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International Centre for development oriented Research in Agriculture (ICRA)

KARI

Kenya Agricultural Research Institute
Kenya Soil Survey - National Agricultural Research Laboratories
National Dryland Farming Research Center, Katumani

PARTICIPATORY APPROACH TO SOIL MAPPING AND MANAGEMENT

A case study of Kasikeu Sub-Location of Makueni District in the lowlands of semi-arid eastern Kenya

Working Document Series 70

PARTICIPATORY APPROACH TO SOIL MAPPING AND MANAGEMENT:

A case study of Kasikeu Sub-Location of Makueni District in the lowlands of semi-arid eastern Kenya.

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This report is the product of team work with equal contribution from the authors whose names are listed in alphabetical order.

DEDICATION

This report is sincerely dedicated to the hard working small scale-farmers of Kasikeu.

PREFACE

The work was carried out in Kasikeu Sub-Location of Makueni District in the semi – arid areas of eastern Kenya. The area is within the research mandate of the National Dryland Farming Research Centre (NDFRC), Katumani. Its one of the cluster sites of Katumani and a general participatory rural appraisal was carried out in 1996. Besides, Kenya Soil Survey (KSS) had done a reconnaissance soil survey in the area.

The KSS wanted a methodology for making soil maps more comprehensible and relevant to the needs of extension agents and farmers whereas NDFRC wanted relevant research issues in soil management identified for future research work.

The study has helped to identify the different soils in the area, farmers' soil management practices, their constraints and opportunities. It has further sorted out the problems and opportunities and attempted to recommend some issues for further research and extension. In so doing, it has involved, an interdisciplinary approach, farmers, extension and researchers in a participatory manner.

The study has therefore; helped to develop a mapping methodology which will make soil maps more relevant and comprehensible to both farmers and extension. It has further identified relevant research issues that will be used to redefine the orientation of NDFRC's soil and water program's on-farm research work.

The 1998 ICRA team worked tirelessly for the three months of their fieldwork. The results of these work will go a long way in improving soil management in Kasikeu and other semi- arid areas of Kenya.

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ACKNOWLEDGEMENTS

We thank our employers for affording us the study-leave so as to go through the course. ICRA is appreciated for having given us this rare opportunity to face the challenging task.

The enormous task could only be achieved through the support of several people without whom the team's activities would have been a nullity. The team wishes to acknowledge the guidance offered by Mr. Kiriro the AD-RRC at KARI headquarters. The logistical support offered by both Mr. Muthoka the centre director - Katumani and Dr. Wokabi the head – KSS is highly appreciated. Invaluable technical comments from KSS scientist were of much help to the team. We thank them all.

In Katumani we are particularly indebted to the technical insights offered by the head of the Soil and Water program, Dr. Itabari. To Esther Njuguna, Mr. Musyoki and, Drs. Ikombo and Nguluu who helped us in participatory research methodologies we are grateful. Of course we cannot forget to thank Josphine and her Katumani guesthouse staff for making our lives so easy and comfortable. .

Without the support of the NLO, Mr. Sprey, who facilitated the teams accommodation and other financial requirements, the team may not have achieved anything. To Margo, the TCS – Katumani, we are grateful for her technical, moral and logistical support.

We do acknowledge the role played by the extension staff in Kasikeu Division. The assistance offered by Ndeka and Kanzele were of much importance. The local administration was of great help to the team. This was particularly evident during our unfortunate road accident. For this were especially grateful for the efforts of the District Officer, Mr. Kamau and the Sub-Chief, Mr. Muthia.

Above all we acknowledge and appreciate the great role of the hardworking farmers of Kasikeu. They shared their knowledge with us and allowed us to work in their farms. Without them nothing would have worked. We heartily thank them. Finally we must acknowledge the endurance and difficulty times our dear families had to go through to allow us accomplish this job.

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AD	-	Assistant Director
AKIS	-	Agricultural Knowledge & Information System
AEZs	-	Agro-Ecological Zones
ASALs	-	Arid & Semi-arid Lands
asl	-	Above Sea Level
CEC	-	Cation Exchange Capacity
CPK	-	Church Province of Kenya
DLC	-	Dryland Composite
DO	-	District Officer
DORA	-	Development Oriented Research in Agriculture
FAO	-	Food and Agriculture Organization
FSA	-	Farming Systems Approach
GDP	-	Gross Domestic Product
GIS	-	Geographical Information System
GoK	-	Government of Kenya
GoN	-	Government of Netherlands
HQ	-	Headquarters
ICRA	-	International Center for Development Oriented Research in Agriculture
ISRIC	-	International Soil Reference & Information Center
KARI	-	Kenya Agricultural Research Institute
KIT	-	Royal Tropical Institute
KSS	-	Kenya Soil Survey
MoU	-	Memorandum of Understanding
MOALD&M	-	Ministry of Agriculture, Livestock Development & Marketing
NAHRC	-	National Animal Husbandry Research Center
NARL	-	National Agricultural Laboratories
NARP	-	National Agricultural Research Program
NDFRC	-	National Dryland Farming Research Center
NGOs	-	Non-Governmental Organizations
NLO	-	Netherlands Liaison Office
PRA	-	Participatory Rural Appraisal
RELO	-	Research Extension Liaison Officer
RRC	-	Regional Research Center
RREC	-	Regional Research Extension Advisory Committee
RRP	-	Regional Research Program
ToR	-	Terms of Reference

ABSTRACT

As per the terms of reference drawn by Kenya Agricultural Research Institute, a diagnostic field study was carried out in Kasikeu Sub-Location of Makueni District in the semi-arid lowlands of eastern Kenya from April to July 1998. The study's two major objectives were to develop a soil mapping methodology to make soil maps more comprehensive and relevant to farmers and extension staff for Kenya Soil Survey, and to identify priority problems in soil management as perceived by male and female farmers considering the apparent farm diversity in order to recommend a possible orientation of National Dryland Farming Research Centre's soil and water program on-farm research. An interdisciplinary team of six did the diagnostic study in a participatory manner with a systems approach. Specific attention was given to various stakeholder interests while there was deliberate attempt to look at different gender perspectives on soil management issues.

In the development of the mapping methodology the team found that the conventional mapping methodologies produced outputs which have problems related to the type of information produced, the way it is presented and the approach to the production of the information. Farmers have a lot of information in relation to soils, their management and uses. They classify soils using colour, texture and coarseness and describe them according to their characteristics like stickiness, hardness, water retention capacity, drainage, erodability, cracking and fertility. Gender perceptions on the soils differs in terms of soil types, spatial distribution and representation on maps. The scientists on the other hand, acquire knowledge on soils in a relatively short time through survey, testing and classifying soils according to diagnostic horizons and properties of the subsoil. The team recommends a participatory involvement of farmers, extension, local administration and other research staff during soil mapping so as to capture all information from all stakeholders. The team found the sub-location level to be an ideal administrative unit for this kind of participatory soil mapping, whereas at higher levels, the conventional methodology can be applied.

