from September 1980 until January 1981.
The research consisted of three parts and the results of these parts are
therefore separately presented:

a. an inventory of local trees and shrubs and survey of their uses; the
   results of which have been published in:
   E. Fliervoet. An inventory of trees and shrubs in the Northern Division
                of Machakos District, Kenya.
                Wageningen/Nairobi, 1982.

b. a survey of the local farming and collecting systems; the results of
   which are presented in this report,

c. construction of a typology cf farming/collecting systems and suggestions
   for the development of system specific agroforestry innovations presented
   in appendix II of this report.

The research area was selected because of the prevailing low input type of
agriculture and the sub optimal climatic conditions for agriculture.
The presentation of the results is preceeded by a description of the
objectives of the research and the methodology used.

1.1. Objectives of the research.

Agroforestry has been defined as "a sustained land management system which increases the overall yield of the land, combines the production of crops – including tree crops – and forest plants and/or animals simultaneously or sequentially, on the same unit of land, and applies management practices that are compatible with the cultural practices of the local population" (King, 1979).

Though this definition provides a fairly clear idea of what is meant in terms of the ultimate result of agroforestry interventions, it does not specify the nature of these interventions or activities leading to such a system. And with good reason because these activities cannot be specified by one universally valid definition. The nature of these activities will vary according to the specific conditions in different situations.
E.g. the development of a taungya system by a forest service on state land will require a different approach as compared to the introduction of trees and/or improvement of tree management practices in farming systems operated by farmers.
As we are here dealing with one example of the latter situation, the general objective of our research can be described as contributing to the development of a specific type of agroforestry interventions, i.e. agroforestry as a set of interventions in farmer operated farming and collecting systems. The appartent similarity between this problematic and the work at different international agricultural research institutes on agricultural interventions in farming systems led to a specification of both the objectives and the approach of the research (see for examples Cimmyt, 1980, Collinson in Ruthenberg, 1980, Herrera, 1981).

In this work three stages can be distinguised:

- description and analysis of the existing farming system and its natural
  and socio-economic environment,
- diagnosis of constraints within these systems,
- development of solutions for these constraints by on farm research.

Accordingly the main objectives of our inventory and survey and the identification of constraints in the farming/collecting system and identification of requirements of solutions for these constraints.

1.2. Methodology

1.2.1. Pre-survey

The study of literature in the pre-survey stage was mainly based on Wallis and Van Waning (1976) and Onchere (1976).

As both are reports about research on related subjects in our research area, this literature enabled us to design an outline of a combined questionnaire and checklist for observations.

This outline has been tested in the field during try out visits and refined. During these visits to the research area it has also been decided to select three villages representing a geographical transect of an area consisting of about 15 villages (see Map   page   ).

In this way the apparent different ecological conditions of this larger area would be covered.

1.2.2. Survey

1.2.2.1. Sampling.

The study of the literature showed that the household is the central socio-economic unit.

The existence of the Medical Research Centre's files, comprising all 345 households of the three villages, made the selection of a random sample of households easy.

This random sample consisted of 61 households representing a sample fraction of 17.7%.

1.2.2.2. Questionnaire/checklist for observations.

The complete questionnaire is attached as appendix I.

Information was obtained through structured questions, supplemented with unstructured questions, observations, estimates and measurements.

The following elements were covered by the questionnaire:

a. Composition of the household and the activities of the members; the strategy - objectives and priorities - towards the natural environment, especially with regard to farming and collecting.

b. The resources available to the household: land, labour and capital. The size of the cultivated area has been measured, the size of the grazing area estimated and the condition of both has been observed. Off farm activities and - estimates of - cash contributions from these activities have been assessed.

c. Farming.
  - cultivation: - inventory of crops grown,
                 - assessment of used inputs and of - sufficiency of -
                   outputs,
                 - ways of ploughing, planting, weeding and harvesting,
                 - experienced problems.
  - animal husbandry: - types and numbers of livestock,
                      - assessment of used inputs and - sufficiency of -
                        outputs and of sale of surplus,
                      - description of animal husbandry practices,
                      - degree of sufficiency of feeding (especially grazing).
d. Management and use of the - semi natural vegetation:
                      - attitude towards trees and tree planting behaviour,
                      - assessment of firewood gathering and - sufficiency
                        of - supply,
                      - assessment of wood used for other purposes like
                        construction and fencing.
e. Self help groups: membership and activities.

For a complete account of the elements of the questionnaire refer to appendix I.
These elements formed the structured core of the survey. If appropriate additional
questions were asked, especially about the underlying reasons and motives for
certain activities.

1.2.2.3. Field implementation.

Five out of the 61 selected households were omitted for different reasons,
without substantially influencing the randomness of the sample.
The remaining 56 households have been visited four times. The first visit
was especially to become acquainted with the farmers and vice versa, and to
explain the objective of the survey, followed by the first part of the
questionnaire.
During the second visit specific questions about farming and collecting were
asked. The cultivated area was measured, the crops observed in the presence of the
farmer and - structured and unstructured - questions were asked.
During the third visit the condition of the grazing area was observed and its
size estimated. Again in the presence of the farmer presenting his or her
views on specific points.

A fourth visit was necessary to collect additional information on points
- especially about self help groups and firewood gathering - which were not
completely clear after the first three visits.

1.2.3. Analytical techniques and presentation of the data.

Due to the exploratory character of the survey, precise hypotheses could not
be formulated. Therefore sophisticated testing procedures were not used.
There may, however, be a more theoretical obstacle to the application of
most analytical techniques, especially the apparent discrepancy between our
- intuitive - use of the systems concept on the one hand and the cause-
and-effect concept,on which most analytical techniques are based, on the
other hand.
We can only here state this problem, discussion of this problem, followed
by a solution will require additional research.

As we could not solve this problem, we have tried to circumvent it by
presenting the data in two stages. First the frequency distributions of
the separate variables - mainly components of the farming/collecting system -
are presented. In appendix II these data are presented in their system-context.
The frequency distributions are presented for the total population and per
farm size class. As the size of the cultivated area is supposedly one of the
major determinants of the other characteristics of the farming system, farm
size classes have been defined according to this criterion.
Four classes have been constructed:
Farm size class I, consisting of households with a cultivated area of up to
0.5 ha.
Farm size class II, households with a cultivated area of 0.51 - 1 ha.
Farm size class III, consisting of households with 1.01 - 1.5 ha.
And farm size class IV, households with a cultivated area of over 1.5 ha.

2 GENERAL DESCRIPTION OF THE AREA

The investigated area is located in the Northern Division of Machakos
District, Mbiuni Location. It comprises three villages (Kalama, Utithini
and Mutula) which are all part of the survey area of the MCN. The area is
located approximately 100 kms east of Nairobi and the actual area investigated
occupies a size of about 14 km^2 (see Maps 1 and 2, pages 7 and 8).

On the west side the area is bordered by the Kanzalu Range (1600 m) and on the
east side by the Athi River (1200 m), both in NW/SE directions. Besides the very
steep slopes of the escarpment and the gullies at its foothills most of the land
is gently undulating. The three villages were chosen to represent a transect in
the SW/NE direction through the area (see Map 3, page 9). The population density is
about 160 inhabitants per km^2 and the annual population growth is 3.4 per cent
(Wallis and Van Waning, 1976).

2.1 Climate and ecological conditions

Data concerning the annual rainfall and other climatic characteristics is scanty
but that from a small weatherstation (located approximately in the centre of
the investigated area (South 1°12'10", East 37°22'50" at an altitude of 1260 m))
is extracted below (Gemert, 1980).

Table 1. Climatic characteristics (means of data collected during the
          last five years).

	Annual rainfall	Number of rainy days	Min. mean temperature	Max. mean temperature	Min. mean humidity
1975	902 mm	54	15.2 °C	26.2 °C	40
1976	665	44	15.9	27.2	42
1977	986	67	16.3	27.3	47
1978	1080	68	16.3	26.1	47
1979	875	83	16.3	26.5	43
mean	902	63	16.1	26.6	43.8

MAP 1. <u>Location of the research area in Kenya.</u>
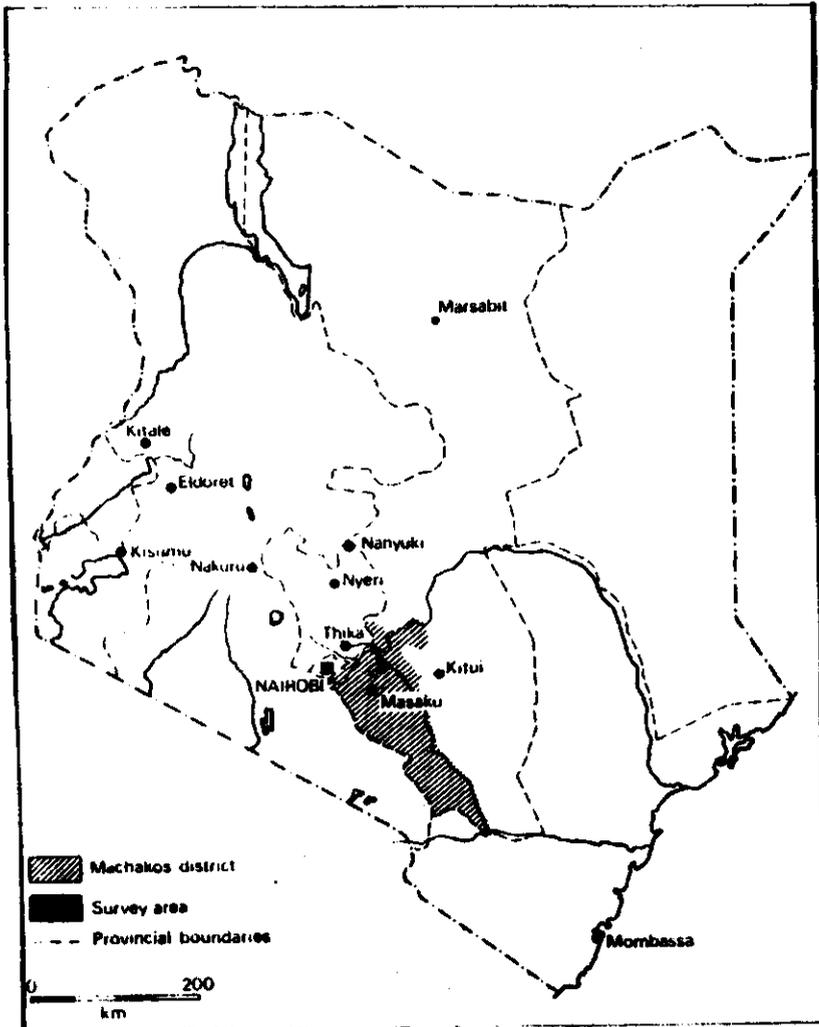
Source: Wallis and Van Waning, 1976.

MAP 2. <u>Location of the research area - 15 villages - and the survey area - 3 villages -.</u>

Source: Wallis and Van Waning, 1976.

MAP 3. <u>Location of the three surveyed villages: Kalama, Utithiini, Mutula.</u>

1 km.
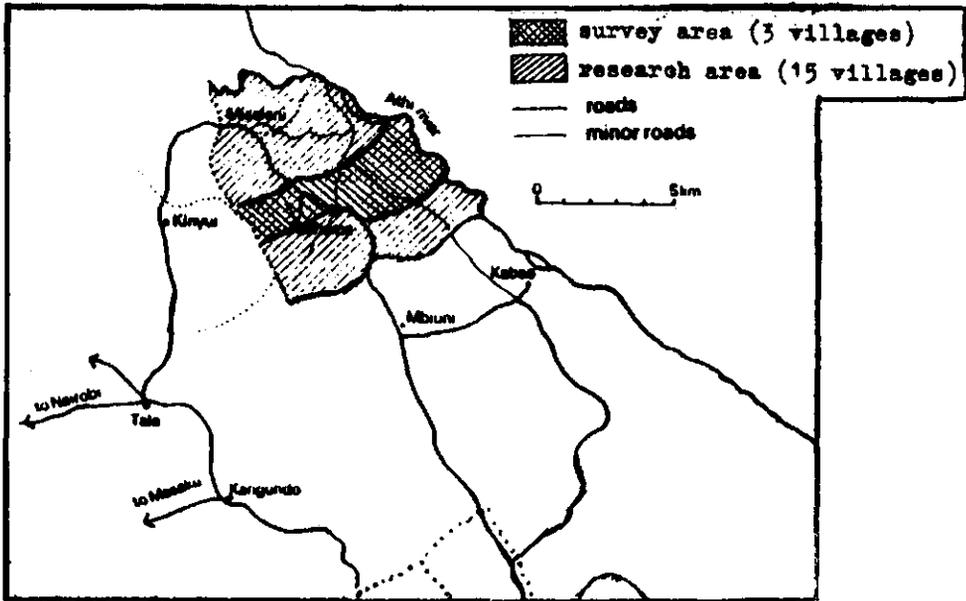
The annual rainfall is mainly concentrated in two periods: October-November ("short rains") and Februari-April ("long rains"). The amount of rainfall per year is liable to great fluctuations, and the onset of the rains is very un-predictable. Furthermore most of the rainfall is concentrated in a few intense showers, thus causing severe run-off.

The average annual rainfall is given as 902 mm over the last five years. Wallis & van Waning (op.cit.) report a significantly lower figure, i.e. 705 mm per year. Their figure was based on data obtained in Mbiuni (located five km to the south-east) over the years 1971-1974. The research-area was originally chosen for its low rainfall (semiarid) character, but the conditions for plantgrowth seem to be more beneficial than was originally expected. This is certainly true for the higher parts of the Kanzalu Range, where apart from a better water-supply, the potential evaporation is less.

Another factor, especially for the area on and near the foothills of the scarp, is that there the groundwater-level is relatively high. Therefore the growing conditions for the deeper rooting crops such as pigeon pea, cassava and (fruit) trees are better here.

For the majority of the area the potential evaporation was reported to be about 2100 mm per annum, thus exceeding the annual precipitation.

The National Atlas of Kenya (1970) classifies the area as belonging to Ecolo-gical Zone IV: "Land of marginal agricultural potential, carrying as natural vegetation dry forms of woodland and "savanna" (often an Acacia-Themeda asso-ciation) or derived semi-evergreen or deciduous bushland. This is potentially productive rangeland - usually less than 4 ha per stock unit -limited mainly by the encroachment of woody species". Apart from this more general description of the vegetation it can be added that indeed Acacia species together with species of the Combretaceae dominate the actual woody vegetation inside the grazing areas. Furthermore, in view of the climatic data, it is most likely that the actual agricultural potential is higher than suggested here. However, the level of farm management remains of extreme importance for the good utilization of

available rainwater, especially during low-rainfall years.

2.2 Soils

Based on the results of Site Evaluation No. 16, carried out in 1974 by the Kenya
Soil Survey, as presented by Collinson (1979), the soils in the area can be
classified as follows:

The majority of the area is occupied by "Moderately deep to deep yellowish red
to reddish brown, sandy loams over sandy clay loam to sandy clay; in places
imperfectly drained".

In the west bounded by the gullied foothills of the Kanzalu scarp with "Moderate-
ly deep to deep reddish brown to yellowish brown clay, well drained".

In the east a band of soil following the course of the Athi, with "Moderately
deep to deep, dark red clay, well drained".

Moreover there is an elongated NW/SE island of "Moderately deep, black to dark
grey clay, seasonal waterlogging" between Kathama and Mutula.

2.3 Historical background

Some 50 years ago the area was populated with some 10% of the present popula-
tion. The then prevailing land use strategy among the Akamba was a typical agro-
pastoralist one, in which cattle was the main enterprise and largely the respon-
sibility of the men. Agriculture was women's work with millet being the major
crop, supplemented with crops such as maize and beans, grown in the traditional
mixture with a range of other crops. This basic diet was supplemented with
protein (milk, blood) from the cattle.

Any agricultural surplus was converted into cattle. Moreover livestock played an
important role in the maintenance of the social system: status was determined by
the number of cattle, dowries were paid with it and cattle was exchanged for
social reasons.

Ownership of the land was only recognized for the cultivated areas. Ownership of perennial crops e.g. for trees with a bee-hive was also accepted. The grazing area ("weu" in the vernacular) was not privately owned; everyone had the right to graze his cattle or bring parts under cultivation. Every woman had her own cultivated area ("mbee" in vernacular) but this remained in the ownership of the husband. This "mbee" was usually taken over by one of the sons (usually the youngest), the others taking up new land from the "weu" for themselves.

With the growth of the population (density) both the tenure system of the "weu" and the system of inheritance changed. Gradually the "weu" was divided between individuals with boundaries established. These, now privately occupied, grazing areas and cultivated areas were inherited and divided between all the son of the household. Thus the fragmentation of holdings has started only 2-3 generations ago.

With the fragmentation of holdings the land use strategy also changed: from a cattle dominated agro-pastoralism to subsistence farming. This was accompanied by a changed mix of crops grown: maize and pigeon pea instead of millet, and livestock took a more subsidiary role.

The traditional division of labour has become less pronounced as well; although the growing of food crops is still very much a woman's job and cash crops and cattle a man's job, in many cases they have intruded and still do into each other's traditional domain. With the gradual decline of the importance and numbers of livestock men became jobless and started to look for other activities, e.g. outside employment (Veer, 1980).

3 HOUSEHOLD CHARACTERISTICS

The household is the basic social unit in the area. The empirical definition of this unit is rather complicated as many different arrangements can be encountered.

In this research a household is defined as the group of people who usually live in the same place and share meals.

It is not uncommon that more than one household shares the compound, the grazing area and/or livestock. Some of these situations can be explained through the prevailing system of inheritance which can lead to temporary communal and individual usage of resources. No further systematic study on these different patterns of household organisation has been done as this would require special research.

3.1 Household size

Table 2. Frequency distribution of the household size.

Size of the household	Number of households per farm-size class				total	% of overall total
	I	II	III	IV		
1 - 3 persons	3	2			5	9
4 - 6	2	7	8	1	18	32
7 - 9	5	6	5	6	22	39
10 - 12	1	3	1	6	11	20
	11	18	14	13	56	100

The total sample contained 395 people and the average household size is 7 persons. The above figures indicate a loose relation between the household size and the size of the cultivated area. Such a relation is an important one because the size of the cultivated area can directly influence the food growing capacity, thus directly influencing the capacity for selfsubsistence.

Besides the size of the household age distribution is also an important factor, e.g. in relation to available labour. Reported ages are not always reliable as elderly people especially do not know their exact ages. Data concerning the ages of younger people are much more reliable and 54% of the sample population was below 15 years of age.

Wallis & van Waning reported a much lower percentage (46.3%) for this age group
and, although their definition of a household might slightly differ from the one
used in this study, these figures are different. An explanation might be that in
Kathama Market the Medical Research Centre, Nairobi (MCN) weekly provides medical
facilities (consultancy and free medicine) for mothers and their children under
five years of age, thus reducing infant mortality.

3.2 Out-migration

Another important factor is the out-migration of family members in search of
work or education outside the area. This can be illustrated by the sex distri-
bution because it is especially men who leave the area; out of the total sample
population of 395, 188 were males and 207 were females, corresponding with a sex
ratio of 91/100.

Table 3. Number of head of households present or absent, distinghuished by sex.

Head of the household:	Number of households per farm-size class				total	% of overall total
	I	II	III	IV		
present, male	4	9	9	8	30	54
present, female	5	1	2		8	14
not present, male	2	8	2	5	17	30
not present, female			1		1	2
	11	18	14	13	56	100

These figures show that about 30% of the heads of households are absent most
time of the year and about all of these are men. The only female head of the
household was working in Nairobi and most of the farm management
was taken over by one of her daughters, as is very common practice if the head
of the household is absent.
In general the migrated heads of households visit their family at home more or
less regularly (at least once a year) depending on the nature of the family
relations in general, and the financial position; travelling is relatively

costly. Moreover, the nature of the outside employment is often not very stable
and then the farm serves as a basis to fall back upon when people are temporari-
ly unemployed.

3.3 Income from off-farm activities

That off-farm employment plays a very important role in generating income in the
area can be seen from Table 4.

Table 4. Income generating employment on off-farm activities.

Families engaged in:	Number of households per farm size class				total	% of overall total
	I	II	III	IV		
Employment outside the area	6	12	8	7	33	59
Employment inside the area	5	3	2	3	13	23
		3	4	3	10	18
	11	18	14	13	56	100

About 18% of the households have to depend only on farming to supply themselves
with the necessities of life, thus showing the increasing dependency on off-farm
activities. Especially for the households in size class I this dependency is
very obvious. People who have found employment outside the area are widely
spread all over the country, although Nairobi is most frequently mentioned. Most
of these people send home part of their income to the family, but the amounts
and the pattern in time vary tremendously from regular and fixed amounts to
incidental (e.g. in case of emergency) and variable amounts. However the latter
pattern seemed the most widespread.

Of the people who are permanently employed inside the area, two are working as
teachers, one as a Kindergarten-supervisor and two as farmhands. Of the other
off-farm activities charcoal burning (6), shopkeeping and running a hotel (3)
are the most important. Further activities that were all mentioned only once
are: repairing bicycles, slaughtering of cattle and selling of meat, woodcarving

4 FARM-CHARACTERISTICS

Together with farm management, farm size (especially the size of the cultivated area) is one of the more important factors which determines the main farming characteristics. All farms have been divided into three parts: one part ("culti-vated area") is under permanent cultivation and covers as an average about half to one third of the total farm size, the second part ("grazing area") is allocat-ed to grazing of livestock and gathering of wood and usually covers the largest part of the holding, and finally there is the third part ("compound") which is the smallest.

4.1 The compound

In the compound all houses, stores and cattle boma(s) are situated. Very often this part has no distinct boundaries because it usually is a continuation of the grazing area. Where it joins a cultivated area or a road, a distinct boundary in the form of a hedge of Finger Euphorbia (<u>Euphorbia tirucalli</u>) is common.
The area directly around the houses is kept clean and bare as a protection against snakes, while the other parts generally are covered with some grass and some trees for shade, ornamental purposes and to provide protection for chickens against birds of prey. In the cattle boma, manure which is used for the cultivat-ed area, accumulates.
Traditionally the Wakamba removed their homesteads to another place once in a while (5-10 years) thus leaving a more fertile site and occupying a less fertile one. Although this moving pattern still occurs it has become less important because of the more permanent type of house that people build nowadays.
No exact measurements of the size of this part were taken because of the indis-tinct boundaries. They were included in the estimates of the size of the grazing area of which they are usually a part.

4.2 The cultivated area

Cropping in this area is done under some form of permanent cultivation. No orderly fallow system occurs, but sporadically people abandon one part of their arable land after which it is left for grazing purposes. The prevailing cropping system is mixed cropping. Besides the agricultural crops the majority of fruit trees are grown inside the cultivated areas.

4.2.1 Size of cultivated areas

Due to the relative importance of cultivation and the influence it has on the major farm(ing) characteristics, the size of the cultivated area is a relevant criterion upon which to classify farms.

Table 5 provides some insight into the relative size distribution of cultivated area in the region.

Table 5. Frequency distribution of size of cultivated area per household.

Farm size class	divided size class	No of households	%	number of households per size class	average size of cult. area/size class
Size class I	0.01-0.25	1	2		
(0.01-0.50 ha)	0.26-0.50	10	18	11	0.44 ha
Size class II	0.51-0.75	8	15		
(0.51-1.00 ha)	0.76-1.00	10	18	18	0.78 ha
Sizeclass III	1.01-1.25	4	7		
(1.01-1.50 ha)	1.26-1.50	10	18	14	1.32 ha
Size class IV	1.51-1.75	1	2		
(over 1.50 ha)	1.76-2.00	3	6		
	2.01-2.25	1	2		
	2.26-2.50	1	2	13	2.52 ha
	2.51-2.75	1	2		
	2.76-3.00	1	2		
	over 3.00	4	7		
Totals		55	101	56[*]	1.23 ha

[*]In size class IV one household is included of which the cultivated area size was estimated to be more than 1.5 ha. This household is excluded from calculations dealing with sizes of cultivated areas.

Half of the households have cultivated areas of less than 1 ha and together

these occupy only 25% of the total arable land in the sample. If households

where the availability of arable land is the main constraint for being self-

sufficient are considered, it is most likely that these are to be found in this

category. However not always the pure availability of land (included lands for

grazing) is the main constraint, but quite often the possibility to cultivate

more land is limited because of other constraints such as available labour

or owning a plough and draught animals.

4.2.2 Land and food availability

To get more insight into the availability of arable land per head of the popu-

lation the results of calculations concerning this subject are summarized in

Table 6. In these calculations no distinctions were made concerning age of the

household members.

Table 6. Availability of arable land per head.

Arable land per head	Number of households per farm-size class				total	% of overall total
	I	II	III	IV		
0.01-0.10 ha	7	8			15	27
0.11-0.20	3	7	7	3	20	36
0.21-0.30	1	3	6	4	14	25
0.31-0.40			1	2	3	6
0.41-0.50				2	2	4
over 0.50				1	1	2
	11	18	14	12	55	100
average per size class	0.1	0.14	0.2	0.3	0.2	

The overall available arable land per head of the population is 0.2 ha. However

this average per head is less interesting than the differences between the size

classes, where households in size class I and II have only half as much land per

head than the households in size class III and IV. This difference illustrates the earlier mentioned shortage of arable land as being an important constraint for a considerable group of households. For households in size class III and IV there seem to be no real shortages of arable land, although some households still seem to have difficulties to grow enough food.

Table 7. Frequency distribution of degree of self-sufficiency[*] for major foodcrops (maize, pigeon pea, cowpea, beans and cassava).

Degree of self-sufficiency	Number of households per farm-size class				total	% of overall total
	I	II	III	IV		
Always self-sufficient	3	8	7	7	25	45
Alternately self-sufficient		2		2	4	7
Never self-sufficient	8	8	7	4	27	48
	11	18	14	13	56	100

[*] The degree of self-sufficiency is based on calculations and interpretations of information concerning crop yields for three successive growing-seasons (two long-rain periods and one short-rain period), supplemented with other information like purchasing and selling practices as indicators of shortages or surplus for that particular crop.

About half of the households do not succeed in growing enough of the major foodcrops to fulfil their needs all year long and therefore they have to purchase them, unfortunately especially at the times these goods are scarce (=expensive), thus eventually leading to financial shortage in the household.

A problem that arose during the execution of the interviews concerning harvesting was that most people do not reallly measure or count their yields; usually answers concerning yields are given in numbers of bags, tins or baskets, and corresponding quantities are difficult to standardize. Finally a considerable part of the crops are consumed before the real harvesting is done.

Another important source of food for quite a number of people are receipts of food of all kinds in the form of gifts from friends, relatives etc. These gifts

play an important role in the social system, e.g. to maintain good relationships with relatives, friends or neighbours.

When people sell part of their harvest this does not necessarily mean that they have a surplus of food, but quite often it is a case of force majeur, sometimes no other sources to obtain some cash are at their disposal.

4.2.3 Labour

The fact that half the people do not grow enough food can partly originate from constraints in available labour, e.g. the size of the land that can be cultivated is closely related to the availability of labour. In Table 8 data concerning the availability of labour at a household level are summarized based on calculations as prescribed by Collinson (in Ruthenberg, 1980, p. 391) where each household member is given a certain labour-unit value.

Table 8. Frequency distribution of arable land per labour-unit.

Arable land per labour-unit	Number of households per farm-size class				total	% of overall total
	I	II	III	IV		
0.01-0.10 ha	1				1	2
0.11-0.20	1	3			4	7
0.21-0.30	3	3			6	11
0.31-0.40	5	4	3		12	22
0.41-0.50	1	6	3	2	12	22
0.51-0.60		1	3	1	5	9
0.61-0.70			1	2	3	5
0.71-0.80			2	2	4	7
0.81-0.90		1			1	2
0.91-1.00				1	1	2
over 1.00			2	4	6	11
	11	18	14	12	55	100
average per size class	0.3	0.4	0.6	0.9		

Not surprisingly more labour is available in smaller farms and less in larger
farms.

Another point of interest is the availability of labour spread over the year.
This is because where there are labour problems these are most evidently per-
ceptible, and of most influence, during labour demanding peaks, which are the
periods just before and during the first weeks after the onset of the rains
(landpreparation, sowing and weeding) and the period of harvesting (January-
February and June-August).
Certainly for harvesting the available labour must be considered as the main
constraint, because harvesting is done by hand only. Land preparation and weed-
ing is, if possible, done by plough and although labour can be a serious problem,
in most cases the availability of a plough and draught animals is of greater
importance. If there is no other choice weeding has to be done by hand in which
situation labour can again become the main limiting factor. This may easily lead
to late and inadequate weedings which, in turn, adversely influence yields. It
is also quite common to put the weeding out to contract, but this must be consi-
dered a solution only for those persons who can afford this.

4.2.4 Tillage methods and constraints

The ideal situation, from the viewpoint of a maximal utilization of the avail-
able rain, would be that all arable land would have been ploughed already before
the onset of the rains.
Unfortunately at that time most soils are hardly tillable because they are
completely dried out. Therefore most people have to wait until the first rains
have softened the soil after which the ploughing and sowing can be done. To do
this as early as possible is extremely important because of the strong correla-
tion between the time of sowing and the yields to be expected. Each delay in-
creases the risk of a crop failure, especially in low rainfall seasons. A diffi-
culty, however, is the uncertainty of identifying the exact time of the onset of
the rains.

The main constraint to timely ploughing and sowing is the possession of a plough
and the neccesary draught animals, which also have to be in a good condition
because ploughing is hard labour for these animals, i.e. the grazing capacity
for these animals at least must be sufficient all year round.

Table 9. Distribution of households which have, or do not have problems
with ploughing.

Problems with ploughing	Number of households per farm-size class				total	% of overall total
	I	II	III	IV		
Always problems with ploughing	6		2		8	14
Never problems with ploughing	5	9	8	12	34	61
Situation not clear*		9	4	1	14	25
	11	18	14	13	56	100

*Mainly households having either the required draught animals but no plough, or
the opposite situation. Otherwise the available data were simply not sufficient.

The data given above should be regarded as representing the most positive situa-
tion, because the data about availability of the draught animals (oxen, bulls
and incidentally cows) were positively interpreted in cases where the available
draught animals had to be shared by more than one household. In spite of this
only 60% of the households have the possibility to do their ploughing and sowing
at the time they themselves consider necessary. In most cases not all of the
land is ploughed in one day but it is spread over several days because the
oxen can plough a limited time per day only, depending on their condition
and the availability of sufficient grass or fodder. A consequence of this is
that households which have to depend on other people, either because they have
to borrow (or pay for) a plough and/or draught animals, or even other people's
labour, often can not do their land preparation in time, thus inevitably leading
to lower crop yields. It is for these households that this lack of ploughing
facilities is one of the main constraints in their farming system and possibly
solutions have to be directed to either development of minimum and zero tillage

systems, or in case the bad condition of the draught animals is the limiting factor, to an improvement of the grazing capacity.

Tilling and simultaneously sowing with the hoe (what can be considered a minimum tillage method) is already practised especially by these people but then it is only as a last minute solution to have at least one part of their land planted more or less in time.

4.2.5 The cropping pattern

As mentioned - page 6 - arable agricultural activities have developed from a supporting enterprise into the main occupation for the vast majority of farmers in this area, while animal husbandry gradually has become less important. Simultaneously there has been a change in the assortment of crops grown; in the past millets and sorghum were the major crops, nowadays these are maize and pulses, supplemented with cassava. Moreover a range of other crops and vegetables are grown, while recently sunflower and cotton have been introduced as cash crops (see Table 10).

Table 10. Distribution of main crops per size class.

Crops	Number of households per farm-size class				total	% of overall total
	I	II	III	IV		
maize	11	18	14	13	56	100
pigeon pea	11	18	14	13	56	100
cowpea	11	16	14	11	52	93
beans	8	16	12	10	46	82
cassava	8	15	9	8	40	71
pumpkins	11	18	14	12	55	98
sweet potatoes	5	6	7	7	24	43
sorghum	2	6	4	2	14	25
sunflower	2	8	7	7	24	43
cotton		1	3	3	7	13

It is clear that maize and pigeon pea are the most important and most frequently grown crops. Maize constitues the main starch component in the diet, while the pulses are mutually replaceable in the diet, and it depends more on the availability than on taste or preference which of the pulses is actually eaten.

The leaves of cowpea are important because these are practically the only source of green vegetables which people grow, any harvest of cowpea is considered a welcome extra.

Pigeon pea is planted during the short rains and is harvested after the long rains are finished (July/August), i.e. it occupies the land for two successive growing seasons. It is grown by all people because it is considered to be a security crop; under harsh conditions (mainly low rainfall) when other crops fail, it is expected still to yield something.

Cassava is usually grown on the ridges of terraces or benches, which thus are made productive and spatial competition is restricted. However, cassava has an extensive root system and therefore it still might compete for water and nutrients, certainly if it is grown mixed with other crops. Occasionally a small patch is planted with cassava exclusively.

Pumpkins are grown by almost all farmers and although the leaves are edible it is mainly cultivated for its fruits.

Sorghum is becoming less important and although it is grown by 25% of the people it occupies only small areas, usually on the ridges of terraces. As sorghum is much eaten by birds, in older times children used to chase these birds away. The introduction of schools has thus been an important cause for the diminishing importance of sorghum. Moreover, people indicate that sorghum is not very tasty and even the colour seems to be an objection, therefore in practise it is almost exclusively eaten by children.

Sweet potatoes are usually grown in pure stands which however only occupy small areas. It does not yield very well and should, just like sorghum, be considered as a minor crop.

Sunflower and cotton are the only "pure" cash crops grown in the area. Sunflower is grown by more people than is cotton, but in most cases it is merely grown "accidentely"; if one has the seeds it is mixed with the other crops at the time of planting. Sunflower is considered not to compete with the other cropbs but this can also be explained by the low density in which it is planted. In general the yields are very low, if any is harvested at all. Much damage is caused by birds.

Cotton is grown exclusively by those people who can afford to allocate part of their arable land for growing non-food crops. An important reason not to grow cotton is that it is a very labour-intensive crop. Adding to this the low yields, poor quality and low prices, makes cotton an unattractive crop for the farmer in this area.

A range of other crops is grown. Among these tomatoes need special attention because they are widely spread and most people do have at least some plants. In most cases, however, they are grown in a wild state and no real cultivation is done. These "wild" tomatoes are rather small but much appreciated by the people. In a few cases improved varieties are grown by people who have access to sufficient water (well or close to the river), and can thus control the growing conditions more easily by regularly watering these plants. Incidentally these tomatoes are sold in the markets. If sufficient water is available other crops can be cultivated, such as onions, sukuma wiki (a perennial brassica), sugar cane and peppers all of these mainly for the farmer's own use.

Other rarely grown crops occupying only very small plots are: tobacco, lablab beans, fingermillet and green grams.

4.2.5.1 Maize

Maize, either in pure stands or mixed with other crops, occupies over 90% of the total arable lands, thus illustrating once more the importance of maize in the farming system, This figure becomes even more significant of plant-densities are taken into account. Research by Collinson (1979) in the same area

provides the following figures, which are based on stand counts during the long rains of 1977.

Investigated crop combinations, with the different crops grown in rows are:

maize & pigeon pea

maize & cowpea

maize & pigeon pea & cowpea

maize & cowpea & beans

maize & cowpea & pigeon pea & beans

maize pure stand

Averages for each crop seperately in the described mixtures are for:

maize   24.000 plants per ha

pigeon pea   6.660

cowpea   16.900

beans   15.600

maize pure stand   25.300

(It was remarked that counts were seemingly high.)

These figures clearly show that maize, even if it is grown in mixtures, is the most densely planted crop.

4.2.5.2. Crop mixtures and planting methods.

Mixtures play an important role in the cropping pattern although the size which is occupied by pure stands seem to be on the increase. In Table 11 the distribution of the most important mixtures and pure stands are summarized.

It is obvious that besides maize, pulses play an important role in the mixed cropping pattern, pigeon pea being the most frequently grown pulse in the mixture.

Although cassava is grown on the edges of terraces or benches, and must therefore be considered as a marginal case of intercropping, it has been included in the mixtures described above.

Table 11. Frequency distribution of the main[*] crop mixtures during the short
rains of 1979, per size class.