A farm typology based on topographical position of the farm (hill, slope or plain), ability to dig terraces to control erosion, apply manure to enhance soil fertility, plough with an oxen, plant and weed early, and possession of major resources to undertake proper soil management like cattle for manure production, ox and ox-plough, land and money was done at Kasikeu Sub-Location. Three management levels, low, medium and good emerged for each topographical position. Farmers were selected in each group and qualitatively appraised. Results from this initial appraisal showed that topography was not a good criterion for farm classification since most major soils occurred anywhere irrespective of topography while the low class soil managers were not well represented. Consequently a village level study was carried out in Mavemba, one of the sixteen villages in Kasikeu Sub-Location. Based on a criteria similar to the one used at the sub-location level, excluding the topological farm position, the farmers identified, good, medium and low levels of management although only low and medium levels were represented in the village. The represented soil management classes were further divided on gender basis to obtain 4 classes from which farms were randomly selected and quantitatively appraised. The study showed that soil management levels in the different farm types are positively related to the resource capacities of the farmers. Key problems commonly identified were low soil fertility, inadequate manure, inadequate knowledge on mineral fertiliser use, inadequate labour for digging terraces and inadequate finance. Major research issues identified were: evaluation of appropriate hedge rows and along farm contours, evaluation of improved fallow systems, increasing the quality and quantity of manure and compost, use of biofertilizers, efficient use of mineral fertilizers, suitable crop rotations, integrated nutrient management and diversification of farming systems.

EXECUTIVE SUMMARY

According to the terms of reference for the 1998 Kenya ICRA team, a field study for Kenya Soil Survey (KSS) and National Dryland Farming Research Centre (NDFRC) – Katumani was done from April to July, 1998. The two major objectives were to develop a methodology to make soil maps more comprehensive and relevant to farmers and extension staff for KSS and to identify priority problems in soil management as perceived by farmers (male, female) in various farm types and recommending the possible orientation of NDFRC's on-farm research program in the field of soil management.

The team was invited to carry out the study in Kasikeu Sub-Location, a part of Makueni District, which in the mandate area of NDFRC and a one of its cluster sites. There are already on-farm research trials being undertaken in the area by scientists from Katumani from the sections of soil and water, maize agronomy and cassava and sweet potatoes. Also a multi-disciplinary team from NDFRC-Katumani and the extension staff has conducted a PRA study in the area. In addition, Kenya Soil Survey had carried out a soil survey in the area.

The work, which was mainly diagnostic in nature, was done by an interdisciplinary team, in a participatory manner with a systems approach. Specific attention was given to various stakeholder interests and roles while a deliberate attempt to look at the gender perspective of soil management was made. The methodology followed included the review of background information, stakeholder workshops, farmer meetings, soil classification, farm classification and finally the information synthesis and analysis. To get the background information, literature review and key informant interviews were used.

Stakeholder workshops were used as the basis of informing them of the study progress and getting feedback. Three workshops were held each at the beginning, around the middle and at the end of the study. To develop a rapport with farmers and finally inform them of the study findings an introductory and concluding farmer meetings were held. Soil classification was done through farmer group meetings, map-drawing and transect walks. Soils were sampled for fertility and survey analysis while soil profiles were described by qualified soil scientists. Later, maps drawn in the field were digitised while laboratory results were interpreted. Farm classification was based mainly on farmer discussions and farm visits. Finally the collected data was synthesised and analysed.

KSS has been using conventional methodology until 1995 when they tried to incorporate the input of extension staff in Mashuru Division of Kajiado District. These conventional methodology without the participation of farmers and extension has produced outputs which have problems related to the type of information produced, the way it is presented and the approach to the production of the information. The team found that, farmers have a lot of information in relation to soils, their management and uses due to long experiences with the soils. In doing so, farmers classify soils using colour, texture and coarseness as the major criteria. The farmers further described the soils according to their characteristics like stickiness, hardness, water retention capacity, drainage erodability, cracking and fertility.

Gender perceptions on the soils of Kasikeu differs in terms of soil types, their spatial distribution, and representation on maps. It was found that women indicate more detailed information on soils, possibly because they are more involved in farm activities than men.

It was further found that gender perceptions differs because of the different activities each group is involved in. The scientists on the other hand, acquire knowledge on soils in a relatively short time through survey, testing and classifying soils according to international standards. The scientists also base their soil classification on diagnostic horizons and properties of the subsoil while the farmers use surface characteristics because they are visible and practical with respect to soil management. As a result, information on soils should start with farmers and be complemented by the scientists knowledge through analytical and other scientific information.

To that effect, the team recommends a participatory involvement of farmers, extension, local administration and other research staff during soil mapping so as to capture all information from all stakeholders. The team found the sub-location level to be an ideal administrative unit for this kind of participatory soil mapping, whereas at higher levels, the conventional methodology can be applied. The recommended participatory soil mapping will be executed in stages whereby all the stakeholders will be involved.

Due to the diversity of low-input agriculture it is important to do farm typology if any agricultural innovation recommendations are to be relevant. In Kasikeu a farm typology was done based on soil management practices. It was first done at the sub-location level based on the topographical position of the farm (hill, slope or plain) and a criteria developed by the farmers for proper soil management. The ability to dig terraces, to control erosion, apply manure to enhance soil fertility, plough with an oxen, plant early weed early and posses major resources to undertake proper soil management like cattle for manure production, ox and ox-plough, land and money. Three soil management levels, good, medium and low were identified by farmers. The farmers grouped themselves according to these management groups for each topographical position. As a result, 9 hypothetical farm types were identified and farms were selected from each type and appraised qualitatively.

Results from this initial appraisal showed that topography was not a good criteria for farm classification for soil management since most major soils occurred anywhere irrespective of topography. Moreover, farmers ability to manage soils was more influenced by their socio-economic circumstances especially access and control over resources for soil management. Also the low class soil managers were not well represented. Consequently, a village level study was carried out to get a better representation of all the classes of farms with respect to proper soil management and for a better understanding of the diversity that may exist among the farms.

One of the sixteen villages in Kasikeu Sub-Location, Mavemba, was selected together with the farmers. The farmers identified three levels of soil management, good, medium and low, based on a criteria for proper soil management similar to those at the sub-location level. Two soil management classes (medium and low) emerged upon grouping themselves. These two classes were further divided bases on gender to obtain a total of 4 soil management classes. Farms were selected and quantitively appraised.

It became apparent from the study that soil management levels of the farms are governed by the resource capacities of the farmers. Thus the medium class who have better resources (more land, ox, ox-plough, labour , grazing land, and cattle for manure, money etc) appear to be better soil managers than the low management class often endowed with fewer resources.

Soil management problems, causes, coping strategies and opportunities for each of the four management classes were listed. Key problems commonly identified were low soil fertility arising from erosion by run-off and inadequate manure, inadequate knowledge on mineral fertiliser use, hard soils due to continuous shallow cultivation, inadequate labour for digging terraces and inadequate finance for undertaking proper soil management. These problems were ranked by farmers and problem causal trees drawn by the team in an attempt to understand the situation better.

Opportunities identified by the farmers for the major problems were analysed by the team. Objective trees were drawn based on this analysis from which research issues in soil management have been proposed for the attention of NDFRC for the on-farm research of its soil and water program. Some of the research issues identified are: evaluation of hedge rows of fodder grass and leguminous trees and plants on terrace banks and along the contours of the farm, evaluation of improved fallow (ley farming) systems, increasing the quality and quantity of manure/compost, use of biofertilizers, efficient use of mineral fertilizers, suitable crop rotations, integrated nutrient management, introduction and testing of suitable implements for water harvesting and deeper tillage, evaluation of methods of reducing labour requirements in making terraces and diversification of farming systems.

CHAPTER 1

INTRODUCTION

1.1 The International Centre for development oriented Research in Agriculture

The International Centre for development oriented Research in Agriculture (ICRA) was established by governments of a number of European countries, with the objective of making their international co-operation efforts more effective through the training of young professionals working in agricultural research in developing countries. Each year people from developing and developed countries attend the ICRA professional training program. There are parallel Anglophone (started in 1981) and Francophone (started in 1991) programs, which are held in Wageningen, The Netherlands and Montpellier, France, respectively. A regional program was started in 1997 in Latin America. ICRA emphasises on development oriented research in agriculture (DORA) which responds to the demands of clients and aims at contributing to poverty alleviation, food security, the competitiveness of farming enterprises and sustainable resource use. DORA uses a participatory and systems approach to integrate diverse perspectives of different stakeholders and facilitates teamwork across disciplines and institutions.

The ICRA program consists of three phases. The first phase of 3 months of knowledge acquisition covers a wide scope of topics including, farming system research, agricultural knowledge and information systems, gender issues, participatory rural appraisal, interdisciplinary approaches and team management amongst others. During the second phase of 3 months, teams of 5-6 multi-cultural and interdisciplinary scientists prepare and execute a field study. The field study takes place in a developing country in collaboration with a partner research institute. The third phase of two weeks consists of presentation of results, finalisation of the future action plans and submission of field study report in Europe.

1.2 Kenya Agricultural Research Institute

The Kenya Agricultural Research Institute (KARI) was formed in 1979 after reorganisation of agricultural research in Kenya. KARI comprises 17 national centres, 5 regional centres and 11 sub-centres. Both the national and regional centres are assigned mandates and responsibilities according to various criteria, which determine the setting up of research. To strengthen its capacity in carrying out the planned programs of research effectively in its centres, KARI has established linkages with various national and international institutions.

KARI has identified the following as the main priority programs for research: crops, soil and water, animal production, range management, agricultural botany, agricultural engineering, socio-economics and veterinary research (Mugah, 1989).

1.2.1 Kenya Soil Survey

The Kenya soil Survey (KSS) is a section of the National Agricultural Research Laboratories (NARL), located about 10 km from the Nairobi City center on the main Nairobi-Nakuru highway. As a soil survey institution, KSS has a dual objective. As a survey organization, it has a servicing objective and, hence, a client orientation, whereas, as a research organization, KSS has a more-basic research objective and, hence, a scientific orientation (Andiesse and Enserink, 1996).

The former objective concentrates on natural resources inventories, at different mapping scales, for different purposes and for different clients. Outputs resulting from the performance of this objective (reports, maps, databases, pamphlets, etc) should cater directly for the clients needs for information that helps solving their rural development problems.

The latter objective focuses on the 'deepening' of the scientific understanding of the natural environment and related land use problems, and on methodology development. Outputs resulting from this (reports, articles, models) should help in solving such problems either directly (development of technology packages) or indirectly (methodology development) by strengthening the former, i.e. the servicing objective, both in terms of adequacy (quality of output) and speediness (quantity of output). KSS is presently developing strategies to cater for the servicing and scientific objectives in terms of:

- Development of increased client oriented outputs, which can be easily understood by the clients.
- Development towards provision of commercial services with future financial sustainability of KSS

1.2.2 National Dryland Farming Research Centre - Katumani

The National Dryland Farming Research Centre (NDFRC) Katumani is one of the 17 national research centres of the Kenya Agricultural Research Institute and is located about 10 km south of Machakos town on the Machakos-Konza road and about 80km south east of Nairobi.

The centre has both a national and regional mandate. Under the national mandate the centre is assigned the responsibility for soil and water management for dryland agriculture. Emphasis is on the conservation of soil and water resources, erosion control, the development of drought-tolerant crop varieties, cropping systems and packages of agronomic practices that maximise the efficiency of moisture use in the semi-arid environments.

Under the regional mandate, the centre is responsible for the improvement of agricultural production in the farming systems of Kajiado, Mwingi, Kitui, Makueni and Machakos Districts with a focus on applied and adaptive on-farm research (NDFRC, 1995). Strong linkages between research, extension and farmer will improve equality and cost effectiveness of research in generating technologies that particularly address the needs of small-scale farmers.

1.3 KIT/Netherlands Liaison Office

On behalf of the Netherlands Ministry of Foreign Affairs, the Royal Tropical Institute (KIT) has been entrusted the responsibility for the technical assistance component, project administration and allocation of GoN funds to NARP II in KARI (NDFRC, 1995).

The responsibility for implementation of the Netherlands programs under NARP II is given to KARI and KIT, through the Netherlands Liaison Office (NLO). NLO's task is to assist the various components with design, planning and implementation of the research programs, and to monitor financial and administrative flows (budgeting, accounting, quarterly and annual reporting). Moreover, the NLO will promote the inclusion of gender aspects in the research programs, and co-ordinate general training activities (NDFRC, 1995).

1.4 Ministry of Agriculture Livestock Development and Marketing

MoALDM is responsible for most of the agricultural extension work. A Memorandum of Understating (MoU) between KARI and the MoALDM was concluded in 1993 which defines the linkages between the two institutions (MoU, 1993). Activities under the MoU are: joint field visits, planning and review meetings, diagnostic studies, on-farm trials, on-farm demonstrations, field days, farmer training and workshops. These activities are co-ordinated by the Research Extension Liaison Officers (RELOs) of both KARI and MoALDM.

In the MoU, a number of fora for facilitating linkage at the regional level were established. The most important one is the Regional Research Extension Advisory Committee (RREAC), whose members are provincial and district heads, farmer representatives, representatives of agro-industries and section heads and program co-ordinators. The role of this committee is to advise and monitor research and extension linkage activities. The committee meets once every three month.

1.5ICRA 1998 Kenya field study

1.5.1 Collaborative agreement and Terms of Reference

A collaborative agreement exists between KARI, KIT and ICRA. In this agreement KARI provides terms of reference TOR) for a field study, provides accommodation and working space for ICRA teams while in the field. KIT on its part gives technical and financial support to the team. ICRA on its part trains KARI researchers in development oriented research in agriculture (DORA).

For the 1998 ICRA team, a TOR were made where the team was to carry out a field study for Kenya Soil Survey (KSS) and NDFRC – Katumani from April to July, 1998.

The main objectives of the TOR were:

- To develop a methodology to make soil maps more comprehensive and relevant to farmers and extension staff.
- To communicate to NDFRC-Katumani the priority problems in soil management as perceived by the farmers (male, female) in various farm types and recommend the possible orientation of its on-farm research program in the field of soil management.