Crop mixture	Number of households per farm size class				Total number of farms with indi- cated mixture	% of all farms	Occupied size per mixture
	I	II	III	IV			
m, pp, cp	9	15	7	7	38	70	11.9 ha
m, pp	3	11	11	8	33	61	15.8
m, pp, b	3	8	5	5	21	39	5.7
m, b	2	2	6	2	12	22	2.4
m, cp	1	4	4	3	12	22	3.5
m, pp, cp, b	3	2	2	3	10	19	3.0
m, pp, cassava	1	5	1	2	9	17	2.1
m, pp, cp, cassava	1	2	2		5	9	1.2
pp, cotton			3	1	4	7	1.0
m, pp, sorghum	2	6	6	8	22	41	7.6
pigeon pea pure stand	1		2	2	5	9	1.0

[*]Crop mixtures which occupied less than one per cent of the total size of

arable land, are excluded.

Most plantings are done simultaneously with, or directly after ploughing.
Seeds are covered with soil either by the soil of the next furrow, or by hand
or feet. Occasionally planting with the hoe occurs. All of these have in
common that the crops are planted in more or less straight lines. The differ-
ent crop mixtures are achieved by mixing different crops in the same row,
different crops in alternating rows, or a combination of both.
If pigeon pea or cotton is included in the mixture it depends on the density
in which these are planted whether or not it is possible to interplant with
other crops during the long rain period, because both need more space to grow
their second growing season.

An interesting aspect of the mixed growing of maize and other crops together
with pulses, is the possibility that these, through their nitrogen fixing

capacities may increase soil fertility and so benefit other crops. The newly
developing tendency to grow more maize in pure stands, a system which can be
maintained only by the continuous input of nutrients through chemical ferti-
lizers or other sources, has to be reviewed with this in mind. Other crops
grown in pure stands are: pigeon pea, beans, cassava, sweet potatoes and cot-
ton, but all of these occupy very small plots only.

Recently "string-planting" has been introduced   , where a string
which is marked for the right plant distances is laid out after ploughing,
after which the sowing is done. Problems seem to be the high labour cost and
the high expenditure to buy this string, a problem which can be overcome by
shared purchase and use. Using this method higher plant densities and more
uniform stands are achieved, while the rows are straighter as compared with
plough planting.

4.2.6 Manure and chemical fertilizers

The main sources of applied nutrients are manure and chemical fertilizers, of
which at present manure is by far the most important.
Manure is collected all the year round inside the cattle bomas where livestock
usually spend the night. It is taken to the land in small baskets, wheelbar-
rows or ox-carts, and in one case even a small truck was used. It is evident
that carrying manure to the field in small baskets, and to a smaller extent in
wheelbarrows, is a rather labour intensive activity and therefore the ox-cart
owners and users are in a very favourable position compared to other house-
holds (20% of the sample households actually possessed an ox-cart). This high
labour demand also explains the existing relatively higher intensity of manur-
ing of these plots which are closer to the compound, in which the boma is
situated.

Fertilizers can be obtained through a farmers' co-operative society in Mbiuni,

however, only for those people who grow cotton, because the payment of this fertilizer is deducted from the price of the produced cotton. Incidentally fertilizers are granted in small amounts through the local church organisations, and it was remarkable that only households in size class III reported this as a source, for which no explanation is provided. Still fertilizers are used in small amounts, and by a few farmers only.

The data given in Table 12, concerning the use and importance of manure and fertilizers, are somewhat influenced by the research carried out by Onchere (1978-1979) who supplied some of the sample households with inputs (fertilizer, hybrid maize and insecticides) during part of the investigation period, which for this subject covered the short rains of 1979 and the long rains of 1980.

Table 12. The use and importance of manure and chemical fertilizers.

Manure/fertilizer use	Number of households per farm size class				Total	% of overall total
	I	II	III	IV		
No inputs	2	2	2	2	8	15
Manure only	6	12	3	7	28	50
Manure and fertilizer		2	5		7	13
Fertilizer only			3	2	5	9
"Onchere farms"	3	2		2	7	13
	11	18	13	13	55	100

From the seven "Onchere households" four did not apply manure at all during the period they received the inputs mentioned above, which might point towards a certain preference for these artificial fertilizers. These households are excluded from the following discussions.

Despite the fact that manure is important for the majority of households, and fertilizers are of some importance for the larger farmers, still eight households

do not use either. The main reasons not to use manure are that it is simply not available, or not produced in sufficient quantities by the present number of livestock and/or that the available labour is not sufficient to carry the manure to the fields.

4.2.6.1 Availability of manure.

On page   innovations based on minimum and zero tillage methods were proposed as possible solutions for problems which arise during ploughing. This way of solving these problems becomes even more significant if the problems which arise with manuring are taken into account as well:

1. Households which have problems with ploughing in most cases also have problems in obtaining sufficient manure.

2. Simultaneously with minimum tillage methods mulch materials should be applied, thus reducing the required quantity of manure.

The main constraints which retard a successful introduction of these methods are the availability of sufficient mulch materials and the required labour to maintain the system. Therefore, to overcome these problems, for a start these methods should be tried out only on a smaller part of the farm, and if this proves to be successful it always can be extended to other parts of the farm.

Trees and shrubs could be important sources of mulch material, for this purpose these   should be planted inside the cultivated area, either as individual trees or in hedges which are regularly coppiced. The best place to plant these trees and shrubs would be at the ridges of the benches to limit the competition for light, water and nutrients with the foodcrops. Other reasons why especially trees and shrubs should be planted and planted especially at those places are:

1. Mulch material is produced directly at the place where it is needed, thus reducing the required labour.

2. Trees and shrubs can, through their deeper and more extended roots make use of nutrients at greater depth, bringing these up through their leaves, branches etc.

3. If some of these trees and shrubs are legumes these possibly can contri-
    bute to increase the fertility of the soil.

4. Other trees and shrub produce is provided.

5. If these trees and shrubs provide fodder, or can be browsed by livestock,
    this indirectly leads to a higher production of manure.

As a supplementary measure the productivity of grazing areas should be improv-
ed so as to obtain extra mulch material and, indirectly, manure.

4.2.6.2 Labour constraints.

Because of the high labour demanding character of carrying manure to the
fields, one solution would be to combine available labour. This is already
done to some extent through existing "self-help" groups. At present 55% of the
sample households reported that one or more female household member(s) belonged
to such a group, and 70% of these groups carried manure as one of their acti-
vities. This looks hopeful, but even these groups are still limited because of
the small baskets in which manure can be carried, and therefore only small
plots of arable land can be manured in this way.
For the same reason most of the manure has to be carried to the field long
before the onset of the rains, which results in a considerable loss in quality
of the applied manure, caused by the exposure to full and intensive sunlight.
However, no solution for this problem can be given because at the time of
ploughing and planting, which time would be the best to apply the manure,
labour availability is already at a minimum.

4.3 Trees in the cultivated area.

Nearly all fruit trees are grown inside the cultivated areas. In the rare cases that some were found outside, it appeared that at the time those were planted this particular land had been under cultivation or had been part of a former compound.

Some indigenous trees are found in the cultivated areas as well, and in Table 13 figures on the occurrence of these different types of trees are given.

Table 13. Occurrence of fruit and indigenous trees inside the cultivated area.

Trees inside cultivated areas	Number of households per farm size class				Total	% of overall total
	I	II	III	IV		
Fruit trees only (including bananas)	3	9	3	5	20	35
Fruit & indigenous trees	4	5	11	8	28	50
Indigenous trees only		2			2	4
No trees at all	4	2			6	11
	11	18	14	13	56	100

These data show that 86% of all households grow at least one fruit tree. If households which have only a limited number of fruit trees are excluded, this percentage is considerably lower, i.e. 71% of households have less than 5 fruit trees.

About 50% of the households have at least one indigenous tree in their culti-vated area, but their numbers are much lower than the numbers of fruit trees grown. Households which have no trees at all in their cultivated area belong to size class I en II. This might indicate that for these households the available arable land is considered to be so scarce that no trees are allowed to grow.

4.3.1 Fruit trees (including bananas)

Generally fruit trees are grown on the edges of benches, primarily to avoid
problems during ploughing, and to avoid competition with foodcrops as well. In
most cases the majority of fruit trees are grown in those parts of the culti-
vated areas which are nearby the compound; and usually these get more atten-
tion than those planted further away. A practical reason for this is that it
is much easier to recognise whether the fruits are already ripe or not. The
number of people who want to grow, or already have fruit trees is still in-
creasing and especially bananas are planted in really large numbers. Besides
bananas a range of other fruit species are grown.

Table 14. Fruit species grown related to their frequency of occurrence.

Fruit species	Number of households per farm size class				Total of house-holds growing species	% of overall total
	I	II	III	IV		
banana	6	11	12	9	38	69
pawpaw	3	8	9	8	28	51
mango	5	11	9	9	34	62
guava	4	3	7	4	18	33
lemon	2	5	6	5	18	33
orange		3	3	4	10	18
mulberry		1	2		3	5
custard appel	1			1	2	4
cashew nut	1				1	2
citrus sp.	1				1	2
passion fruit				1	1	2

Banana together with mango are by far the most frequently grown fruit species,

while pawpaw, lemon, guava and orange are also reasonably well represented.
All of the other fruit species are only incidentally grown. More quantita-
tive information is given in Tables 15 through 20.

As far as management is concerned this is at a rather low level, only
incidentally some weeding is done. Diseases and pests are recognised but
hardly any combative measures are taken.
About 20% of the households sell part of their fruits, thus earning an
always welcome extra cash income.

Table 15. Distribution of fruit selling household per
          size class subdivided per fruit species.

Sale of:	Number of households per farm size class				Total of households	% of all farmers
	I	II	III	IV		
fruit produce	3	2	5	2	12	21
mango	3	1	5	1	10	18
pawpaw	1	1		1	3	5
banana	2		1	2	5	9
guava			1	1	2	4
lemon	2	1	3	1	7	13

Mango and lemon are the most frequently sold fruit species, also consider-
ing the quantities sold. Fruits which are offered in sufficient quantities
are collected by some traders in Kathama market, after which these are
taken to Nairobi. Other fruit species are sold locally in small quantities
only, either in the market or incidentally at home.
Mbiuni market is the local trading centre for pawpaw, but until now hardly
any farmer has grown enough of these fruits to make it worth while to take
and sell them there.

After this more general introduction on the following, the most important
fruit species are dealt with seperately and in a more detailed way.

4.3.1.1 Bananas

Banana is the most important fruit species in the area, not only because of

the large numbers grown, but also because they can, and in some cases

already do, contribute to an increasing extent to the starch supply in the

peoples' diet. Another important property of bananas is that they yield

more or less all year round, which is especially important in periods when

other starch providers (maize) are scarce, or expensive.

To grow fruits in general is a rather new enterprise in the area; about

thirty years ago hardly any fruits were grown.

More recently the number of banabas has increased enormously and this still

appears to be the trend as can be illustrated by the number of planting

holes already dug. This "banana boom" might be an indication that innova-

tions easily diffuse among the people, especially if no high expenditures

are involved and the benefits are evident.

Table 16. Distribution of bananas (clumps) per size class.

Number of banana clumps per house-hold:	Number of households per farm size class				Total	% of all households
	I	II	III	IV		
No banana clumps	5	7	2	3	17	30
1-10	2		3	1	6	11
11-25	1	6	5	4	16	29
26-50	1	2	2	1	6	11
51-75	1	2	1	2	6	11
76-100	1	1			2	4
over 100			1	1	2	4
	11	10	14	12	55	100
average number of clumps per household	20	24	23	33		

Out of 70% of households which actually grow bananas, about half of them already have, or will soon have enough to be sure of a more or less regular banana production, which number amounts to 30% of the entire population.

Bananas are propagated by broad leaved suckers of about 1 m length, which are sold for K.Shs. 1/- each in Kathama and Mbiuni markets. Another source are suckers which are derived from the farmers' own banana plants, which are also regularly exchanged with other people who want to grow bananas.

Before planting, a hole, or a line of holes, is dug. As this is usually done during the dry season, this is really laborious because the soils are dried out and are hardly workable. A subsidiary effect of this digging of banana holes often is that a kind of terrace is constructed, because lines of holes usually follow the contours. After digging these holes, smaller holes are made within them in which the banana sucker is planted and usu- ally some manure is applied. After the planting the bottom is sometimes covered with mulch.

Micro-catchments are sometimes laid out. They are not very well constructed, but they often show how the availability of water can be considerably improved with limited means and using simple methods and natural waterways (e.g. roads, footpaths, etc.).

After planting hardly any further management is done and therefore older bananas have a kind of bushy appearance because all suckers are allowed to mature. Groups of bananas were recorded having even more than 10 stems. Every clump has been recorded as one plant only and therefore the number of producing banana stems is not indicated in Table 16.

4.3.1.2. Mango

Although the absolute number is less than for bananas, mangoes influence the outlook of the environment more. They occur as easily recognizable evergreen trees.

It is only 20 to 30 years ago that mangoes were introduced in the area, but since that time their number has increased continuously. These first mangoes were introduced by a few people who received some seeds from a mission post in Kinyui, a market centre located on the other side of the Kanzalu Range, to try whether they would grow or not. Together with the seeds they received planting instructions.

Table 17. Distribution of mangoes per size class.

Number of mango trees per household	Number of households per farm size class				Total	% of all households
	I	II	III	IV		
No mangoes	6	7	5	3	21	38
1- 3	3	9	4	3	19	34
4- 6	1		3	2	6	11
7- 9		1	1	3	5	9
10-15				1	1	2
16-20	1				1	2
over 20		1	1		2	4
	11	18	14	12	55	100
average number of mangoes per household	3	3	4	4		

The number of mango trees per household is less than that for banana clumps, but it should be mentioned that one fully grown mango tree can yield many fruits. Both of the households which grew over 20 mango trees received considerable amounts of money out of the sale of fruit (up to K.Shs. 500).

A problem with the marketing of mangoes is that the bulk of the harvest is concentrated in a short period, thus leading to low prices (K.Shs. 15-20 per bag). Transport is often a problem as well.

Propagation is a special problem with mango. Except for the first introduced mangoes, the majority of the others have originated from discarded

seeds. This explains the more accidental and scattered occurrence of mangoes
inside the cultivated areas. Seedlings are not raised in nurseries because
the transplanting of seedlings is hardly ever successful.

Another problem with mango is that if it is fully grown (but in an earlier
stage of growth also), it casts a heavy shade, under which maize and pigeon
peas hardly give any yields. As far as could be observed there seem to be
no distinct negative influences outside the crown of the tree and it appear-
ed that beans did not experience visible growth limitations if grown under-
neath, but it may be possible that yields are much lower then (however, no
yield measurements were done). It was interesting to see that although
people are very well aware of the bad conditions for maize and pigeon peas
underneath mangoes, they still planted these crops right up to the stem for
which no explanation was given.

4.3.1.3 Pawpaw

Pawpaw is also one of the more important fruit species (Table 18). Until
now the number of pawpaw trees has been too small to produce fruits in
sufficient quantities to make it worth while to take these to the market to
sell. Therefore most of the produced fruits are consumed in the households.
Even in the market at Kathama, pawpaws were seldom offered for sale.

Table 18. Distribution of pawpaws per size class.

Number of pawpaw trees per households	Number of households per farm size class				Total	% of overall total
	I	II	III	IV		
No pawpaws	8	10	5	4	27	49
1- 5	2	4	6	5	17	31
6-10		4	1	2	7	13
11-15						
16-25	1		1	1	3	5
26-50			1		1	2
	11	18	14	12	55	100
average number of pawpaw trees per household	2	2	6	5		

The data show that out of the households which grow pawpaws, the majority has a few plants only. At its best they provide sufficient fruits for consumption in the household only.

Two aspects which go with the growing of pawpaws are important: their relatively short juvenile period and their place in the farming system.

The pawpaw is a short lived perennial and this influences propagation and management methods. In order to maintain a constant level of production it is necessary to replace part of the total number of pawpaws regularly. The actual situation is that plants are kept in the fields until they fall down, i.e. about 10 years after planting. This aspect is therefore important because in some cases people reported that they used to have pawpaws in the past, but after that they fell down, they did not know how to obtain new plants again. Therefore instructions should be given on how to raise seedlings, and how to make a plant to maintain production as well.

Pawpaws are mainly planted on the ridges because they easily break (wind), and especially during ploughing, the oxen could easily trample them if they are grown inside the bench.
Food crops growing close to pawpaws did not show any sign of being adversely affected.

4.3.1.4. Lemon and orange

Both belong to the same genus (Citrus). The common orange cultivar grown is Washington Navel, which are grafted by local experts using rough lemon as rootstocks. They ask a price of K.Shs. 2 per budding, care for the plant until the budding has succeeded is included.
The growing of oranges is relatively new in the area, only a few local experts have yielding trees, but none of these were included in the sample. That more people want to start growing oranges can be illustrated by the large number of lemons that have recently been planted (Tables 19 and 20).

Table 19. Distribution of lemon trees per size class.

Number of lemon trees per household	Number of households per farm size class				Total	% of overall total
	I	II	III	IV		
No lemons	9	13	8	7	37	67
1- 5	2	3	2	3	10	18
6-10			1		1	2
11-15		1	1	1	3	5
16-25			2		2	4
26-50		1			1	2
over 50				1	1	2
	11	18	14	12	55	100
average number of lemon trees per household	–	3	4	9		

Table 20. Distribution of orange trees per size class.

Number of orange trees per household	Number of households per farm size class				Total	% of overall total
	I	II	III	IV		
no oranges	11	15	11	8	45	81
1- 5		1	2	2	5	9
6-10		1	1		2	4
11-15		1		1	2	4
16-25				1	1	2
	11	18	14	12	55	100
average number of orange trees per household	–	1	2	3		

These data show that especially households in size class IV are interested
in the growing of orange trees, and some already have a considerable number
of these grafted. Only one household had oranges that were grown directly
out of the seeds. In size class I no orange growing households were record-
ed.

An explanantion for the differences between size classes might be that oranges are considered to be an "exclusive" crop, which can only be grown by richer farmers who can afford to buy the necessary expensive inputs. Another explanation might be that it is considered a difficult crop to grow, and this is certainly true because of the required high level of management. Therefore it is interesting to see how this orange culture will develop. For most people it is a completely new method of management, which could have a great influence on other enterprises through improved management.

4.3.1.5. Guava

This is not a very important fruit species (Table 21). It is sold by a few people in the market where they get very low prises (one penny per fruit). Propagation is done either through discarded seeds or occasionally seedlings are raised in a small nursery after which they are transplanted.

Table 21. Distribution of guava trees per size class.