The team was to carry out a series of activities, which were to produce the following outputs.

- A baseline document that includes points of action for research and extension for the further development of participatory research methodology.
- An extra impulse to the development of the on-farm participatory farming systems research in the regional research program (RRP) by exposure of the research and extension staff to the ICRA interdisciplinary team approach.
- Strengthening the collaboration of the partners in the region by the inter-institutional activities of the ICRA team.

- Three KARI participants are trained in an interdisciplinary team approach to farming systems research.

1.5.2 Selection of field study site

The team was invited to carry out the study in Kasikeu Sub-Location, a part of Makueni District, which is a mandate area of NDFRC-Katumani. Katumani has also selected the Kasikeu area as one of the four cluster sites in the mandate districts. The aim of the clusters is to conduct on-farm research and results from these clusters can be extrapolated to other areas with similar characteristics. There are already on-farm research trials being undertaken in the area by scientists from Katumani from the sections of soil and water, maize agronomy and cassava and sweet potatoes. Also a multi-disciplinary team from NDFRC-Katumani and the extension staff had conducted a PRA study in the area. In addition, Kenya Soil Survey had carried out a soil survey in the area.

1.5.3 Major goal and specific objectives

The major goal of the study was to contribute to the orientation of research and development in soil management in a client focused way in semi-arid areas of eastern Kenya.

The specific objectives were:

- To improve upon the existing soil mapping methodology used by the Kenya Soil Survey (KSS) in order to make soil maps more comprehensible and relevant to farmers and extension.
- To actively involve farmers, extension and research in soil mapping methodology.
- To identify, in a participatory manner, problems and opportunities in soil management for different farm types.
- To recommend soil management research topics to NDFRC-Katumani for different farm types.
- To communicate study findings to stakeholders through workshops.
- To make an action plan for follow-up on the diffusion of learnt participatory methodologies and findings of study in KARI, KSS, NDFRC - Katumani and NAHRC - Naivasha.
- To give ICRA team members direct experience in applying development oriented research in agriculture (DORA)

1.5.4 Problem statement

The outputs (reports and maps) produced by Kenya Soil Survey (KSS) after carrying out land inventories are not user-friendly as they are too technical to be understood by the extension staff who are the main clients of KSS and other ''non-scientist outsiders''. The reports and maps contain indepth scientific terms and technical scientific classification names, which are not familiar to them. The extension staff and farmers are never involved in the development of those outputs, and since the reports are just given to the extension to implement, they don't understand them since they were never involved in their development. KSS expects the extension to interpret the information to the farmers, but without training them, it becomes difficult for them to use those KSS outputs. Further, the information contained in those reports and maps lacks the input of extension and farmers knowledge.

NDFRC-Katumani has recognized the role of farmers in agricultural research and doing research in a farming system perspective has been going on for a long time. The need to target research technologies to the appropriate end user was identified. The on-farm research cluster in Matiluku in Makueni (FAO project) was geared to this area. Numerous other on-farm trials have been conducted. Further farmers in a particular area are not the same (ICRA, 1996). Mostly research technologies in the past have been made to cater for a wider group of clients. There has been a strong need to effectively generate or adopt technologies that suit certain target groups, so as to better target research technologies. Soil and water management problems in the semi-arid areas are known and research has been undertaken or is on-going to address these problems. Soil management practices influence crop production and are in turn influenced by a host of other things like social economic status of the farmer. Thus, different farmers will respond differently to the research technologies. Therefore the need to better target research technologies means that soil management problems and opportunities need to be identified according to farm types based on soil management practices.

1.6 How the report is organised

The main part of this report is organized into 5 chapters. Chapter 1 gives the background to the study including a brief description to the key institutions involved in the study. Chapter 2 outlines the background information on agriculture in Kenya and associated policies. The chapter further gives information on Makueni District which narrows further to Kasikeu Sub-Location (the study site), giving the biophysical and socio-economic characteristics. Chapter 3 outlines the methodology approaches and tools used to meet the study objectives.

Chapter 4 is devoted to the findings of the study. This chapter is divided into two sections, one related to soil characteristics, soil mapping and the other to soil management. Chapter 5 comprises recommendations and conclusions. It contains the improved participatory soil mapping methodology for KSS and research issues for NDFRC -Katumani in conjunction with extension and farmers of Kasikeu Sub-Location. The appendixes contain further detailed information summarized in the main report.

The data collection and writing up of this report was a team work approach. It is hoped the report will assist in improving the agricultural production of Kasikeu Sub-Location farmers. The researchers, extension and farmers should continue to work in a team approach. Lastly, the approach for soil mapping will assist KSS in producing client focused outputs.

CHAPTER 2

BACKGROUND INFORMATION

2.1 Kenya: A brief introduction

Kenya straddles the equator and covers an area of 582,644 sq km, which includes around 13,600 sq km of inland lakes (Survey of Kenya, 1995) with a population of around 27 million people. 7.5% of Kenya's land area is set apart exclusively for wildlife purpose which mainly supports the tourist industry. Kenya is a country of tremendous topographical diversity with practically every landform type ranging from glaciated mountain and permanent snow (found above 4,600 m asl) to a true desert landscape (Chalbi Desert).

The rainy seasons are March to May (the `long rains') and October to November (the `short rains'). Mean annual rainfall ranges from less than 300 mm in the northern and interior eastern areas to over 2,000 mm on the slopes of the mountain ranges

Mean temperatures in Kenya are closely related to ground elevation. For example, night frosts occurs above 3,000 m and permanent ice and snow cover the areas above 4,8000 m (Mt. Kenya). Highest temperatures are recorded in the arid regions of the northern and eastern lowlands and in the northern Rift Valley.

English and Swahili are the official languages and are taught in schools throughout Kenya. But there are also many other major tribal languages which include Kikuyu, Luhya, Luo and Kikamba as well as a plethora of minor tribal languages.

2.2 Importance of Agriculture

The agricultural sector is important to the Kenyan economy and contributes about 25 per cent of the GPD (Economic Survey, 1996). In addition, the sector is estimated to have a further indirect contribution of nearly 27% of GDP through linkages with manufacturing, distribution and other service related sectors. The sector is also a major source of the country's food security and a stimulant to growth of off-farm employment. The sector accounts for 80% of national employment mainly in the rural areas, contributes about 45% of Government revenue and 60% of total export earnings through the export of crops and livestock products (GoK, 1997).

2.2.1 National food policy

The sessional paper No. 2 of 1994 on national food policy notes that the country has potential for self-sufficiency in most food crops and livestock products. The aim of the policy is to ensure the availability of adequate and nutritionally balanced food in all parts of the country by increasing food production and promotion of inter-district trade. At the household level, food security is to be achieved through increasing opportunities to generate cash income and providing incentives to farmers to improve agricultural productivity. Due to the uncertainty and vagaries of weather and changes in social and economic parameters, there is a need for continued maintenance of a strategic reserve for maize. The need to diversify the base for food security calls for the production of other crops such as wheat, pulses, sorghum, millet and root crops.

2.2.2 Dryland farming systems development policy

The main dryland farming support in the arid and semi-arid lands (ASAL) is the development and demonstration of low-cost technical packages through development of farming systems approach (FSA). Involvement and co-operation of farmers in the ASAL is a key element of the onfarm trials and demonstrations (GoK, 1994). Cultivation of drought resistant but high yielding cereals and pulses is intensified with special emphasis given to sorghum, millet, pigeon peas, green grams, and beans. Other crops include cotton, oilseeds and root crops such as cassava. Desertification and environmental degradation is fought by increasing the use of agro-forestry practices. Suitable tree seedlings are developed and distributed to farmers. Since most of the farmers in ASAL regions are small-scale operators, the government encourages the training of oxen, donkeys and camels for animal-draft work such as ploughing, furrowing, weeding and pulling of carts.

2.3 The Study Area

2.3.1 Introduction to Makueni District

Location, area and population

Makueni District is in the Eastern Province of Kenya (Figure 2.1) and lies between latitudes 37°00'E and 38°30'E and longitudes 1°S and 3°15'S. The district borders Kitui District to the east, Coast Province to the south, Kajiado District to the west and Machakos District to the north.

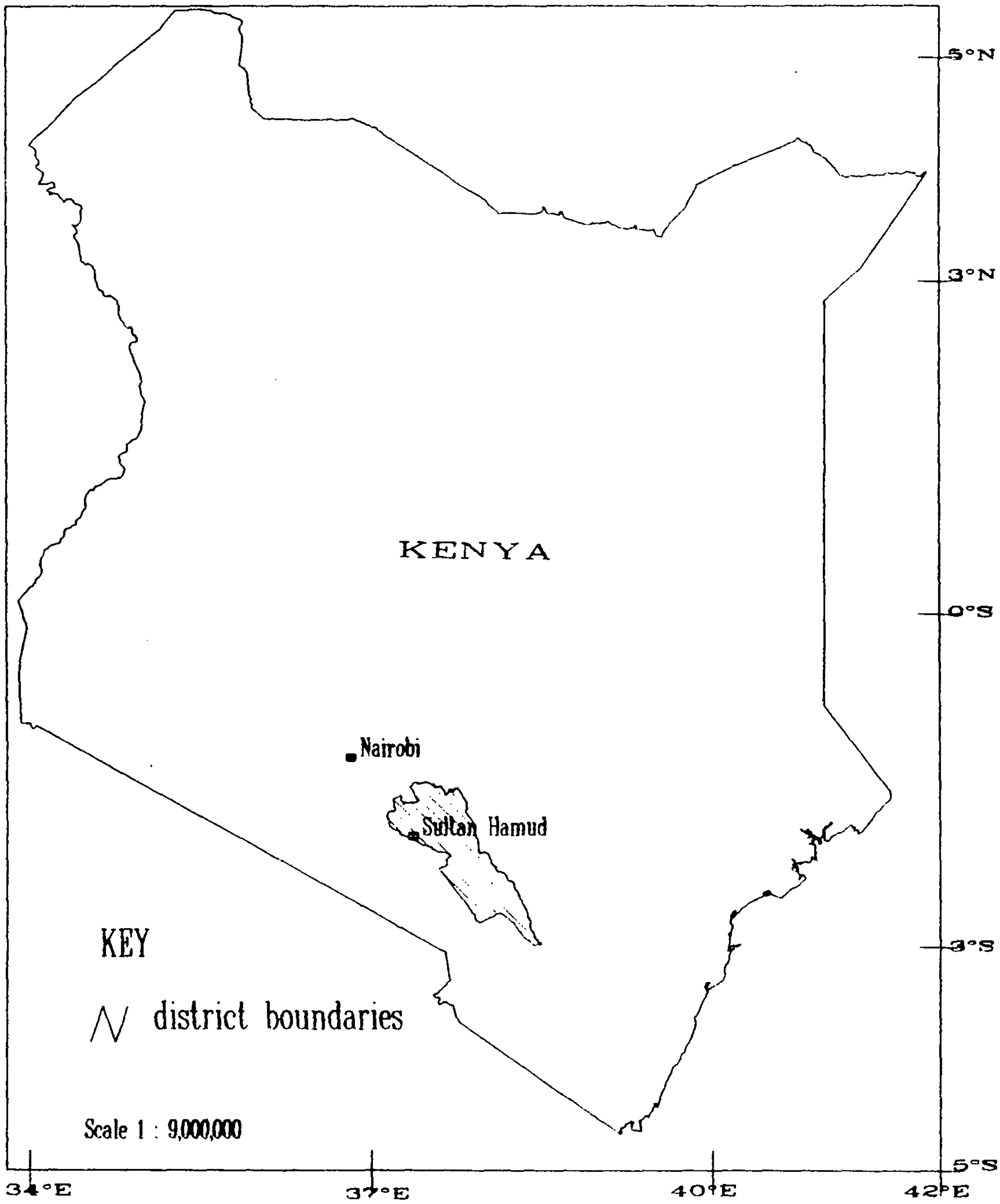
The district has 16 administrative divisions namely Wote, Matiliku, Kathonzweni, Kaiti, Kisau, Tulimani, Mbooni, Kilome, Makindu, Mulala, Nguu, Kibwezi, Kalawa, Mtito-Andei, Kasikeu and Kilungu. There are 62 locations and 187 sub-locations and new ones continue to be created. The district covers an area of 812,845 ha (Kamoni, 1997) of which 75% is considered as the arable land. About 50% of the arable land is being utilized for agricultural production currently and more land continue to be opened-up for crop production as a result of sub-division of ranches and settlement within the district (MoALD&M, 1997). The district has an estimated population of 808,500 (with a national growth rate of 3.2% per annum) and the number of farm families is estimated to be about 115,000.

Climate

The district has an altitude range of 600 m above sea level (a.s.l.) (Kibwezi) to about 1900 m a.s.l (Mbooni and Kilome). It has a bimodal pattern of rainfall namely, the long rains of March-May and the short rains of October-December. The short rains are evenly distributed, reliable and thus more effective than the long rains. The average rainfall ranges between 800-1200 mm per year for upper zones (hill masses) and 200-900 mm per year for the lower zones. Rainfall amount and distribution determines the type of crops to be grown.

Relative humidity is low in the lowlands (50-60%) and high in the hill masses (75-90%). The temperature is fairly cool in the hill masses and sometimes drop to as low as 15°C with misty mornings during the cold season (June-August). During the hot season (September-May) temperatures rise to about 25°C. Lowlands are quite hot throughout the year with peak temperatures of over 30°C in January-February.

Figure 2.1 Location map of Makueni District in Kenya



Physiography and soils
The physiography in the district ranges from lowlands to uplands to hill masses. The main soils are highly weathered (Ferralsols) and are found mostly in the uplands. They are light textured, permeable and relatively less erodible. They are chemically poor with deficiencies of nitrogen (N) and phosphorus (P) and have a low cation exchange capacity (CEC). They are agriculturally important for drought tolerant legumes and cereals (ICRA, 1996).