Number of guava trees per household	Number of households per farm size class				Total	% of overall total
	I	II	III	IV		
no guavas	7	15	7	8	37	68
1- 5	4	3	4	3	14	25
6-10			2	1	3	5
11-15						
16-25			1		1	2
	11	18	14	12	55	100
average number pf guava trees per household	1	-	4	1		

4.3.1.6. Other fruit and nut species: mulberry, custard-apple, cashew nut.
          citrus sp. and passion fruit

All of these species were recorded only rarely and not in great numbers

(hardly ever more than 2 specimens per family).

Mulberry shows good prospects for extension because this fruit is very tasty,

and contains much vitamin C.

The data as given in Table 13 for passion fruit might be rather too low

because these fruit species have not been taken into account in a systematic

way. Passion fruits are sometimes grown inside the compound and therefore it

is possible that some plants were overlooked. This fruit species is never

grown for commercial purposes or on a large scale and its yield is poor.

4.3.1.7 Nursery techniques

Nurseries play a role in the propagation of some of the fruit species grown

(lemon, pawpaw and guava), but for foodcrops (especially vegetables) their

role should not be overlooked either.

At first sight sufficient and easily available water seems to be the main

limiting factor to establish and maintain a good nursery. However, for 20

sweet pepper plants and 10 Jacaranda seedlings in a small nursery less than 1

liter per day was required (author's experience). Of course, the water need

of a nursery is closely related to its size and this should be restricted to

the amount of water available. Even a minimum nursery (e.g. 30 x 30 cm provid-

ing, say, 25 seedlings) should be sufficient for individual household needs

for fruit seedlings. Materials necessary to establish a nursery are all

easily obtained locally without any costs, so this cannot be an obstruction

to having a nursery. Materials which can be used are: thorny branches, twigs

or sisal poles for fencing, old tins, etc. The only requirements are that the

young seedlings are protected against full sunlight and animals (mainly

chickens).

At present 34% of the households have their own nursery, ranging from a few plants in small tins to more advanced constructions with different fruit and vegetable species. Three households (5%) indicated that they already had enough fruit trees and therefore did not need a nursery anymore. It was remarkable that none of the households in size class I had their own nursery, thus illustrating the limited contribution of these households in the total of the fruit growing enterprise.

4.3.1.8 Limiting factors in fruit production

One important restriction to planting fruit trees arises from the nature of the prevailing inheritance system. As long as the land has not been formally divided, and the heirs do not exactly know which part they will ultimately get, they usually are not very much concerned with, or interested in carrying out "long term investments" like planting trees, digging terraces, etc. In this situation often an over-exploitative attitute is common, which especial-ly finds its expression in the grazing areas (overgrazing, cutting trees, etc.). The situation for the arable lands is different because on these lands some personal rights are valid until the division, for those people who actually cultivate that particular piece of land.

Another reason not to grow fruit trees originates from earlier unsuccessful tree planting trials, after which people became disappointed and did not try again. Quite a number of people considered this as the main objection.

4.3.1.9 An example of a typical fruit grower

The farm, combining fruit trees and food crops is situated on the higher parts of the Kanzalu Range at an altitude of about 1350 m where the avail-ability of water is better than in the lower parts of the investigated area.

Size of arable land is 0.46 ha laid out on 12 terraces all of about 50 m

length and a width of 5-10 m. In the middle of the cultivated area the com-

pound is situated, where some fruit trees and a few ornamentals (Plumieria)

are grown as well, occupying an area of about 250 m^2. There are about 4 goats

and 2 head of cattle, grazing an area of 0.1 ha which the farmer considers to

be insufficient.

Foodcrops grown are: maize, pigeon pea, cowpea, beans, lablab beans, cassava,

pumkins, sorghum, sweet potatoes and gourds.

Good yields were obtained from all crops, except for sorghum. Apart from

green consumed crops, per harvest the following yields were usually obtained:

2 bags of maize, ½ bag of cowpeas and ¼ bag of beans.

Mixed with the foodcrops, but almost all grown on the edges of the terraces

the following fruit trees occur: 95 banana clumps, 18 pawpaws, 18 mangoes,

4 lemons and 2 guavas.

Mangoes, lemons and pawpaws are usually sold, while bananas are all consumed

in the household.

Apart from these fruit trees 2 Kigelia aethiopicum trees were grown, both

already carrying fruits. The fruits are used for beer making.

The compound consists of 3 houses and a small cattle boma. All of these

enterprises are concentrated in an area of about 0.6 ha.

4.3.2 Indigenous trees inside the cultivated area.

As follows from Table 12, 54% of the households have indigenous trees inside

their cultivated areas, which is an interesting figure with regard to the

agroforestry background of this study. To give an impression of the different

indigenous tree species grown Table 22 presents some data which have been

abstracted from the results of the inventory of indigenous trees and shrubs

by Els Fliervoet (1982).

Table 22. Distribution of indigenous trees inside the cultivated areas.

indigenous tree species	Number of households per farm size class				total	% of all households	Overall total of ind. trees
	I	II	III	IV			
Terminalia brownnii	2	4	7	8	21	72	44
Kigelia aethiopicum	1		3	3	7	24	9
Combretum zeyheri	1	1	5	1	8	28	9
Combretum collinum			2		2	7	9
Grewia plagiophylla	1		1	2	4	14	14
Vangueria sp.	1	2			3	10	4
Balanites aegyptica		1		2	3	10	4
Cassia singueana		1	1		2	7	4
Combretum apiculatum		2			2	7	3
Erythrina abyssinica			1		1	3	3
Acacia robusta	1				1	3	2
Lannea schweinfurthii	1				1	3	2
Lonchocarpus eriocalyx		1	1		2	7	2
Boscia augustifolia			1	1	2	7	2
Ormocarpum kirkii			1	1	2	7	2
Acacia polyacantha			2		2	7	2
Croton megalocarpus				2	2	7	2
Clerodendrum sp.	1				1	3	1
Pappea capensis		1			1	3	1
Ficus sp.		1			1	3	1
Commiphora africana			1		1	3	1
Vitex payos				1	1	3	1
Steganotaenia araliaceae				1	1	3	1
Commiphora madagascariensis			1		1	3	1
							117
Number of households having indigenous trees	4	7	11	7	29		

Terminalia brownii is by far the most common species, both as far as fre-
quency and absolute numbers are concerned. Other reasonably common species
are Kigelia aethiopicum and Combretum zeyheri. It is not a coincidence that
especially these species are most frequently found; Terminalia brownii is
considered to be one of the most important tree species because it yields a
very good quality of timber which is not attacked by termites, while Kigelia
aethiopicum yields fruits which contain an ingredient used with traditional
beer brewing. Combretum zeyheri has less pronounced positive qualities but it
is still considered a useful tree.

The prevailing vegetation inside the grazing areas is dominated by Acacia and
Combretum species, but inside the cultivated areas hardly any acacias occur.
An explanation for this is that at the time a piece of land is put into use
for permanent cultivation, the existing vegetation is removed. Depending on
the individual farmer few or none of the more appreciated and older trees are
kept. This aspect partly explains the relatively high number of Terminalia,
Kigelia and Combretum specimens. Because of this personal preference one
might expect that the acacias would be conserved in the cultivated area as
well, in view of their usefulness for many purposes. However, this is not the
case.
First of all most of the acacias are very thorny, which is detrimental if one
has to work alongside them, especially the small specimen with a shrubby
habit would cause severe problems. Another reason not to have acacias is that
they are seen as carriers of all kinds of vermin which are said to destroy
the crops.
Acacia seedlings coming from the surrounding areas are not given the chance
to grow. Seedlings of other species are sometimes kept, thus explaining part
of the more frequent occurrence of the species mentioned above.

The number of indigenous trees is rather low. Therefore their influence
(positive or negative) on the growing conditions of foodcrops is rather
limited, certainly if compared with the larger numbers of fruit trees.

Nevertheless in some individual cases this influence might be of great importance, e.g. some older legumes have, through their nitrogen fixing capacities, a positive influence on the crops grown in their vicinity. It is certainly important to investigate these individual cases (not only legumes) to obtain more knowledge about these interactions and based on this knowledge some of the more promising indigenous trees for agroforestry purposes can be identified. Farmers' opinions as to what extent trees influence the growth, or the growing conditions, of the foodcrops was sought. However, this approach led to very unsatisfactory and highly biased answers, probably because the questions had not been phrased properly.

4.4 The grazing area

Grazing areas play an important role in the prevailing land use and farming systems; they occupy a considerable part of the totally available land, in which a series of enterprises are concentrated:
- grazing of livestock
- gathering of firewood and other tree/shrub produce
- making of charcoal and bricks
- bee keeping

At present the land for grazing and the other enterprises is no longer sufficient, and therefore external sources of animal feed have become necessary.

4.4.1 Size of grazing areas and the nature of their use

Sizes of all grazing areas were estimated, and not measured exactly (Table 23). In addition the farmers were asked to compare the size of their grazing area with the size of their cultivated area, which information is included in the calculations.

Table 23. Distribution of sizes of grazing areas per size class.

Grazing area size	Number of households per farm size class				Total	% of overall total
	I	II	III	IV		
0.1-1.0 ha	7	8	3	2	20	36
1.1-2.0	2	6	5	1	14	25
2.1-3.0	1	2	4	1	8	14
3.1-4.0		1	1	4	6	11
4.1-5.0	1		1	1	3	5
over 5.0		1		4	5	9
	11	18	14	13	56	100
Average size of grazing area (ha)	1.3	1.3	2	4		

A relation between the sizes of cultivated and grazing areas can be identified; households with small cultivated areas tend to have smaller grazing areas, and the households with larger cultivated areas tend to have larger grazing areas as well. This relation becomes even more significant if the specific nature of the use of the grazing areas is also taken into account. 45% of all households share the grazing area with one or more other households. Data presented in Table 24 show that the smaller farms are overrepresented in this category. Rights for grazing are derived from family relations, "Grazing on the 'kisese' may be shared communally by all a man's sons for a while, but sooner or later it gets divided up" (Penhill, 1951, p.45). Another practice is just to pay; either in cash or through rendered services, e.g. ploughing in exchange of grazing. However, this latter practice is less common.

Table 24. Distribution of individual and shared use of privately
owned grazing areas.

Type of use of grazing	Number of households per farm size class				Total	% of overall total
	I	II	III	IV		
Exclusive use of grazing	4	4	11	9	28	50
Shared use of grazing	6	12	3	4	25	45
Hardly any land for grazing*	1	2			3	5
	11	18	14	13	56	100

*Included in this category are those households which dispose of a
grazing area of 0.1 or less.

In spite of the fact that households in size class I and II often have rela-
tively small grazing areas, the majority of them (62%) even have to share it
with other households. Whereas the majority of the households in size classes
III and IV, with relatively larger grazing areas,   have   the
exclusive   use   of it. This is remarkable because it is not very
likely that differences in the patterns of shared use are related to the size
of cultivated areas. An explanation for this discrepancy might be that,
because of the continuous fragmentation of holdings the situation for the
smaller farmers has reached the point that such small grazing areas remain
that these can hardly carry any livestock at all. Having reached this situa-
tion it may be that several households still share their privately owned
grazing areas, as the ultimate solution to having at least some cattle.
From an agroforestry point of view it is interesting that in these situations
rights on trees remain individual and are never part of the agreement.
Out of this fragmentation of holdings the relatively high number of indivi-
dual owners and users of grazing areas in size class III and IV can partly be
explained. Of course, sharing of grazings does occur in these classes, but it
has also occurred that some households extended their properties by means of
purchasing land.

Naturally these new individually purchased lands are not shared with other households. However, because of the country wide extending land and population pressure, it is becoming increasingly difficult and expensive to purchase land, not only inside, but outside the area.

4.4.2. External and other grazing (fodder) sources

Of the sample households 52% reported that their grazing area alone was not sufficient to feed their present number of livestock. As a solution many households make use of crop residues and other grazing sources.

4.4.2.1 Crop residues

An important extra source of fodder is the feeding of crop residues, maize and pigeon pea being the most important. The use of crop residues was reported by practically all households, mainly depending on availability. These residues are taken to the animals when they are in the boma, especially the residues which remain after threshing the crops, which is usually done in the compound.

Some times the animals feed on the crop residues inside the cultivated area itself. At first sight this latter method seems better. It requires less labour compared with the situation where the crop residues are transported to the boma, and manure is thus brought more easily to the land instead of carrying it there in small baskets. However, a negative side effect is that the risers of the terraces may be damaged.

4.4.2.2. Supplementary sources for grazing

Common supplementary sources for grazing, the use of which was reported by 29% of the households, are:

1. To pay for grazing someone else's land (EXTRA GRASS)*

2. A government forest across the river, in which grazing is allowed after paying K.Shs. 1 per head of cattle per month. This forest is especially important during the dry season when the river is not too high and the animals can easily cross the river. However, even more important is that during this season the farmers' own sources for grazing are limited (FOREST)*

3. Communally-owned lands across the river which are only accessible for those people who are members of the society (SOCIETY)*

4. An island, formed by Athi river and Kikumini river where people, individually, have bought lands which also have to be considered an external source because of the distance and the extensive management.

5. The higher slopes of the Kanzalu Range which are all privately owned, and which are grazed to the top.

*The words in capitals between brackets refer to the way the specific grazing sources are presented in Table 25.

The extra sources for grazing as mentioned under points 2, 3 and 4 are important for those people who live close to the river. It is clear that distance plays a role in the limits of accessability for the different sources. The limiting distance can be considered to be about 3 km from the source.

For the same reason grazing on the Kanzalu Range is important for the people in Kalama only.

To "buy" grazing inside the area, mentioned under 1., is common throughout the area.

The number of households which partly or totally depend on the upper slopes of the Kanzalu Range for grazing their livestock is 5 (9%) while 2 households (4%) have some land on the island. The forest across the river is important for 7 households (13%).

Table 25. Importance and distribution of external and other grazing sources per size class, subdivided into categories of households with individual or shared use of privately owned grazing areas.

Source of grazing	Number of households per farm size class				Total	% of overall total
	I	II	III	IV		
Hardly any land for grazing	1	2			3	5
OWN LAND ONLY	2	3	8	5	18	32
OWN + EXTRA GRASS	2.		1	1	4	7
OWN + FOREST		1		2	3	5
OWN + SOCIETY			2		2	4
OWN + FOREST + SOCIETY				1	1	2
SHARED LAND ONLY	4	9	3	3	19	35
SHARED + EXTRA GRASS	1	1		1	3	5
SHARED + FOREST	1	2			3	5
	11	18	14	13	56	100

This forest grazing combined with the gathering of wood has led to a serious deterioration of the vegetaion, especially along the paths and this has led to completely bare soils already. Also because of previous degradation this forest has recently been brought under protection. As a result of this, people have to ask permission and have to pay for grazing. It is to be expected that the protection will be more strict, perhaps ultimately leading to a total prohibition to graze and gather wood there.

Another aspect of this forest grazing, or grazing other sources in general, is that it gives people an opportunity to lower the grazing pressure on the grazing areas at home. This in order to save grass for the livestock at the beginning of the rains, at which moment it is extremely important to have enough grass to feed the oxen and bulls.

4.4.3 Management and condition of grazing areas

Here we only describe management and conditions of grazing areas inside the
investigated area, excluding the external grazing sources.

As more than half of the households report that their grazing areas alone are
not sufficient to feed their livestock, it is certainly important to know what
the possibilities are to increase the capacity of the grazing within the
area, e.g. through improved management.

4.4.3.1 Management

One management activity is to divide the grazing area into separate parts,
which are grazed gradually. In total 31 households (55%) reported such a
rotational pattern of grazing.

Other management actions are the clearing of unwanted vegetation, i.e.
especially Lantana camara, to improve the growing conditions for grass.
This was reported by 52% of the sample households to be done more or less
regularly, however, in view of the actual numbers of Lantana shrubs growing,
this clearing is not always done consistently or successfully. The posses-
sion of certain types of livestock may influence the decision as to which
vegetation is unwanted as well, e.g. one farmer always cleared Aspilia
 mosanbicensis scrub - this in spite of the fact that this species is
considered to be very useful as browse for goats - because he did not
possess goats.

Another method, only incidentally practised, is the planting of creeping
grass species at places where bare plots occur inside the grazing area.
Advantages of this method are the increased grass production combined with
an effective erosion control; at least if the planting is successful.
However, these grasses are rather liable to over grazing and it takes a
relatively long time before a bare place is completely overgrown by them.
Nevertheless this certainly is an interesting method which deserves more

attention, given the low cost involved, i.e. only the required labour to
look for suitable grass and to do the actual planting.

Except for one farmer no other management practices of the grazing areas
were mentioned or noticed, thus showing the rather low level of management
of the grazing area.

The one exceptional farmer practised the management actions mentioned
above, and in addition to these, at those places where grass (or sisal) was
to be planted, first a few ploughlines were made and manure was applied to
initiate a better growth. Furthermore it was planned for the coming season
to establish a few small cut-off drains at places where slight gully ero-
sion was developing. Moreover, he lopped certain trees, mainly: Terminalia
brownii, Acacia tortilis, A. Mellifera and A. etbaica. These eventually
better-shaped trees will provide better timber, e.g. straighter poles for
construction purposes.

As a whole this farmer certainly was more inventive than the average one
and more inclined to develop or accept innovations in his farming system.
As this example shows, improvement of the covering capacity of the vegeta-
tion and possible "enrichment" of the natural vegetation, is possible.

The rather low level of management apparently has some roots in the tradi-
tional, exploitative attitude towards the "natural" (i.e. grazing) environ-
ment: "Trees grow by themselves" as many farmers put it and it certainly is
not common to interfere in this "natural" process.

The example of the erosion control measures inside the cultivated areas
shows that changes of attitude are possible. A similar change in attitude
towards the grazing area now seems to be needed, in view of the deterio-
ration of many of these grazings.

4.4.3.2. Erosion

That erosion and erosion control measures in grazing areas are not new is shown by the remnants of terraces, especially in the area near the river. Farmers reported that large tracts of land were completely bare during the colonial time. The enforced terracing which was undertaken at that time has resulted in a regrowth of the vegetation, which is still underway in some parts.

At first sight for all grazing areas erosion seems to be of limited importance, as only 5 households had a completely eroded grazing. Inside these areas hardly any vegetation was left and therefore they were practically unproductive. In many other grazing areas erosion was very serious at specific sites, even resulting in rapidly expanding gullies, especially on Kanzalu Range and near the river. Roads and paths are often starting points for developing gullies, especially there where livestock often passes. Often grazing areas are situated on steeper slopes than the area occupied for cultivation. This can be explained because at the time the land was brought under permanent cultivation, first the more fertile and flat parts were taken, and the remaining ones were left for grazing purposes. Therefore many of the grazing areas are rather liable to erosion because of their exposure to the slope.

Table 26. Occurrence of erosion in grazing areas

Degree of erosion	Number of households per farm size class				Total	% of overall total
	I	II	III	IV		
No obvious erosion	7	13	8	8	36	64
at intervals eroded	2	3	6	4	15	27
seriously eroded	2	2		1	5	9
	11	18	14	13	56	100

Only if the erosion effects were obvious, has that particular grazing area
been included in one of the two erosion categories. Therefore the data
presented in Table 26 must be seen representing the actual numbers of
grazing areas where erosion control and soil conservation measures are
urgently needed.

One possibility to improve the condition of eroded grazing areas is to re-
establish a permanent groundcover, by means of planting or favouring certain
elements of the indigenous vegetation (or exotics). However in some cases
more extended rural engineering works may be necessary to stop erosion.
Incidentally some work has been done already; in some eroded roads and
waterways a dam was built, making use of the trash (often sisal boles) or
stones. The already mentioned plantings of grass must also be considered in
this context. As the actual natural vegetation is very important with
regard to erosion, this will be dealt with in the next chapter.

4.4.3.3 Natural vegetation

The prevailing vegetation is only natural in the sense of "not managed", on
the other hand it is much affected by a long history of human influence.
Some insight in this history is a prerequisite for understanding the pre-
sent vegetation.

The part of the area most resembling a natural, in the sense of original,
situation is the forest across the river. Despite the human influences the
species composition of the present forest vegetation probably has not been
altered extensively. Acacia mellifera is the dominating tree species and it
is most likely that the same species has been dominant in the research area
as well.

After the lands were put into use for grazing,   most specimens of this
acacia species were gradually removed because of their excellent fuel wood,
and other trees and shrubs entered from the already occupied surroundings.

This sequence of development of the vegetation can still be recognised in the abandoned cultivated parts, in which the ground is first covered with grasses and herbs, whereafter spontaneous regeneration of mainly acacia species takes place. Apparently these are the most important pioneer tree species.

The regeneration of the originally dominating Acacia mellifera to mature trees is obstructed because all occurring specimens are heavily browsed by goats. Therefore this species is still quite common but it always has a shrubby appearance.

For more detailed information concerning the indigenous vegetation refer to Fliervoet (1981).

4.5 Animal husbandry

Traditionally the Akamba were herdsmen, and remnants of the pastoralists' attitudes are present, especially, but not exclusively, with elderly people.

4.5.1 Tenure and inheritance systems

The following quotation illustrates the traditional tenure and inheritance systems as far as livestock is concerned:

"The pattern of inheritance of cattle, goats and other property is likewise largely determined beforehand. When a man marries his second and later wives and establishes them in their houses, the new wife takes a present of bananas to the first wife, and asks her for a cow that she can remove to her own cattle pen - her 'nza'. Previously all stock is, often actually and always theoretically, in the 'nza' of the first wife. The new wife asks for a cow for milking - 'ng'ombe ya kukama'. Were the husband very rich, more than one might be asked for, but only one or two will be given at first. From this beginning, a man's herds of cattle and goats are steadily split up between his

wives. The Kamba see two good reasons for this: the prevention of
interbreeding and the division of herds to try to prevent all a
man's wealth from being lost through disease at one time. The
husband will carefully supervise the process of change and inter-
change which goes on continuously. So that by the time a man dies,
if he has several wives, his cattle will have been seperated be-
tween their various cattle posts, the first wife still retaining
more than the others. The cattle in the 'nza' of each wife form the
inheritance of her sons and provide the bride price to get them
wifes." (Penhill, 1951, p.28).

As far as herd size is concerned, the present situation is less favour-
able than in the former days when herds of more than 100 cattle were
common. However, the described principles are still followed.

4.5.2. Types of livestock

In an attempt to obtain more reliable data people were questioned twice
with an intermediate period of about six months. Unfortunately this did
not lead to more reliable data concerning the actual numbers and types
of livestock, because of the great differences in the answers given.
Nevertheless more insight into the development of the situation could be
achieved in this way. Therefore the figures given in Tables 27-31 must
be regarded as representing the situation in a certain limited period of
time and one must be aware that the actual number of livestock are
liable to fluctuations.

Table 27. Distribution of different types of livestock per size class.

Type of livestock	Number of households per farm size class				Total	% of all household
	I	II	III	IV		
No livestock*	1	1			2	4
Oxen/bulls	6	12	12	13	43	78
Cows	8	15	12	13	48	87
Goats	9	14	13	12	48	87
Sheep	5	6	5	7	23	42

*Both households had relatives (husband, son) who lived at Yatta where they
 permanently kept livestock.

In addition practically all households keep some poultry to which they do

not pay much attention. Most people were not aware of the exact number of

chickens they owned. Chickens are an important, and in some cases even the

only source of animal protein (meat and eggs), therefore they really deserve

more attention.

In total 48 households (87%) were cattle owners. This figure is significant-

ly higher than the figures reported by Wallis & van Waning (1975) and

Collinson (1976-1977): i.e. 72% and 75% respectively, thus pointing towards

an increase in the cattle population during the last five years. This

development should be considered to be very remarkable, in view of the

observed decrease in the cattle population in both earlier investigations.

In view of the complexity of this subject no satisfactory explanation for

these differences can be provided, and certainly more reasearch concerning

this entire subject is urgently needed.

Furthermore the above figures show that sheep are not so common as the

other types of livestock. Reasons for this are that "eating mutton makes

one lazy", and the social status of owning sheep is low as compared to

cattle and goats.

The figures presented in the next chapters refer to the period of August 1980, i.e. about half-way through the long dry season. The distribution of the different types of livestock per farm size class was about the same for the second period (January 1981), however, the average numbers were smaller.

4.5.2.1 Oxen and bulls

Table 28.   Numbers of oxen and bulls per size class.

Number of oxen and bulls per household	Number of households per farm size class				Total	% of overall total
	I	II	III	IV		
0	5	5	2		12	22
1	2	1	1	1	5	9
2		4	4	3	11	20
3	1	2	3	3	9	16
4		1	1	1	3	6
5	1	1	1	1	4	7
6-10	1	3	2	1	7	13
over 10	1			3	4	7
	11	17	14	13	55	100

Oxen and bulls especially are important as draught animals for ploughing. Therefore the possession of a pair of working oxen is extremely important, and plays an essential role in the farming system. In spite of the fact that in the figures given above the ages of the animals were not taken into account, it still can be concluded that at least 30% of the sample households do not possess a pair of working oxen.

Livestock is replaced through breeding or purchasing animals the latter especially for working oxen, and to a lesser extent, for the other types of livestock.

As far as breeding is concerned hardly any management or selection of promising animals is done, which is in contrast to the situation in the former days. At that time breeding management was at a rather high level and only a few bulls per herd were selected for breeding new livestock. At present it depends more on coincidental matings. An important consequence is that the genetic potential of the present livestock certainly is not optimal, and considerable improvements through improved breeding management should be possible.

Already a few, more well-to-do farmers have recently introduced grade cows with the main objective to increase milk production.

However, it is clear that this is not a solution for small farmers because these grade cows are very expensive and need considerably more grass, or grazing area, which most of the smaller farmers do not have at their disposal.

The prospects to introduce upgraded local bulls seem better, however no experience herewith has been achieved yet. Because one bull can serve many households for breeding purposes, purchasing cost might be considerably reduced if it is purchased communally. Another advantage is that the mixed off-spring would probably be more adapted to the local conditions.

Another solution would be to start a breeding program based on the present available livestock, by means of selecting good local bulls. This method has the advantage, above the other two, that cost can be reduced to a minimum and all off-spring certainly is well adapted to the local, sometimes harsh, conditions. Every day long distances have to be covered under hot weather conditions because of the often distant grazing areas and watering places. The composition and irregular supply of sufficient fodder might be another important obstruction.

However, it is evident that improved breeding management is not the only way of solving livestock related constraints in the farming system, but certainly it is a point for further research.

4.5.2.2 Cows

Most households have some cows which do not produce much milk. In spite of
this, milk is an important component in the Akamba diet, especially for the
younger children.

Table 29. Number of cows per size class.

Number of cows per household	Number of households per farm size class				Total	% of overall total
	I	II	III	IV		
no cows	3	2	2		7	13
1- 3	4	9	10	3	26	47
4- 6	3	6	2	5	16	29
7- 9	1			2	3	5
10-12				1	1	2
13-15 .				1	1	2
over 15				1	1	2
	11	17	14	13	55	100
number of households having milk producing cows	7	10	8	10	35	64

Once again the differences between households in farm size classes I and IV
are evident, however, the disposal of milk producing cows seems not to
differ so much. In general the households with larger farms have more cows
and thus have a larger production of milk per household. In total 64% of
the sample households have milk from their own cows, at least towards the
end of the dry season. Therefore the number of - potential - milk producing
households may be a bit higher.
Incidentally some people sell milk but never in commercial quantities.
Because of the limited local milkproduction, hotelkeepers have to buy
packed milk from Tala almost daily and, certainly, these people would
benefit from a better local milk supply.

4.5.2.3 Goats and sheep

Tables 30 and 31 show that goats are kept by more households, as well as in larger numbers than sheep.

Table 30. Number of goats per size class.

Number of goats per household	Number of households per farm size class				Total	% of overall total
	I	II	III	IV		
0	2	3	1	1	7	13
1- 3	4	5	5	3	17	30
4- 6	4	3	6	2	15	27
7- 9		3	1	2	6	11
10-12	1	1	1	2	5	9
13-15		1			1	2
16-25		1		1	2	4
over 25				2	2	4
	11	17	14	13	55	100

Table 31. Number of sheep per size class.

Number of sheep per household	Number of households per farm size class				Total	% of overall total
	I	II	III	IV		
0	6	11	9	6	32	58
1- 3	5	3	2	4	14	25
4- 6		3	3	1	7	13
7- 9						
10-12				1	1	2
13-15						
16-25						
over 25				1	1	2
	11	17	14	13	55	100

This small livestock is especially important as an almost directly available, potential source of cash. Goats and sheep are always easily convertable into cash without influencing the farming system.
This is in contrast to the - perforced - selling of e.g. working oxen as such sellings affect the farming system considerably, especially if only one working ox remains.

On the other hand, even if people have small grazing areas it still is quite possible to have some small stock, especially goats. This is because of the limited demands goats make upon their food supply. Besides, goats also browse on thorny scrub while sheep do not. Furthermore, all kind of household waste can be fed to the goats.

Except for their meat and skins no other direct benefits are derived from goats. However, thay pley an important role in the whole of the social system as gifts and food on important occasions.

4.5.3 Livestock management

Livestock is grazed and watered daily and as far as management is concerned, these are also the most time-consuming activities. The required time is of course closely related to the distances that have to be covered.
If the man is present this is usually his task, otherwise it is done by other familiy members.

Occasionally water is found inside the farm but most households depend on the Athi river, which carries water the whole year through, or on some other seasonal waterstreams where, during the dry periods, holes have to be dug to reach the water.
A few households have fenced drinking places on the borders of these streams which are usually well established and have water almost all year.

In one household water is taken to the animals at home, making use of an ox-cart loaded with drums of water.

Another important aspect in relation to the seasonally determined water availability of these small streams is the digging of sand in the river beds that has been carried there as result of the erosion upstream. Daily sand lorries come from Nairobi to collect this sand, thus providing people in the area with some means of transport and some additional income. However, because of this sand digging, the groundwater table is going down, thus resulting in the drying-up of the waterholes on the border. Therefore deeper holes have to be dug inside the riverbed to reach water during the dry periods.

Another management action is the regular dipping of livestock as a prevention against pests and diseases. Dips, established by the Ministry of Livestock Development, are sufficiently available throughout the area. These are run by local people and only towards the end of the dry season problems caused by the lack of water arise.
Occasionally people buy dipping chemicals for their own livestock but hardly any other medication is ever bought. The use of mineral blocks was reported twice.   .
Animal diseases are cured by local experts who mainly use traditionally prepared medicine. Most of these local medicines are derived from plants - including trees and shrubs - which grow inside grazing areas or elsewhere. Therefore it can be concluded that these medicines are one of the minor products which are obtained from the indigenous vegetation.

4.5.4 Economic aspects

During the year preceding the investigation 60% of the sample households sold livestock, in exceptional cases amounting up to K.Shs. 3000.

Sales of livestock usually are not planned, but often are needed because no
other sources of cash are available.

Under more beneficial circumstances people keep their livestock as long as
possible, thus ultimately leading to the selling of old livestock with a
poor quality of meat. With the money received replacements can be purchased.
However, more often it occurs that livestock has to sold earlier and prices
received on average are:

cattle:	K.Shs.	400 - 1200
goats and sheep		70 - 120
poultry		10 - 15

As these prices indicate the sale of certain types of livestock is closely
related to the amount of money required.

Small stock and chicken especially are sold in cases when suddenly a rela-
tively small amount of money is needed, while cattle are usually sold to
finance a certain high expenditure.

Cases before court often result in fines expressed in a certain number of
livestock as well. Furthermore dowries are commonly paid for with live-
stock. Besides an internal system of loans is based on selling livestock
with pay-back terms stretching over many years.

5 TREE PLANTING

In view of the decrease in the number of trees inside the grazing areas one
might expect that if trees are planted this would be done inside these
areas, but this is not the case. Nearly all trees are planted inside home-
steads or along boundaries. Most of these are exotics thus pointing once
again to the neglect of the indigenous trees.

In general two types of tree planting can be distinguished namely trees
planted in a hedge, and individually planted trees.

5.1 Hedge plantings

Whereas it is quite uncommon to plant trees inside cultivated or grazing
areas, it is a common and fully accepted practice to plant trees on bound-
aries for fencing purposes. The species that is most frequently planted for
this purpose is finger euphorbia (Euphorbia tirucally) propagated through
small cuttings (30-40 cm length), and densily planted in a row. In general
these plantings always succeed, after which they show a vigorous growth
making this species very suitable for hedges. Besides it yields a reasonable
quality of wood for fuel in a rather short time. Finger euphorbia hedges
are very common throughout the whole area and almost all people have them
on their lands.

Less frequent but still common is the use of some of the Commiphora species
to establish cattle bomas, for which purpose they are propagated by cut-
tings of $\pm$ 1 m length. These tree species bear big thorns and because of
their easy way of propagation they are suitable for hedges as well.

5.2 Planting of individual trees

The planting of individual trees is not so common as the hedge plantings
described above; at present only 39% of the sample households actually had
planted some. Table 32 shows that only a limited variety of species has
been planted.

Table 32. Distribution of tree species planted per size class.

Tree species	Number of households per farm size class				Total	% of overall species
	I	II	III	IV		
Croton megalocarpus		5	6	2	13	23
Grevillea robusta	1			1	2	4
Jacaranda mimosifolia			2	2	4	7
Eucalyptus spp.	1	3	2	1	7	13
Cassia siamea			2	1	3	5
Plumierai acutifolia	1	1			2	4
Cupressus lusitanica		1			1	2
Melia azedarach			1	1	2	4
Number of households that did not plant any of these	9	10	6	9	34	61

Of these only Croton megalocarpus is an indigenous species; all the others
are exotics.

Croton megalocarpus is also the only species that is propagated through
direct sowing. This is possible because the seeds are easily locally obtained
from   seed   producing specimens which are found to be growing all over
the area. Usually plantings of this species, using this method,
succeed.   This   explains   the   relatively large number of trees of this
species planted. Moreover, it reproduces itself easily through natural
regeneration.

All other species were planted through bought or donated seedlings. A place nearby where seedlings can be obtained is a Government nursery in Mbiuni. The main species which were raised here are: <u>Cupressus lusitanica</u>, <u>Eucalyptus maculata</u>, <u>E. saligna</u> and <u>E. paniculata</u>, and a range of other species in very small quantities.

Most of the other seedlings are brought from more distant places; often by one of the family members working outside the area. In a few cases it also occurred that seedlings, mainly fruits, are raised by the people themselves where they have better possibilities to do this e.g. if they live in places with a regular water supply.

Although no data were obtained concerning the exact number of trees planted, many people reported that many, or all, seedlings failed. The main cause of this low rate of survival probably is late planting i.e. long after the onset of the rains and sometimes even after the rains. The quality and condition of the seedlings may also be affected by transport. Moreover some species, like <u>Cupressus</u>, may not be well adapted to local climatic conditions.

The idea to plant trees usually arises from one of the male family members, perhaps as a remnant of the traditional pattern of labour division between men and women.

Tree planting does not usually arise out of a concern with the decreasing total number of trees, but other motivations play a role. Reasons given for planting trees are:

1. To obtain building poles <u>(Eucalyptus spp)</u>

2. To obtain wood for fuel <u>(Croton)</u>

3. For ornamental purposes <u>(Jacaranda</u> and <u>Plumieria)</u>

4. To create wind-breaks in the compound <u>(Euphorbia)</u>

5. To protect chicken against birds of prey

6. To increase the amenity and look of the farm <u>(Grevillea</u> especially).

It is interesting that it was sometimes mentioned that especially Eucalyptus "attracts" water, for which no further explanation or proof was offered. Another interesting point is that although wood for fuel is by far the most common use of wood, few trees were planted for this purpose. The most common reason was to obtain building poles in the future. These poles are necessary to construct roof frames to which corrugated iron sheets can be attached. Therefore these poles have to be straight and the indigenous tree species do not provide poles which are straight enough to use them for this purpose.

At the moment the only possiblity to obtain these poles is to buy them in Mbiuni, which makes these poles more scarce than wood for fuel, because this can still be collected from the local trees and shrubs without buying.

Finally it has to be mentioned that of the exotics especially Cassia siamea showed a very good growth. Its valuable timber and the fact that is a legume makes this species worth-while for more extensive trials.

6   WOOD AND ENERGY

Wood obtained from indigenous trees and shrubs is by far the most important
source of fuel. Supplementary sources are the woody stalks of pigeon pea
plants, lopping wood off fruit trees (mango), paraffin-oil and even dried
out sisal leaves were said to be used. Wood is burned directly - fuelwood -
or indirectly - charcoal - for cooking, heating and lighting purposes.
Further fuelwood is used to make bricks.