The plains and bottomlands have the commonly referred to black cotton soils (Vertisols). They are characterized by cracking clays with low permeability and high moisture holding capacity. These soils have a poor drainage and are prone to waterlogging. Thus, they require special tillage practices to make them productive. The soils are important for cotton, maize and chickpea. Chemically they are moderately fertile but can be deficient in zinc.

Other common soils, although occupying a minor fraction as compared to the first two, are generally strong brown in colour (Luvisols). They are well drained but characterized by low inherent fertility, formation of hardpans, low water holding capacity, low organic matter content and high erodibility. Where rainfall permits, coffee is grown. They are also useful for drought tolerant crops including some cereals and legumes, however, N and P deficiency is a common problem.

Crop production is concentrated mainly on the Ferralsols and Luvisols with extensive grazing and little cultivation on the Vertisols. Gachini (1996) concludes that the inherent soil fertility in the district can be classified as low since only 5.9% of the district has moderate to high nitrogen levels, 18% has moderate to high phosphorus and 60% has moderate amount of potassium.

Agro-ecological zones
According to Jaetzold and Schmidt (1983) the district falls within agro-ecological zones II-VI.

i) AEZ II - Lower highland zones
These cover the hill masses of Kilome, Mbooni and some parts of Chyulu Hills. The zone is known as dairy-potato zone and ranges between 1800-1900 m a.s.l. It has the following characteristics.

- Receives 800-1200 mm per year of rainfall which causes leaching of mineral
- Occupies 20% of arable land in the district
- Farm holdings rarely exceeds 2 ha
- Crops grown include coffee, garden peas, French beans, potatoes, cabbages, kales, tomatoes, spinach, maize H511 and H512, beans, wattle, plums, peaches and avocados.
- Temperatures are low usually with misty mornings.
- Soils are shallow and well drained sandy clay
- Good for dairy cows.

(ii) AEZ III & IV - Upper midland zones
These cover the lower hill masses and occupy about 30% of the arable land. These include some parts of Mbooni, Kilome, Mulala, Matiliku and Kaiti Divisions.

- Average farm size is 5-10 ha
- Rainfall received is between 600-1000 mm per year
- The crops grown include maize H511, coffee, beans, citrus, tomatoes, cotton, sorghum, mangoes, millet, pigeon peas, cowpeas and macadamia nuts.

(iii) AEZ V - Lower midland zones

These include parts of Kibwezi, Wote, Makindu and lower Mulala and Matiliku and occupy about 40% of arable land (lowlands):

- They are ideal for range activities
- Average farm holding is between 20-50 ha with more acreage in ranches
- Crops grown include composite Katumani maize/DLCI sorghum, millet, cowpeas, cotton, sisal, irrigated horticultural crops (dudhi, chillies, karella, egg plant etc), green grams, citrus, castor, sunflower, sisal and mangoes.
- Rainfall received in these areas is between 300-600 mm per year.

(iv) AEZ VI - Lowland zones

The area covers about 2% of the district and is located around Kibwezi (from Mtito Andei to River Athi):

- Rainfall is approximately 350 mm per year
- Temperatures are high
- Land is mainly used for ranching with little cultivation.

2.3.2 Introduction to Kasikeu Sub-Location

Location

Kasikeu Sub-Location is in Kasikeu Location of Makueni District (Fig. 2.2). It is situated at about 2°S and 37° 25'' E. It is surrounded by Ngiluni and Nzamba Hills to the east, Nduluni Hills to the north and Muuwa River to the west and south. Kasikeu market is the biggest shopping centre which is situated at the southern part of the sub-location. Its area is approximately 14 km^2 (Sub-Chief, Personal communication).

Climate

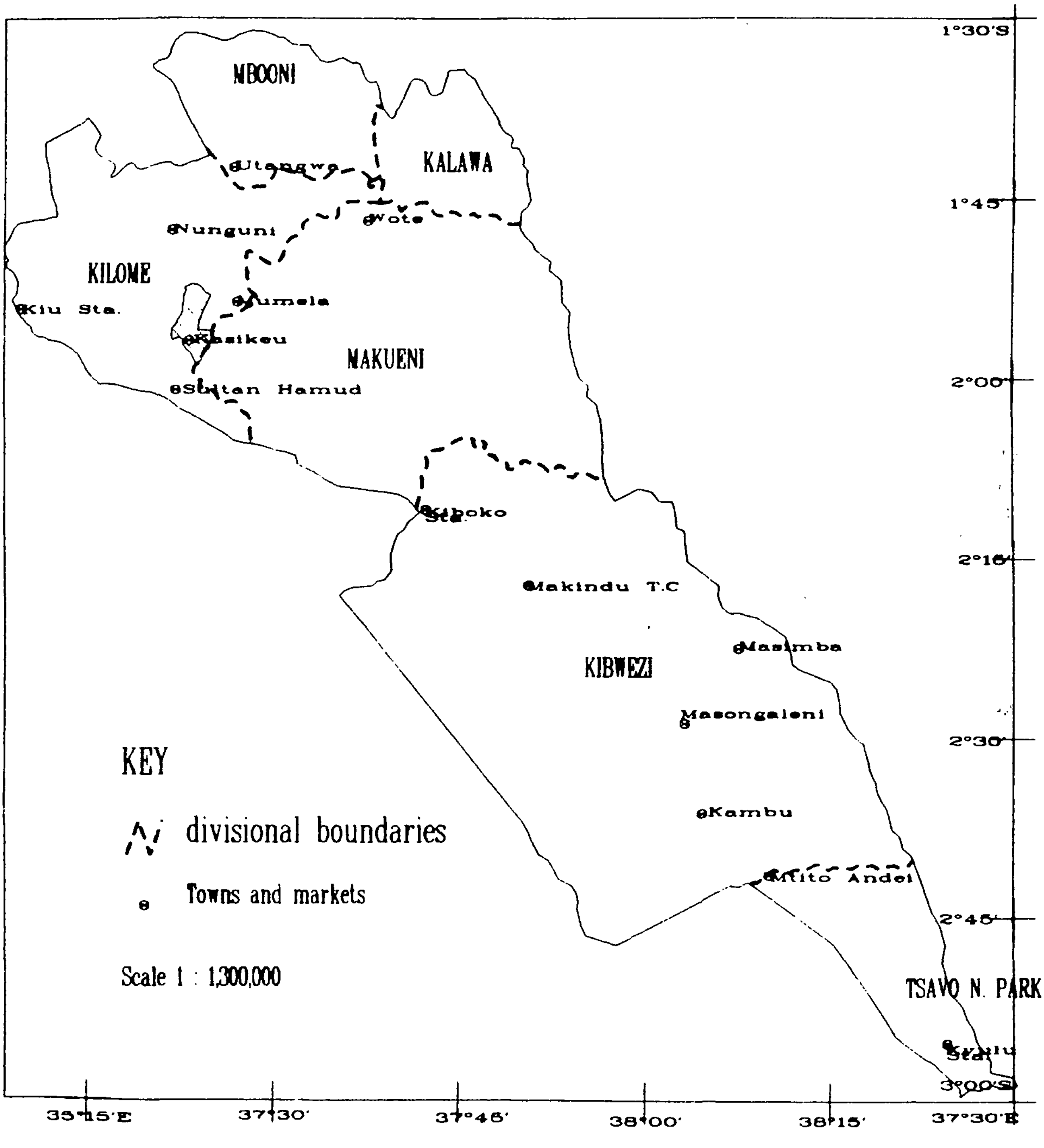
The rainfall distribution is bimodal with two distinct peak periods occurring in April-May (long rains) and October-December (short rains). The average annual rainfall for the last 10 years at Kasikeu Secondary School, located in the sub-location is 742 mm. The mean seasonal rainfall is 344.9 mm for short rains and 304.5 mm for the long rains. According to the residents, short rains are usually more reliable than the longs rains (NDFRC, 1996). The temperatures are fairly high (about 25°C) throughout the year with peak temperatures of around 30°C in January-February.