6.1   Fuelwood

Direct burning of wood is done on open fires and not in stoves or in other
more sophisticated equipment; it is mainly done to prepare food and hot
beverages like tea. However it is not uncommon to burn wood exclusively for
heating purposes, because in the early morning it can be rather cold,
especially when the weather is cloudy.
For lighting purposes paraffin-oil lamps are often used. For the majority
of the people, paraffin-oil is to expensive to use it for preparing meals.

In general, wood for fuel purposes can be, and actually is, obtained from
all of the present woody vegetation. However, there is a preference for
certain species. The most appreciated species are: Acacia mellifera,
A. tortilis and A. robusta. Besides these also the Combretum spp. and
Rhus tenuinervis are commonly used, however for these species the avail-
ability is of more importance than the quality of the wood.

The gathering of wood is usually done by women, for whom this really is a
time consuming and tiring activity.
Wood is gathered as dead wood or branches are cut. The method used influ-
ences the time necessary for the gathering of a bundle of suitable branches.

However green wood is, of course, heavier than dried wood, thus limiting
the size of the load one can carry.

Occasionally wood is taken home by making use of oxen with which much
heavier loads can be carried.

6.1.1 Fuelwood sources

Labour can be reduced to a minimum if wood can be obtained near the home,
e.g. from grazing areas close to the compound. However, besides the above
mentioned supplementary sources still 53% of the sample households partly
depend on external sources for their wood supply, thus resulting in even
more difficult labour conditions (Table 23).

Table 23. Importance of external sources of fuelwood.

Nature of fuelwood sources*	Number of households per farm size class				Total	% of overall total
	I	II	III	IV		
OWN LANDS ONLY**	6	7	7	6	26	47
FOREST	1	5	1	5	12	
SOCIETY	3	3	3	2	11	
ISLAND		3	1		4	53*5
KANZALU*3	2		1	1	4	
OTHER SOURCES*4		1	1		2	

*   See page   for the description of the different sources of fuel wood
    that are listed in this table in capitals.

** From these, 2 households emphasized the role of trees inside their
    cultivated areas as important fuelwood sources.

*3 Beside these 4 households, 5 more households have grazing areas of
    their own on Kanzalu bringing the total of households that depend on
    this source up to 9 (16% of the sample households).

*4 Only 2 households reported the gathering of wood from other people's land.

*5 3 Households reported the use of more than one external source. Any shared
    use of grazing areas has not been taken into account.

It is common to gather wood in the whole of the shared grazing area. Only
in cases where the use or cutting of whole trees is concerned, one has to
come to an agreement with the actual owner first.

6.1.2 Constraints in the fuelwood supply

The utilization of external sources due to lack of sufficient wood inside
the own lands is only one aspect of the whole fuelwood problem. Only 37% of
the sample households reported that they had no problems at all with their
fuelwood supply. However, even in this group of households it was sometimes
mentioned that people experienced the gathering of wood as very laborious
but because they had accepted and integrated this labour into their normal
working pattern they did not look upon it as a real problem as yet.
The next figures can provide some insight into what people consider real
problems in relation to their fuelwood supply:

Labour constraints: - distance (16)*

                    - tiring experience (9)

                    - lack of sufficient (household) labour (7)

                    - too time consuming (1)

Wood supply: - lack of sufficient wood (15)

                - stocked wood was not sufficient to cover the whole
                  rainy season (4)

Technical problems: - gathered wood to wet (2)

                    - time needed to dry fresh wood is too long,
                      especially during the rainy season (2)

                    - during the rainy season the river is too high to
                      cross (2)

*The numbers between brackets refer to the number of households that have reported that specific problem.

It appears that labour constraints together with shortages of wood are the most important of the experienced problems. Therefore solutions should be directed to solve these problems first. However, in this area, the main concern of the majority of the people is not their fuelwood supply, but to have sufficient food to eat. Therefore improvements in wood supply and gathering must be integrated with solutions to improve the farming system as a whole.

Finally, each improvement which diminishes the labour involved in the gathering of fuelwood would enable the women to pay more attention to food production.

6.1.3 Pattern of use

The pattern of fuelwood use is strongly influenced by the lack of sufficient dry wood and available labour during the rainy season periods. Several solutions to obviate this problem are practised. One solution is to stock wood during the dry season when labour demand is not so high, which is actually done by 67% of the sample households.

Another solution is the utilization of charcoal during this period which is done more or less regularly by 50% of the households. In 36% of the households both methods were applied, while 22% do not take any of these measures.

One aspect that is important in this respect is the method of cooking. The main food of the Akamba is 'isio', i.e. maize cooked with pulses, mainly pigeon pea, cowpea and beans. The dry seeds are not soaked in water before preparation, thus needing a rather long time to cook (2-3 hours). This period is easily covered by the use of charcoal burned in a 'jiko' (local small stove) without the need of personal attention. If this type of food

is prepared making use of fuelwood, someone has to watch and maintain the fire, and besides it consumes a lot of wood.

Therefore a substantial reduction of wood needed for food preparation can be achieved simply by soaking the dry seeds before cooking. Another positive result would be that the need to use charcoal will become less and fuelwood can be used instead. This is important because of the higher efficiency of burning wood instead of charcoal.

An important supplementary source of fuel during the short rains (Oct-Dec), which all households have at their disposal, are pigeon pea stalks. These have to be cleared off the land as part of the land preparation, before the start of the short rains ploughing, this providing a valuable stock of dry wood before the onset of the rains.

6.1.4 Economic aspects

In view of the difficulties which many people experience in relation with their fuelwood supply, it is interesting that until now people do not purchase wood for fuel as a solution to meet their needs. Only hotel keepers in the market places, who need wood in larger quantities, purchase wood regularly. Either from people who have sufficient wood in their own grazing areas (reported once), or from people for whom this is a welcome additional cash income (reported twice) and who obtain this wood in some of the more distant external sources. The price of an average bundle of wood is about K.Shs. 4.

It is quite common to buy individual trees for other purposes, like making bricks or woodcarving, however, this is limited to occasional events. Prices up to K.Shs. 45 per tree were recorded, especially trees suitable for woodcarving purposes make relatively good prices.

6.1.5 Future prospects

The present fuelwood supply situation is already problematic and the future
prospects are even worse. This can be illustrated by the fact that 58% of
the respondents expect problems in connection with their fuelwood supply in
the very near future apart from other problems like e.g. labour constraints.
This concern for the future by the majority of the people may be affirmed
by the actual situation and the expected developments, not only within the
farms but also in most of the external sources.

It is to be expected that the gathering of wood inside the forest will be
limited or possibly even completely prohibited, given the overgrazing
actually occurring and the overexploitation which has already resulted in
serious local erosion.
In view of the development of the national policy, it is probable that a
more strict protection of the local forest will be effectuated in the near
future.

The society grounds, together with the lands on the island, are being
strongly overexploited at the moment. Large quantities of charcoal are
still derived from these areas and grazing density is high. Therefore it is
to be expected that these lands soon will be put into use for permanent
agriculture.

At Kanzalu range the situation seems to be slightly better, although,
according to the people, here the number of trees is also decreasing.

Within the farms - grazing areas - the fuelwood supply situation will
become worse as well. Because of the rapidly increasing population more
fuelwood will be required, while on the other hand it will be hardly
avoidable that more land will be occupied for arable purposes, thus li-
miting the production capacity for wood inside grazing areas.

6.2 Charcoal

The use of charcoal in this area has been known from colonial times on,
however, most people have started to use it more recently i.e. during the
last 10 years (Table 34).

Table 34. Number of households using, making, purchasing and
selling charcoal.

Number of house- holds which	Number of households per farm size class				Total	% of overall total
	I	II	III	IV		
make use of charcoal	4	9	7	8	28	50
purchase charcoal	3	6	3	4	16	29
make charcoal by them selves	2	8	7	8	25	45
sell charcoal	2	6	3	6	17	30

As 45% of the respondents make charcoal themselves, 6 (24% of the charcoal
burners) are 'commercial' charcoal makers, i.e. for these households the
making of charcoal is their main 'off-farm' income. The remaining house-
holds make charcoal occasionally and sometimes sell small amounts, or keep
all of it for their own use.
Out of the 16 households which purchase charcoal, 8 households depended on
purchased charcoal only.

6.2.1 Pattern of use

Advantages of the use of charcoal above fuelwood are that it burns equably
during a relatively long period and hardly produces smoke. However, this
long burning time which proved to be a great advantage for the preparation
of 'isio', turns into a great disadvantage if other types of food or drinks
are prepared on it which need a much shorter cooking time. Unfortunately

this is commonly done (boiling tea, frying chapatis, etc.), thus resulting in a rather low efficiency of use.

No exact figures concerning the actual quantities used are provided. A reasonable estimate for an average household, besides the other sources of fuel, is 1 bag per rainy season (about 2 months). During the other dry periods of the year charcoal is used in much smaller quantities.

Reasons given by the other 50% of the households not to use charcoal are:

- prefer the use of fuelwood instead of charcoal (29% of the non-users)
- do not possess the required implements, i.e. a jiko (18%)
- do not possess sufficient trees of suitable size to make charcoal (11%)
- cannot afford to purchase charcoal (7%)
- no clear answer (29%)

The nature of some of the answers together with the great number of respondents which could not provide clear answers, may point to the still existing unfamiliarity with this source of energy, in spite of the fact that charcoal has been known for quite some time.

A few households reported that they cannot afford to use charcoal because it is too expensive, thus underlining the general idea that the use of charcoal is something for wealthy people.

6.2.2 The making of charcoal

The method of making charcoal is rather simple: first, trees of suitable size are felled, after which the thicker branches are cut into parts of about 1 m. The remaining smaller branches and other tree residues can be used for other purposes such as fodder or fuel. With these logs a heap of about 2 m long and 0.75 m high is made (sizes mainly depending on the available quantity of wood), which is covered with grass and mud and put into fire at one side.

The efficiency of the applied method of converting wood into charcoal
appears to be rather low and depends to some extent on the skill of the
charcoal burner.

The highest efficiency is reached by a slow burning process which is con-
trolled and maintained by making small gaps in the covering layer. This
technique requires experience.

Common places where trees are cut and the actual charcoal making takes
place, are the grazing areas (usually charcoal made for private use only)
or the society grounds and the island where the commercial charcoal making
is concentrated. The cutting of trees inside the Governemnt forest is
prohibited.

At the particular place where the charcoal is made the groundcover comple-
tely disappears. These bare spots sometimes erode, and it certainly takes
some time before the grass and other vegetation can overgrow these places
again. An interesting method to avoid this problem would be to carry the
wood from the place where it is cut to the cultivated area, and do the
actual making there. Thus improvement of soil fertility is obtained through
the remaining ashes.

The main objections of this method are the high labour demands and the
need of proper means of transport with working oxen.

Apart from these objections, this method provides an example of an appro-
priate method of solving problems and improving farm conditions, which in
practice has proved to be successful already.

The most appreciated tree species for making charcoal and which provide the
best quality of charcoal are Acacia mellifera and Acacia tortilis. Besides,
charcoal is made of all trees that have the required size, but the quality
and the price of this charcoal are lower.

Finger Euphorbia is also commonly used for making a low grade charcoal.

6.2.3 Economic aspects

Because of the extensive exploitation of the available sources for commercial charcoal making the number of suitable trees is running down rapidly. Therefore it is to be expected that most of the commercial charcoal makers will not be able to maintain their present rate of production.

At present there are still traders in Kathama who collect the locally produced charcoal, after which it is transported further to Tala. The price people get for a bag of charcoal in the market is about K.Shs. 15-18/-. Most charcoal is produced near and across the Athi river, from where it is taken to Kathama with ox-carts. The price paid for one bag at the river is about K.Shs. 12-15/-, so the costs of local transport are K.Shs. 3/-. Charcoal is not transported by the actual makers themselves, because these people are rather poor and do not possess ox-carts. The social status of charcoal burners is rather low.

Another factor that influences the seasonal determination of charcoal prices to some extent is the higher expenditure and lower production of charcoal during the periods of rain.

Furthermore, an interesting aspect of having some trees of reasonable sizes at one's disposal is that these are always easily convertable into money as charcoal. The households with small grazing areas only have limited possibilities to 'save' a reasonable number of trees for this purpose.

6.2.4 Final remarks

Because of the required sizes of trees for charcoal making, the supply of these trees is problematic for many households.

In view of its conveniency or use charcoal certainly is an acceptable source of energy, in spite of the fact that it is not the most efficient way to use wood for fuel purposes. Therefore attention must be given to

develop methods which enable people to at least make their own charcoal

without depleting the available sources (trees).

Due to the existing and growing population pressure it is doubtful whether

commercial charcoal making can be continued on a sustained yield basis.

Specific investigation of this possibility should be carried out.

6.3 Bricks

To build houses making use of baked bricks is becoming increasingly popular.

The life span of these houses is considerable longer than that of the tradition-

al houses. Moreover, many people prefer a more permanent roof of corrugated

iron sheets, thus making the construction of a house an expensive enterprise.

Although the amounts of wood required for baking bricks is substantial the

total woodconsumption for this enterprise is limited because for most

people this is only a 'one-off' activity.

50% Of the households had baked bricks at least once, but not all of these

have actually yet built a house of bricks. This is because it is quite

common to spread the actual building over several years because of the high

expenditures in time and money.

6.3.1 Brick making methods

The method that is applied to make bricks is rather labour intensive.

Sometimes water has to be carried from distant places. Squares are formed

from moisturized clay, making use of a wooden shape, after which they are

left to dry for a few days. With these squares an 'oven' is constructed,

after which the actual baking takes about 2 to 3 days.

As far as labour is concerned it is quite common that for the making of the

squares a group of people is invited, which are usually paid in kind (meals).

The construction of the oven and the control of the actual baking requires less labour and is usually done by the people themselves.

To obtain an equable fire and sufficient high temperature, wood of a certain minimum size is required. Because of the above discussed scarcity of these trees, purchasing is sometimes inevitable.

Tree species which are most frequently used are <u>Acacia tortilis</u> and <u>Acacia robusta</u>.

6.3.2 Economic and social aspects

Besides better housing and living conditions, the social status of the households is enhanced by having such a dwelling. An implication of this development of building a more permanent house is, that people take up permanent residence at one place for a longer time. This in contrast with former days when people used to move their homesteads more often.
This new living pattern certainly influences the farming system to some extent, in view of the existing, positive correlation between intensity of management and distance from the compound. Also cattle bomas remain longer at one place, thus resulting in an accumulation of manure.

One household made bricks on a commercial base thus requiring wood in larger quantities. Wood was obtained from trees inside the own grazing area and frequently purchased. The price of one baked brick ranged from K.Shs. 0/50 to 0/70, which makes the baking of bricks quite profitable as a commercial enterprise, if bricks are made in large numbers.

7. CONCLUSION.

The character of farming in the research area is largely determined by the
subsistence strategy, implying in this case that the production of sufficient
food crops is the main objective of the households. Animal husbandry is
subsidiary to this food crop production.

Half of the households in the area experience occasional food shortages, in
view of the farming strategy this must be considered to be the main problem.
Grazing shortages are also experienced by many households, and with the
negative effects of e.g. the condition of oxen these shortages may also
influence food - crop - production.

Problems with firewood supply do exist for some households, but these
problems are probably less serious than the early food and grazing problems.
The first conclusion must therefore be that there certainly is an urgent
need for intensification of production of food, fodder and - less urgent -
of firewood.

The subsistence character of agriculture, combined with the small holdings
- an average 3 ha - and the marginal climatic conditions practically exclude
intensification through bought inputs.

It is against this background that our main conclusion must be seen: Not
only can agroforestry contribute to the solution of most of the identified
problems, but moreover agroforestry may be one of the few low input strategies
for intensification and would therefore be a very appropriate strategy at the
present stage of agricultural development in the area.

APPENDIX I

Reconstructed questionnaire/checklist

Village   : ....
Household number: ....

1. Household characteristics

    1.1 Head of household: a. sex
                              b. age
                              c. full time farmer
                                 part time farmer
                                 full (off-farm) employment
                                 c.1 nature of job
                                 c.2 nature of side activities
                                 c.3 place of residence
                                 c.4 amount of money sent home
                                 c.5 frequency of joining the family
    1.2 Who usually takes the important farm management decisions?
    1.3 Characteristics and activities of each other member of the household.
        a. name
        b. age
        c. sex
        d. education
        e. farm work
        f. employment
        g. amount of money contributed to the household
    1.4 For how many persons do you normally prepare food?

2. Farm characteristics

    2.1 Size of cultivated area: all benches have been measured separately
    2.2 For each bench: different - mixtures of - crops grown during three
        consecutive seasons
    2.3 For each agricultural crop, comprising three succesive seasons:
        a. yield
        b. degree of sufficiency of yield until the next harvest
            b.1 if not, was anything bought (how much, at what price)
        c. any, and if yes, how much given away
        d. food received

e. part of harvest sold

    e.1 was this sale planned; if not, why was sold?

    e.2 money used for which purposes?