Physiography and drainage

The main physiographic units in the sub-location consist of hills of the basement rocks, footslopes and valley bottoms (floodplains). The hills are stony and rocky and are covered by dense vegetation whereas in the footslopes and valley bottoms is where cultivation is concentrated.

The Sub-Location is well drained with rivers running from the north to the south. The main rivers which are the major source of water for domestic and livestock use are Muangini, Mikuyuni and Muuwa (Kaluku) rivers. Although they are seasonal, water is always available after scooping of sand. Other sources of water for domestic, livestock and irrigation of vegetable and horticultural crops are from shallow wells in valley bottoms and boreholes.

Figure 2.2 Location map of Kasikeu Sub-Location in Makueni District



Soils

The soils of Nduluni to the north of the sub-location are well drained, very deep, dark reddish brown and friable clays. Around Nduluni Primary School, there is a big portion of heavily eroded sodium affected soils where big gullies have formed to the detriment of any type of land use. The soils on the isolated hills north of Kasikeu shopping centre are shallow, stony and chemically very poor. The area has been overgrazed and serious soil erosion has taken place with deep gullies dissecting the hills and exposing the bottom rocks. Ploughing and planting is done when there is rain, as they become compact and hard when dry.

The soils on the footslopes and around Kasikeu shopping centre are mainly sandy loams and chemically poor. These soils are over-cultivated with no fallow period and thus require application of manure or fertilizer for optimal yield returns. These soils are also preferred for brick-making.

The soils at the plains and bottoms are deep, dark brown and dark greyish brown alluvial clays to sandy soils. They are fertile and retain more water than other soils hence farmers get more yields of maize, beans, pigeon peas, cowpeas, sugarcane, bananas, mangoes, vegetables and tomatoes.

Vegetation

The following table gives an indication of the types of vegetation commonly found in the sub-location.

Table 2.1: Vegetation of Kasikeu Sub-Location.

	Common trees	Common shrubs	Common grasses
Well drained reddish brown soils	*Acacia polyacantha, A. gerrardii, A. tortilis, A. seyal var. seyal, A. nilotica, Albizia anthelmintica, Balanites glabra, Euphorbia candelabrum, E. tirucali, Terminalia brownii and Croton megalocarpus.*	*Acacia mellifera, A. brevispica, Grewia fallax, Commiphora sp., Aloe sp.,* the fast spreading invader *Lantana camara,* the poisonous *Gnidia latifolia, Agave sisalana* and *Sansevieria intermedia.*	*Chloris roxburghiana, Enteropogon macrostachyus* and *Panicum maximum.*
Sandy loam soils	*Acacia polyacantha, A. tortilis, A. nilotica, A. senegal, Croton megalocarpus and Euphorbia tirucalli.*	*Dombeya rotundifolia, Cordia ovalis* and *Gnidia latifolia.*	*Cynodon dactylon and Cenchrus ciliaris*
On valley bottoms	*Acacia polyacantha, A. gerrardii, A. kirkii, A. seyal var. seyal, Ficus syscomorus, Balanites glabra* and fruit trees *Mangifera indica and Carica papaya*	. *Lantana camara*	*Pennisetum purpureum* and reed grass *Phragmites mauritianus*

Land use

The major land use type of Kasikeu Sub-Location is cultivation of food crops mainly on the footslopes and valley bottoms. The farmers intercrop maize, beans, pigeon peas, cowpeas, cassava, sweet potatoes and sorghum. Most of the farms are terraced *("Fanya Juu")* for soil and water conservation. On the terrace edges, farmers plant citrus, lemons, napier grass, sweet potatoes, bananas, guava and avocados. A few farmers practice run-off water harvesting into their farm ditches where they have planted bananas.

On valley bottoms, other crops grown in addition to the above are bananas, cabbages, kales, tomatoes, french beans, napier grass, pawpaws, mangoes and sugarcane. They have many shallow wells where they do bucket irrigation of mainly vegetables and horticultural crops.

Livestock rearing is also important where indigenous cattle (*Zebu*), donkeys, sheep, goats and poultry are kept. Goats and poultry are for the provision of cash income to the family whereas cows are for milk and bulls are for ploughing, fetching water and transport. The cows are mainly fed with napier grass and farm stubble since there is very little communally owned land for free-range grazing in the sub-location. Bee-keeping is also important and are kept in indigenous beehives.

Sand harvesting used to be a major natural resource from the seasonal rivers but has now been banned due to the drying-up of water which is found after scooping the sand. Since there are no permanently flowing rivers, these seasonal rivers are the only source of water for domestic and livestock use. Mud-bricks are an important building material and also a source of income for the residents who sell the bricks either individually or through organized groups to people even from outside the sub-location. The sub-location is also endowed with raw materials used in ceramic industries.

2.3.3 Socio – economics

Demography

Kasikeu Sub-Location which is made up of 16 villages was settled between 1910 and 1920 mainly by Kambas. Surface area is about 14 square kilometres with a population of 15,000 people according to the areas sub-chief. There are about 2000 farm families with an average of 7 persons per family. Although people do not have title deeds for their land which is still being subdivided every individual knows the size and number of their land parcels. The average holdings are between 1.2-4 ha.

Infrastructure

Infrastructure in the region is generally poor. All the roads except the main Nairobi -Mombasa highway which borders the area are earthen. Telephone communication is poor with no facilities nearby. Although the railway line passes nearby, it is of little use to the residents. There are 6 primary schools and 2 secondary schools in the sub-location but no institution of higher learning. Three dispensaries each owned and operated by the catholic church, the Church of the Province of Kenya and the local community are found in the area. Several *posho*-mills found in the area are an integral part of the local community.

Community groups

There are a total of 17 women, 4 youth, 1 self-help groups and 1 water project group in the sub-location. Many women groups are involved in various income generating activities such as growing and selling vegetables, selling other farm produce, running small shops (*kiosks*) establishing tree nurseries from which they sell seedlings to other members of the community. Another activity carried out by some of the women groups is soil conservation. Most of the women groups are also involved in collection of money which is given to different members of the group in turns - a phenomena called ''merry-go round". The youth groups are engaged in income generating activities like making and selling bricks, selling hardware and vegetable farming. Further, these youth groups are also involved in recreation activities like football and netball playing.