2.4 For all fruit trees: spatial pattern has been observed

    2.4.1 for each species: a. actual numbers counted

                             b. yield

                             c. sales (in kind and value)

                             d. purchased (in kind and value)

                             e. propagation and planting methods

                             f. diseases, pests, any other problems

2.5 For all non-fruit trees: spatial pattern has been observed

    2.5.1 for each species: a. actual numbers counted

                             b. name in vernacular

                             c. reasons for keeping it there

                             d. planted or natural

                             e. estimated age

                             f. any problems (e.g. affecting the agricultural crops)

2.6 Inputs for agricultural crops

    2.6.1 bought inputs: a. fertilizers

                             b. pesticides/insecticides

                             c. manure

                             d. others, specify for each input:

                               1. quantity

                               2. prices

                               3. applied with which - mixture of - crops

                             e. seeds (quantities and prices)

                             f. hired labour

                               f.1 when

                               f.2 for what purposes

                               f.3 for what prices

                             g. own ox-plough

                             h. own ox-cart

    2.6.2 Other inputs

        a. manure (from own livestock)

           a.1 for short rains planting

           a.2 for long rains planting

                for both: 1. applied with which - mixture of - crops

                             2. quantities

        b. any other inputs, specify

2.7 Animal husbandry

    a. numbers of oxen, cattle, goats, sheep, poultry

    b. sale and purchase of animals (reasons; money used for which purposes)

    c. number of animals died and born last year

    d. numbers of animals used for home consumption (special occasion?)

    e. place of grazing and watering of animals

    f. inputs: medicine and bought fodder

    g. own bull and/or he-goat for breeding

        g.1 if not, how is breeding done

    h. milkconsumption; quantity and/or from own cows

    i. livestock-crop   interactions (e.g. feeding of crop residues)

2.8 Grazing area

    a. estimated size

    b. number of households sharing grazing

        b.1 if shared use: what arrangements

        b.2 total numbers of different types of livestock using grazing

    c. improvements of grazing area: e.g. grass and/or tree planting

                        bush clearing; which species?

    d. rotational pattern of grazing

    e. rough estimate of average height of trees

    f. rough estimate of tree density

    g. rough estimate of bare spots and soil erosion

    h. slope

    i. species of trees and shrubs most liked by livestock (cattle and goats)

    j. sufficiency of grazing area for present number of livestock

        j.1 if not, what is done

    k. changes in size and condition of grazing area since the land survey

2.9 Tree planting

    a. ever planted a tree

        a.1 if not, why not

        a.2 if yes: 1. when

                        2. which species

                        3. where planted

                        4. for what purposes

                        5. who planted

                        6. seedlings obtained from where

2.10 General farming strategy

    a. do you try to grow enough food

    b. do you usually succeed

    c. do you intend to plant (more) cash crops; reason

2.11 Consumption of non-farm products

    a. physical quantities and monetary value of purchases
       (e.g. meat, tea, coffee, sugar, maize flour, etc.)

3. Wood and energy

  3.1 Fuelwood

    a. who collects

    b. where (own holding and/or elsewhere); during dry season

                                    during rainy season

    c. how much time is involved

    d. how much wood is gathered each time

    e. is any stock of wood made

    f. what type of wood is collected (live branches, dead wood, etc.)

    g. preferred and actually gathered species

    h. specific problems

    i. future (expected) problems

    j. sale or purchase of wood (quantities, monetary value, to whom)

    k. do other people gather wood on your land

  3.2 Charcoal

    a. use of charcoal

      a.1 if not: why not

      a.2 if yes: 1. why

                  2. when

                  3. how much

                  4. for what purposes

                  5. bought and/or home made

    b. making of charcoal

      b.1 if not: why not

      b.2 of yes: 1. how often

                  2. how much

                  3. when

                  4. amount sold

                  5. amount for home consumption

                  6. place of making charcoal

                  7. where does wood for the charcoal production come from

                  8. which species are preferred and which are actually used

         9. at present, sufficient trees for charcoal production

     10. changes in quantities of produced charcoal

     11. any future problems expected

3.3 making of bricks

    a. number of bricks made; when and how often

    b. number of trees used

    c. species used

    d. approximate size

    e. bricks sold

    f. where did trees come from (own holding or elsewhere)

    g. bricks bought

3.4 Construction wood and fencing

    a. shortages

4. Self-help groups

    a. any member of household with membership of self-help group?

    a.1 if not: why not

    a.2 if yes: 1. who

                   2. since when

                   3. any special function in group

                   4. name of group

                   5. number of members of group

                   6. activities and future activities of group

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Appendix II.   Types of farming/collecting systems and suggestions
for the development of system specific innovations.

Preface.

Unfortunately Hans Gielen had no time left to analyse the survey
data in such a way as to enable the construction of a typology
of the farming/collecting systems of the research area.
Therefore this appendix has been written by me, Cor P. Veer, his
Wageningen University supervisor.

Introduction

The presentation of the results of the survey did enable us to identify
the major problems and the magnitude of these problems in terms of
the proportion of households experiencing these. But it has been
impossible to identify the way these problems are interrelated at
household or farm level.
Understanding of these relations is, however, a prerequisite for the
development of appropriate solutions. More often than not, households
are confronted with more than one problem and this fact should be
reflected in the solutions which are to be developed.
Moreover the solutions should not only be effective and efficient for
the identified problems, but also be compatible with the rest of the
system.

During the survey and the analysis of the results gradually an image of
the major components and relations emerged, which is here presented as
the ideal type - in the sense of an abstract representation - of the
prevailing farming/collecting system.
From this ideal type different empirical types can be deducted, according
to the presence or absence of functional problems (constraints) and/or
important components of the system.
As this could create the false impression that we are dealing with
static systems, we shall first summarize the historical development of
the farming/collecting system in Norbhern Machakos.

I. System dynamics

A description of farming systems usually provides a static image of the
system.
Certainly in this case such an image would be false: fast growing
population has led to constant adaptations in the farming system and
is now leading to increasing difficulties in the system of exploitation
of the semi natural environment, i.e. in the grazing and wood collecting
system.

The change in farming strategy can be described as a change - in about
50 years - from an agropastoralist strategy towards a subsistence
agricultural strategy. The original relation between predominant
livestock and subsidiary crop production has been reversed to the present
predominant role of food crops and subsidiary role of livestock.
The conscious positive adaptions or improvements have mainly been
effectuated in the cropping system: introduction of oxplough,
replacement of millet by maize as main staple, terracing, introduction
of fruits etc. Even at present this process is continuing, e.g. with
the present widespread planting of banana.

The shift of emphasis from livestock to arable farming has been
accompanied by a neglect of improvements in animal husbandry or even
deteriorating animal husbandry practices. The same applies to - the neglect
of management of - the grazing and wood collecting sources, leading to
deterioration of these and to problems in these fields now becoming
apparent.
Both for diagnostic and for intervention purposes it is important to
consider both these two sides of the historical development: i.e. both
the positive adaptations in arable farming - and the need for further
improvements in this respect and the present neglect of animal husbandry
and grazing and collecting sources - and the need to change this
exploitation into farming or management.

Another adaptation to growing land pressure has been the search for
off farm activities. One category of activities is of special interest to
agroforestry, i.e. the intensification of the exploitation of the semi
natural environment, especially through the burning of charcoal for
commercial purposes.

The majority of off farm activities has, however, taken the form of
employment outside the area. Cash from off farm employment provides
an important supplementary source of survival for more than half the
households.

Most of these contributions   are of an irregular nature and
are mostly used for consumptive purposes. Therefore these cash contributions
do not substantially alter the subsistence strategy of the households.
This subsistence nature of farming and exploitation is the most important
factor, which should be taken into account in planning interventions
into these systems. Implying that, certainly initially, low cost
innovations should be developed.

It is against this, admittedly too superficially sketched, historical
background that the following presentation of the ideal type farming/
collecting system must be seen.

2. The ideal type farming/collecting system

The predominant subsistence character of farming and collecting in the
area implies that most household needs must be satisfied through the
exploitation of the local natural environment.
And this in turn implies that a correspondence exists between household
needs and sub-systems as identified through the nature of the output and
its characteristic attributes and also that where such correspondence
does not exist this represents a problem.
We thus can identify the following sub-systems:

a. The food crop production system; mainly food crops from the cultivated
   land, supplemented by animal produce and bought food stuffs.
b. The energy collecting system: mainly firewood from the woody grazing
   areas within the farms and from sources outside the farm.
c. The construction system: the irregular need of material for the
   construction of houses, stores and fences leading to such diverse
   activities as brick baking with locally collected firewood, cutting
   of poles for construction and of thorny branches for fencing.
d. The "cash system"; there certainly is a need for cash, but one can
   hardly speak of a cash system. Cash is obtained in a variety of ways,
   like sale of surplus of crops, sale of livestock, cash contributions
   from off farm employment and activities like charcoal production.
e. The livestock system; functionally livestock is so strongly related
   to food production that it could almost be classified as being part
   of it. Both its special attributes and the existence of functions
   not directly related to food production warrant the analytical
   distinction of the livestock production and grazing system.

3. Empirical types of farming/collecting system.

Different empirical types can now be identified according to functional
problems (constraints) and structural attributes.
By combining these criteria we get the following empirical types of
farming/collecting system.

I. Households without draught animals.
    Two sub-classes can be distinguished: one group of households with
    food problems, grazing areas of less than 1 ha and very little
    livestock. And another less homogenous group with larger grazings,
    more livestock and less frequent food problems.
II. Households with draught animals.
    Three sub-classes can be distinguished according to functional
    problems: food problems, grazing and/or energy problems and those
    "without problems".

It must be emphasized that "functional problems" are here defined as
experienced and reported acute shortages, so households reporting to
have no problems may in fact be most interested in increasing e.g. food
production.
A second caveat is that erosion, especially in the cultivated area,
should perhaps have been considered as an important criterion.
This ommission must be corrected if improved techniques are going to
be planned and developed.

According to the mentioned criteria the two main classes and five sub-
classes of households (representing the major empirical types of
farming/collecting system) can be sketched:
Different relations exist between the components of the sub-systems
and between the sub-system and between the components of each sub-system.
These relations have been described in the foregoing report, here we
want to single out one supposedly crucial relation between sub-systems:
the relation between food crop production and grazing area through
draught animals and manure. Considering that food crop production is
the major objective of all households and that supply of nutrients
and draught animals are - the most - important factors in this production,
we think this emphasis is justified.

The above can be schematically represented as in Fig. 1.

Fig. 1. Ideal-type of farming/collecting system in research area.
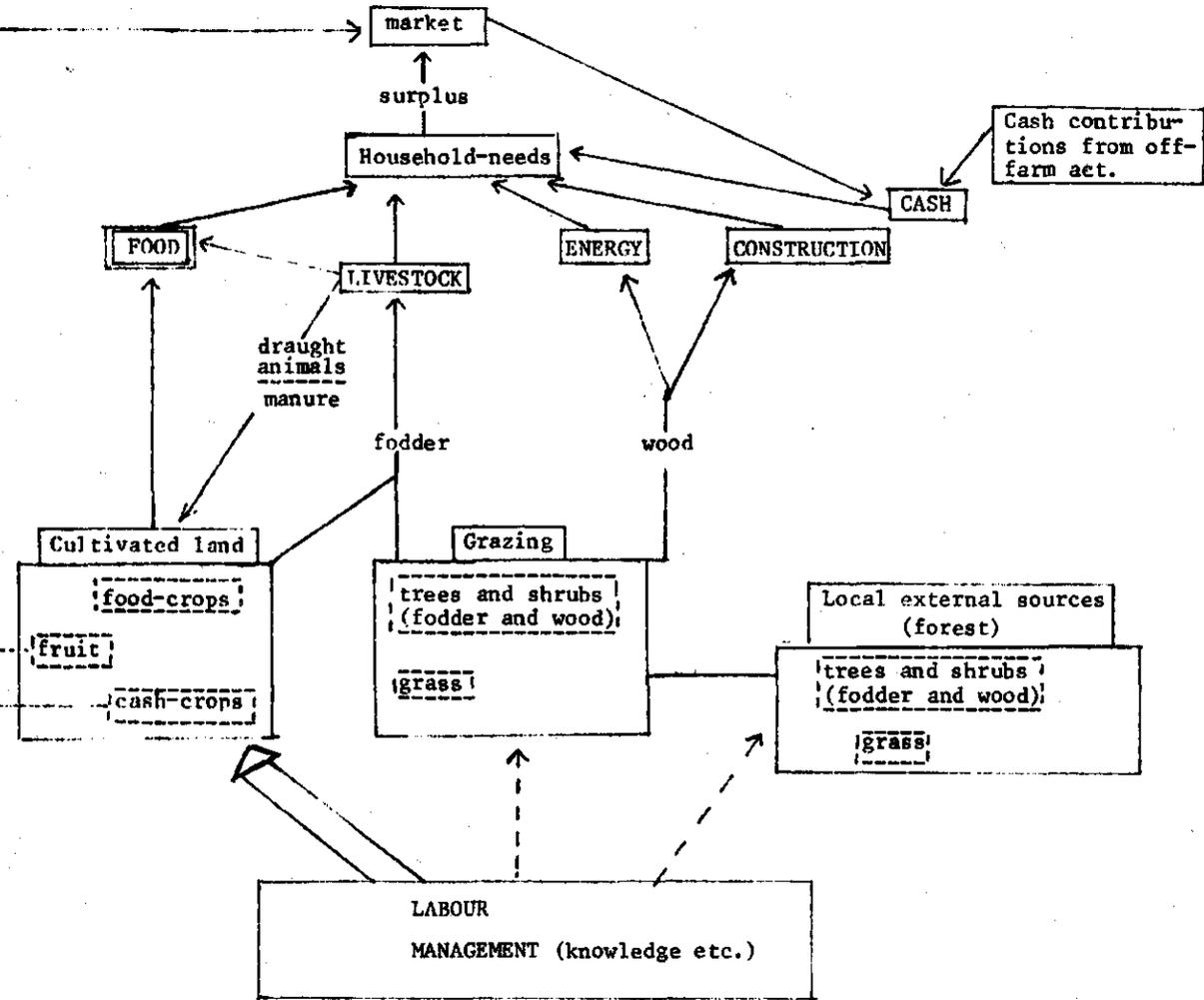
Class I.   16 households (29% of all h.h.) <u>without</u> draught animals

I.A. 8 households (14% of all h.h.) experiencing food problems, having
     little livestock and grazing of less than 1 ha.
     Six of these also report grazing problems and five also labour/time
     problems in firewood gathering.
     These households have small farms: an average 1.4. ha (0.67 ha
     cultivated area and 0.7 ha grazing) and little livestock: an
     average 1.1. heads of cattle and 3.5 sheep and goats (together
     indicated as "shoats" in the following).
     The households from Kalama are overrepresented in this sub-class
     (6 out of 8 h.h.).

I.B. 8 households (14% of all h.h.).
     Compared to the I.A. group these households generally have larger
     farms, more livestock and not all of them report food problems.
     In fact only 3 out of 8 h.h. reported food problems; 1 of these
     also had energy problems.
     Two households reported grazing problems only; one household only
     energy problems and two households reported no problems at all.
     The characteristic averages reflect the differences with h.h. from
     class I.A.: average size of farm is 3.2 ha (1.07 ha cultivated and
     2.1. ha grazing); 4.5 heads of cattle and 3 shoats.
     In this sub-class the majority of h.h. (5 out of 8) is from
     Utithiini; 2 from Mutula and 1 from Kalama.

     In both sub-classes the possible existence of satisfactory ploughing
     arrangements with other households has not been considered. This
     should of course be done in the planning of experiments.

Class II.   42 households (<u>71%</u> of all h.h.) <u>with</u> draught animals.

According to functional problems three types can be distinguished:

A.   18 households (<u>32%</u> of all households) with food crop problems and
     in most cases additional grazing and/or energy problem.

B.   15 households (<u>27%</u> of all households) with grazing and/or energy
     problems (but without food problems).

C.   7 households (14% of all households) reporting "no problems".

Thus food crop production problems are taken as the first criterion
for dividing class II into types and the "absence of problems" as
second criterion.

II.A.   18 households (32%) with food problems (and often additional
         grazing/energy problems).
         Within this sub-class again different types can be distinguised:
         - 6 households reporting only food problems,
         - 4 households reporting food and grazing problems,
         - 4 households reporting food and energy problems,
         - 4 households reporting food, grazing and energy problems (of
           these 2 h.h. reported labour/time problems with gathering of
           firewood).

         Characteristic averages indicate that farms in this sub-class
         are a bit smaller than the average farm; average farm size in
         this sub-class is 2.95 ha (1.13 ha cultivated and 1.82 ha grazing)
         with 8 heads of cattle and 8 shoats.

         Geographically households of this sub-class are evenly spread:
         6 households from Kalama, 6 from Utithiini and 6 from Mutula.

II.B.   15 households (27%) without food problems, but with grazing and/or
         energy problems.
         Here we can distinguish:
         - 4 households reporting only grazing problems,
         - 5 households reporting only energy problems,
         - 6 households reporting both grazing and energy problems.

         Characteristic averages indicate that farms in this sub-class
         are larger than the average farm in the whole population.
         The average size here being 6.09 ha (2.01 ha cultivated and
         4.08 ha grazing) with 16.5 heads of cattle and 14.7 shoats.
         (It should be noted that one "old-fashioned" agro-pastoralist
         with 112 heads of cattle and 93 shoats is included in this sub-
         class, thereby increasing the averages).

Geographic distribution of households: 1 household from Kalama,
6 from Utithiini and 3 from Mutula.
A remarkable fact is the high proportion of membership of self
help groups in this sub-class: 12 h.h. have members of self
help groups.

II.C.   7 households (13% of all h.h.) "without problems".
Once more the reader is reminded of the operational definition
of this sub-class.
Characteristic averages indicate that the farms of these households
are a bit larger than the average farm.
The sub-class average is 4.42 ha (1.25 ha cultivated and 3.17 ha
grazing) with 10 heads of cattle and 10 shoats.
Geographic distribution: 4 households from Kalama, 1 from Utithiini
and 2 from Mutula.

Just like in the former sub-class "membership of self help groups"
is rather remarkable here, in this sub-class no households have
members of self help groups.
It seems justified to investigate whether we are here dealing
with a spurious correlation or a fact which can be explained

The described empirical types of farming/collecting system are
in summarized form represented in Fig. 2, page 11.

Fig.2:   Empirical types of farming/collecting system.

characteristics and criteria.	I.Households without oxen. (16 h.h. = 29%)		II.Households with oxen. (42 h.h. = 71%)			whole population.
	A.Food a.o.problems less than 1 ha.	B.Food a.o.problems/grazing more than 1 ha.	A.Food (a.o.) problems	B.Other problems	C.No problems	
a.draught animals a.number of h.h.						56 h.h.= 100%
types of problems (and size of grazing) (types of system)						
a.number of h.h.	(8 h.h.= 14%)	(8 h.h. = 14%)	(18 h.h.= 32%)	(15 h.h.= 27%)	(7 h.h.= 13%)	
b.characteristic averages:						
b1.size cult.area	0.67 ha	1.07 ha	1.13 ha	2.01 ha	1.25 ha	1.23 ha
b2.size grazing	0.7 ha	2.1 ha	1.82 ha	4.08 ha	3.17 ha	2.43 ha
b3.number of cattle	1.1	4.5	8	16.5	10	8
b4.number of "shoats"	3.5	3	8	14.7	10	8
c.membership self-help group (per type of system)						
c1.member h.h.	37.5%	62.5%	44%	80%	100%	50%
c2.non-member h.h.	62.5%	37.5%	56%	20%		50%
d.specification of types in heterogeneous classes.	-only food:2 h.h. -food+energy:1 -only grazing:2 -only energy:1 -no problems:2		-only food:6(11%) -food+grazing: 4(7%) -food+energy: 4(7%) -food+grazing+ energy:4(7%)	-only grazing: 4(7%) -only energy: 5(9%) -grazing+energy: 6(11%)		

4. Diagnostic description of major constraints

The identified functional problems occur mainly in the food crop
production, the livestock and grazing and the energy collecting sub-
systems. Constraints in the construction system seem less serious.

a. Food crop production.
   Major problems in food crop production are:
   - delayed planting and weeding
   - insufficient manure
   - erosion.

The main cause of delayed planting is delayed ploughing. This in turn
is caused by either lack of oxen - and/or plough - or relative weakness
of oxen at the end of the dry season (relative; i.e. in relation to
soil type and seasonal condition of the soil).
Some households without oxen and plough solve this problem adequately
by making proper arrangements with ox-owners; these arrangements are
often based on family or friendship relations.
Different solutions should be developed for the two categories:
- For households with oxen: improvement of the condition of oxen at
  the end of the dry season. And depending on type of soil; accompanied
  by measures to prevent hardening of the upper soil in the dry season.
- For households without oxen: development of techniques which reduce
  or spread the labour input for ploughing and weeding.

This latter problem deserves special attention. It concerns the poorest
farmers. A succesful intervention in this problem would indicate that
agroforestry's claimed contribution to solving the problems of marginal
farmers could at least in this case be substantiated.

Moreover, it is a very challenging technical problem, because of the
frequent correlation between absence of draught animals and presence
of little livestock and small grazing areas. Therefore the development
of labour reducing techniques for ploughing and weeding should be
combined with the improvement of the nutrient supply.

This nutrient supply can probably be more easily improved in cases
with sufficient livestock and grazing. In these cases a better
application of a larger quantity of manure would certainly be important.
However, efforts to increase manure production by improved feeding of
livestock should be supplemented with investigations and development
of solutions for bottlenecks in the manure application system.

Especially the labour problem is difficult to solve. Both the drudgery
of the work and the time of the year it takes place, are hard problems.
The drudgery could be lessened by the development of appropriate
transport techniques, thereby also increasing the probability that the
distant parts would also be regularly manured.
The occasionally used ox drawn sledge is useful, but leads to damages
to the terraces. If no other appropriate transport technique can be
developed, improvement of the sledge supplemented with adaptations
of the terraces could be tried.
The spreading of manure at ploughing/planting peaks seems hard to avoid.
Earlier spreading of manure will probably lead to considerable nutrient
losses.

At last it should be pointed out that this strategy involves a nutrient
subsidy from the grazing area to the cultivated area. The magnitude of
the treat to the sustainability should be investigated.

One other such threat of which the danger to substanability is certain,
is the erosion.
At least two forms of erosion should in this case be distinguised:
run off (splash and rill erosion) within the cultivated area and the
gully erosion predominantly in roads and grazing areas.

The run off within the cultivated area is often accompanied by the
washing away and/or covering of seeds with soil.
It is especially about this phenomenon that farmers do complain.
These complaints were regularly heard during control visits to half
of the sample farmers, six months after the survey.
Farmers had just experienced heavy rains and expressed their intention
to construct new terraces and repair the existing ones.

As this would entail a lot of hard work they were interested in less labour intensive functional equivalents. In view of the already existing good terraces it is probable that in many circumstances supplementary devices such as hedgerows combined with trashridges would be sufficient. These could be constructed either on the risers of the terraces so as to prevent or regulate the overflow or on the terrace itself so as to shorten the slope.
The resulting reduction of run off would supposedly also contribute to a reduction of gully erosion.
Stabilization of the existing gullies would require extensive rural engineering works.

b. Livestock and grazing.
The seasonally varying bad condition of livestock, especially cattle, can be attributed to two main groups of causes:
a. low level of animal husbandry practices, especially neglect of breeding and selection,
b. general or periodic shortages of animal feed.
These points apply to all households, but the seriousness of especially the second constraint varies with the extent and condition of the grazing and of supplementary feeding sources.
Some important benefits of improved feed production like increased manure production and improved condition of oxen have already been mentioned.
Other obvious benefits are increase in milk- and meatproduction and diminishing susceptibility to diseases.

Improvement of dry season feeding could be achieved both by improving the total amount of animal feed in the dry season and by increasing the digestable crude protein content of the diet whereby the effective intake of fibruous material would be increased.
Probably some of these improvements could in principle   most effectively be achieved by the growing of fodder crops. But the competition between fodder crops and food crops for land and labour makes the growing of fodder crops in this area unfeasible.

It will, therefore, be necessary to try to alleviate the feeding
problems by improving the production of the grazing lands, both
inside the farms and the external grazing sources like the forest
across the river.
Different strategies could be tried out, such as improvement of
indigenous species composition, introduction of fodder trees and
shrubs, introduction of combinations of N-fixing trees and higher
yielding drought resistent grasses.
At last we want to point out that the proposed innovations require
a profound change in the prevailing attitude and strategy towards the
semi natural environment. However, the required change from an
exploitative attitude and strategy to sustained yield management
of the grazing wood lands seems under the present circumstances
unavoidable.
Not only for the alleviation of the animal feeding problems but also
to the energy supply.

c. Energy (firewood and charcoal).
The energy sub-system and problems with energy are at least as
complex as the agricultural and animal husbandry systems and problems,
and probably more complex in relation to our present knowledge.
Not only physical shortages are important problems, but also lack of
time and labour, especially in peak periods, degree of drudgery of the
different activities, distance, quality of firewood, division of labour,
way and purpose of processing (charcoal), cooking practices and
implements are very significant elements.
Further investigations of these aspects are necessary.
However, already some problems can be identified and solutions suggested
on the basis of the survey. More than one third of the households did
not experience any problems with energy supply for subsistence purposes.
The rest of the households mentioned shortages of firewood and distance
between place of gathering and the homestead, as the most important
problems. Both could be solved by growing more firewood in the farm,
especially in the grazing-wood-lands.
Due to the general firewood situation in the area and the fact that for
very few households firewood is their only problem, it would not be
advisable to plan pure firewood trials.

The firewood problem can probably be best solved by considering
firewood as a by-product of trees planted for fodder etc.
Only in some cases the planting of trees for firewood only can be
justified.
Besides attention should be paid to possibilities of economising
on firewood use by storage methods, improved stoves etc.
One third of the households produces charcoal for commercial purposes.
Often this type of charcoal production is part of a conscious deforestation
strategy for agricultural purposes.
Though it is doubtful,whether charcoal making at the present intensity
could be practised on a sustained yield basis, the possibilities for
improvement of both the sustainability of charcoal production and the
charcoal production process should be investigated.

d. Construction.
Different qualities and quantities of wood are required for construction
purposes: fuelwood for making bricks, poles and stems for construction
of houses and stores, thorny branches for fencing.
Especially for construction purposes some indigenous - termite resistant -
species are saved and exotic species planted.
For the planning of trials this need of wood should be kept in mind,
without, however, devising "pure-construction-wood" trials.

5. Suggestions for the development of solutions and for additional research.

Development of solutions by on farm trials and experiments would serve a
practical and a theoretical purpose.
The practical purpose is self evident, the theoretical purpose would be
served if the on farm trials are properly monitored and could thus be
used as a test of the foregoing analysis and diagnosis of problems.
The trials could be supplemented with research activities on related subjects.
We shall here describe the most important trials and additional research
activities.

5.1. Agroforestry trials and experiments at farm level.

The major problems to be solved and characteristics to be taken into
account, are included among the criteria upon which the sub-classes (types)
of households (and farms) are based.
One important problem, to wit erosion in the cultivated area, has not yet
been included in that way and therefore requires special attention at this
stage.
As trials and experiments will have to be system-specific, we shall sketch
the proposed activities according to the different classes of households.

a. Class I. Households without draught animals (little livestock and little
            grazing).
   Certainly for the typical representatives of this class (i.e. h.h. of
   sub-class I.A.) mulching/minimum- or zero-tillage experiment are proposed.
   Some of the I.B. households can for this purpose be considered as I.A.,
   some others as falling within class II.
   The source of mulching material would have to be regularly coppiced
   hedgerows, made up of N-fixing species, in and around the cultivated
   area.
   The major expected effects of this experimental intervention are:
   - improved nutrient supply (especially nitrogen),
   - improved physical structure of soil,
   - protection of soil; diminished evaporation and diminished splash
     erosion, by the layer of mulchy material. The hedgerows (if need be,
     combined with trashridges) would prevent any remaining run-off of
     water and soil particles,
   - suppression of weeds.

Two types of trials can be distinguished, species and spatial arrangement trials on the one hand and effectiveness tests on the other hand.

In the species and spatial arrangement trials, the selection of the different species for trial should be guided by the following requirements:
- leguminous species (N-fixing),
- suitable for coppicing,
- fast growing,
- not too many superficial roots,
- adapted to local climatic and soil conditions,
- resistant to termites, or at least not attractive to termites.

As it may be hard to find species which satisfy all requirements, special attention should be paid to the way different species are mixed. In this way also the disadvantageous characteristics of individual species could in some cases be neutralized, e.g. by mixing species with quickly decomposing leaves with species with slower leaf-decomposition rates.

The selection of spatial arrangements in the cultivated area should especially be guided by the threat of erosion through run-off.
Depending on the situation this could lead to hedgerows on the risers of the terraces, in the terraces or a combination of both.
The number of hedgerows could be increased so as to amount to alley-cropping, at this stage this should, however, only be tried at a small scale.
The number of lines of trees in the hedgerow should also be varied.
In some cases small patches could be planted for the production of mulch, e.g. in water-logged parts of the cultivated area.
Both the earlier mentioned expected effects of mulching will have to be tested under local conditions, as the compatibility with other sub-systems assessed (labour pattern etc.) and especially an estimate of quantities of mulch production and of quantitative effects on crop production is needed.
This could be done by using readily available mulch material of a similar nature in preformance and effectiveness tests.

An obvious advantage of this type of test is the gain of time, i.e while
the species indicated above 1. are growing, we can assess the effects
of mulching in a more exact way.

Class II. Households with draught animals and more livestock and larger
        grazings.
The main objective of experiments proposed for this category is the
improvement of the production of the grazing area.
In cases where erosion in the cultivated area is a problem, trials for
grazing improvement could be combined with hedgerows/trashridges in the
cultivated area. Prevention of splash-erosion will be harder for this
category as mulching may not be compatible with ox-ploughing. Implying
that in this case species for hedges should not be selected for their
mulch quality, but rather for their fodder quality. Besides these
differences and the consequences thereof for the experimental lay-out,
the same observations apply as made under Class I.

The type of experimental improvements of the grazing depends on the kind
of functional problems.
Households with food and grazing problems would need different (mixtures
of) species as compared to households with energy problems.
For the first category (sub-class II.A. and some households of sub-class
II.B.) the objective of the experimental interventions is to improve
production of livestock feeding, material, whereby manure-production
should be increased and the condition of livestock in general (and of
oxen in the dry season in particular) improved.
So for this category the manure-collecting, -storage and -spreading
system should also be monitored and, where needed, improvements suggested.
Also here two main types of experiments can be distinguished:

1. Species and spatial arrangement trials.
a. Species trials with different (mixtures of) fodder trees and shrubs.
   Spatial arrangement will in the first place depend on the present
   condition of the grazing: interplanting of introduced species with
   existing vegetation in some cases; on tree-less spots mixtures of
   introduced trees and shrubs could be planted.
   Special aspects to be taken into account in this case are:
   - seasonal variations in leaf and fruit (pods) production.
     Species producing or keeping leaves and fruits well into the dry
     season are of special interest.

- digestible crude protein content of leaves and fruits of some of
  the species should be high so as to increase effective intake of
  fibruous material like maize residues.
- the fact that shrubs are grazed and branches of trees must be lopped,
  points to the desirability of mixed trees and shrubs trials.
- protection against livestock in early stages of growth will be
  necessary.
- suitability for pollarding should be taken into account.

   b. Combined trees/shrubs/grass trials.

   N-fixing tree species should be selected and planted after which
   improved grass (e.g. Rhodes spp.) could be undersown.
   The major function of the trees would in this case be the fertilization
   of the grass.
   Also in this case the spatial arrangement of trees requires special
   attention; though a closed canopy might be desirable from the viewpoint
   of fertilization, attention should be paid to probable negative side-
   effects, like dripping on livestock after rain.

5.2. Manure performance and effectiveness tests.

The major objectives of these experiments are:
- determination of effects of specified quantities (and if possible:
  qualities) of manure on crop production.
- estimate of present and potential manure-production per livestock unit,
- estimate of effects of increased manure application on the physical
  structure of the soil, especially on hardening of upper soil in dry
  season.
  Special attention will have to be paid to the need for improvement of
  storage, collecting and transport of manure and to labour requirements.

Part of sub-class II.B. (h.h. with energy problems) and sub-class II.C.

For some h.h. of sub-class II.B. more emphasis could be laid on firewood-
species. This, however, only in so far as it can be expected that the
planting and use of fodder species will not substantially improve the
firewood supply.
This would in practice amount to no or minor trials with pure firewood-
species.

The need for further investigations of the whole energy situation will be discussed later on.

For the households of sub-class II.C. it could be maintained that in principle all of the above suggested trials could be carried out also in farms of this sub-class. This would, however, entail a less problem-oriented approach, it is therefore suggested that preferably the suggested trials are carried out on farms of the aforementioned sub-classes and that exceptionally these trials are executed here.
In the latter case combined trials - i.e. different types of trials on one farm - would be preferable.

One very important type of investigations followed by experimental interventions which could very well be carried out in farms of this type, concerns the possibilities of increasing the carrying capacity of the grazing by improving the species composition and growth of the present "natural" vegetation.
Based on the results of the inventory of indigenous trees and shrubs, characteristics of promising species like Acacia tortillis, Ballanites aegyptica etc. could be investigated, improved management practices suggested and the effects monitored.

One last type of trials which is also not specific for any sub-class is the introduction of more useful species to replace the existing hedges of Euphorbia tirucalli around the homesteads.
As last we want to emphasize one crucial aspect of all types of experiments: it is most important to explain to the farmer (in the sense of "relevant members of the household") both the analysis and diagnosis underlying the experiments as well as the set-up of the experiments and the expected effects.
If this is properly done relevant members of the household may very well be incorporated into the monitoring procedure as "fellow-researchers".

Besides these trials and experiments at farm level some additional research is needed.

5.3. Additional research.

The activities proposed here are of different kinds. Some are only investigations, some are of experimental nature and some are experiments preceded by investigations.

All of the activities are in my opinion important for agroforestry, but it will depend on the available manpower whether all activities can be actually carried out.

A. Energy.

The present insight into the energy-collecting and -use system does not go much beyong a global idea based on reported shortages and haphazardly collected background information.

It is necessary to obtain more accurate information about the energy-system(s).

Two different systems can be distinguished: the energy-subsistence system (mainly firewood and less charcoal and oil-based products) and the commercial system (mainly charcoal and less firewood for sale).

More detailed knowledge about the following aspects of the subsistence system is needed:

- time spent in firewood gathering,
- the different social categories (men, women, children) involved in gathering and differences in activities of these categories.
- preferred species, size etc.
- storage patterns,
- interhousehold arrangements with regard to use of collecting sources,
- used quantities of different types of firewood, charcoal and oil-based products.

These aspects should be investigated in relation to scarcity of fuelwood and to seasonal variations, implying that households with access to different quantities of firewood should be compared.

The results of these investigations should provide more insight into the qualitative and quantitative need for additional planting of firewood.

Also the feasibility of improved practices and devices, like more efficient stoves, should thus be determined.

The sources, quantities and prices of firewood for commercial purposes should be assessed.

Charcoal production for commercial purposes seems to be more important, therefore the technical aspects, especially the efficiency of presently used methods, should be investigated as well as the preferred species and sizes, the quantities produced in relation to yearly, estimated, growth rates.

The possibilities of practising this enterprise on a sustained yield basis
should be assessed.

B. Self help groups.
The organization, functioning and reasons for (variations in) membership
of self help groups should be investigated so as to assess the possibilities
of involving these groups in agroforestry-activities like planting of waste
lands, road sides and management of nurseries.

C. Vertisol trials.
The exceptional nature of this soil-type and the present miserable condition
of the vegetation justify special attention to this problem.
Based on the study of the relevant literature trials to improve grass-,
shrub- and tree-growth should be designed and executed.

D. Reclamation trials.
One small watershed in Mutula has been completely eroded and now largely
consists of bare rock-bottom. Possibilities to reclaim this area by (among
other things) planting of trees and shrubs should be investigated. Trials
should be based on study of relevant literature and on experiences elsewhere
in Kenya.

E. Gully erosion.
If the gullies in Kanzalu foot hills, Athi River banks and (to lesser degree)
in the vertisols are not stabilized the present loss of fertile land will
in future be aggravated.
Due to the magnitude of the problem, tree planting can in these cases be
no more than one element of a rural engineering approach.
Meaning that trials should be based on a study of the water catchment area
as a whole and that tree planting should be incorporated among other means
like construction of check dams.
The possible involvement of self help groups should also be considered in
this regard.

E. Present and potential role of the forest reserve across Athi River.
The forest reserve across the river can only geographically and juridically
be considered as outside the research area.

The economic importance of the forest for grazing and energy makes this
forest a very important part of the research area.
A more detailed insight into the precise role of the forest reserve for the
people in the area, into the vegetation and the management of the forest,
is needed. The presently endangered sustained yield principle could perhaps
be restored by improved management practices based on trials.

F. Medicinal use of trees and shrubs.
Local doctors use parts of many tree- and shrub-species to cure and
prevent diseases of man and animals.
This use is based on an extensive knowledge of the indigenous species.
An inventory of medicinal plants and uses could be made and the composition
checked by chemical analysis.

G. Refinement of analysis and theory.
It may seem superfluous to mention this as a separate item, because this
has already been mentioned as one of the major overall objectives of all
activities. And indeed this objective will largely have to be achieved
by monitoring of trials and experiments and the already mentioned additional
research activities.
However, weak elements in the analysis have already become clear and it is
expected that more weaknessess will become clear.
Development of some satisfying indicators of output-deficiences, a formal
monitoring procedure, evaluation techniques taking efficiency and
compatibility into account are examples which probably require special
attention.