The Kasikeu self-help group is involved in running a *kiosk* and the making and selling of bricks. The only water project (Kasikeu water project), endeavours to supply piped water to the members of the society.

Gender roles and labour distribution

The major activities in the region are season dependent and are shared differently by the different gender. During the rainy season they include land preparation, manure application, planting, weeding, attending to livestock and wildlife scaring. Most of these activities are carried out by both men and women. However, weeding and livestock attendance is also done by children. Wildlife scaring is not done by men but rather by women and children. During the dry season, activities are reduced to brick making which is done by men and household activities are mainly carried out by women. The household duties include fetching fire-wood and water from long distances and preparing meals for the family. Due to differences in reproductive roles, women have much more to do than men. The women wake up early and sleep late with little time for recreation while in most cases men only work in the morning and spare the afternoon for recreation and socialising.

Being a rather dry area and therefore a land of few opportunities, most of the better able young men and women have migrated mainly to urban centres chiefly Nairobi, Mombasa and Thika in search of employment. It therefore follows that, most of the available labour is from the very old and the very young. Labour demand is highest in the months of March-April and again in October-December during the long and short rains respectively. During these periods labour is required for crop production purposes. In the months of June to August most of the time is spent in brick-making, an income generating activity.

Credit systems

Credit availability is rather poor. For instance, there is not a single bank in the sub-location. The fact that the populace has no title deeds, the most popular collateral makes access to credit even more difficult. However people, particularly the women have groups (merry-go-rounds) which offer money to each other in turns.

Crop and livestock enterprises

Farmers in the sub-location grow cereals, vegetables, legumes, fodder crops while few grow cotton as a cash crop. Maize is the most popular cereal crop followed by sorghum and millet. These are grown for subsistence purposes although any excess may be sold to neighbours or at the local market. The major vegetables grown are kales, tomatoes and onions. These are mainly grown for sale in the local market. The legumes found in the area are beans, pigeon peas and dolichos. These are again grown for home consumption although any excess produce may be sold locally. Cassava,which is used for home consumption is a common root crop in the sub-location. Bananas are grown in the valley bottoms while mango trees are found all over the sub-location especially on the lower slopes.

The major forms of livestock in the area in order of importance are zebu cows, goats, sheep, indigenous chicken and donkeys. Cattle, shoats and donkeys are kept under free ranging conditions where they feed on natural pastures and farm by-products like maize stovers. Like the big animals, chicken are also kept under free ranging conditions but their feeding is supplemented with kitchen remains. Disease control is basically based on the use of local knowledge. The cows are kept mainly as a source of milk although they also act as saving banks for the farmers. Some bulls are trained to provide draft power in ploughing. Further they are used in cultural activities like paying dowry during marriage. The goats and sheep are kept as saving banks to be sold in time of need. Chicken are also kept for sale although a large proportion of them and their eggs are consumed at the farm level. Donkeys are kept as draft animals mainly for transport.

Extension services

Agricultural extension services are offered by officers from the Ministry of Agriculture Livestock Development and Marketing. However, the forestry department under the Ministry of Natural Resources also offer extension services in areas related to agriculture particularly on agro-forestry. Kenya Agricultural Research Institute specifically, the National Dryland Farming Research Centre - Katumani is also involved in agricultural extension in the area. The Ministries of Health and Education are also at times part and parcel to extension services mainly in the area of food security and public health. The churches in the area especially the Catholic and CPK churches also play a part in agricultural extension as they are interested in the issue of food security.

The mode of information transfer is varied. In most cases the Chief calls *barazas* where government officers come and offer the information to the farmers. At the same time there are demonstration plots used by government officers to show farmers new technology while still some contact farmers are visited in their farms. Another popular mode of technology transfer is through the use of field days. Further, both the radio and print media are also used to reach the farmers. Some of the constraints to effective extension work result from the scarcity of resources like transport and low number of extension officers.

CHAPTER 3

METHODOLOGY

3.1 Principles underlying the study

According to the TOR, the team was expected to develop a soil mapping methodology for KSS to make soil maps that are comprehensible and relevant to farmers and extension agents. Further the team was to identify research issues in soil management for NDFRC taking into consideration the diversity of the various farm practices and resource endowment of the farmers. To do this, the team conducted a *diagnostic survey* in Kasikeu Sub-Location. The survey was carried out at two levels - *sub-location and village.*

Out of necessity, small-scale farmers not only grow different types of crops and keep different types of livestock as circumstances may allow but also endeavor to carry out some off-farm activities for their subsistence. Any attempts to improve their livelihood should therefore take into consideration all the different activities. Unfortunately, the narrow training approach of most of the agricultural professionals who are expected to assist the farmers, limit them to only a few commodities at a time therefore not allowing them to deal with the farm holistically. A way out could be looking at farmers' situations in a functional *interdisciplinary approach* by a group of specialists in different disciplines. This was the approach followed during the study.

The study took *a systems* approach to soil management for various reasons. Improved soil management, the basis of the study, is likely to be influenced by agro-ecological factors that are within and without the farm. Further, socio-economic factors like land ownership, availability of off-farm income, quantity and quality of available labour among others and central government polices for instance those on fertilizer subsidies may also influence a local farmers soil management practices. If there is hope to improve soil management at the farm level all this factors must be considered together as a system.

The study attempted to be *participatory* in almost all stages of execution for several reasons. Out of experience, it is expected that people living in a particular environment may best understand of the same. As such, we expected the farmers in the region to have the best knowledge in soil management in the area. Bringing the farmers into discussion groups was expected to help the farmers share knowledge among themselves and therefore reflect on both their constraints and opportunities in soil management. In the process, researchers and extension agents had an opportunity to learn the farmer circumstances and reasoning behind most of their activities which would otherwise appear irrational. The researchers with general and broad knowledge were able to impact on the farmers any new ideas that may be of help.

Innovations such as improvement of soil management are not the monopoly of agricultural scientists or even the farmers. As a result different stakeholders may have conflicting interests which may require trade-offs to achieve anticipated goals. As such there is need to involve all interested parties - *stakeholders*. In the study, the male and female farmers are obviously the major stakeholders whose interests and wishes in rehabilitation and maintenance of soils were taken into account. The researchers mainly from KSS and NDFRC were interested in soil mapping methodology and identified soil management research issues respectively.

Table 3.1 Overview of the methodologies used in the study.

Activity/period	April Wk 2	April Wk 2	April Wk 2	May Wk 1	May Wk 2	May Wk 3	May Wk 4	June Wk 1	June Wk 2	June Wk 3	June Wk 3	July Wk 1
1. Background information	Further literature review	KSS interview	Farmers Local Adm. Kasikeu	NDFRC Soil and water program					Extension service - RELO	Literature review		
2.Stakeholder workshops	Initial workshop					Midterm workshop						Final W/shop
3.Farmers meetings		Initial baraza									Final baraza	
4. Soil classification			Farmer group meetings		Farmers map drawing		Transect, Sampling and profile description	Laboratory analysis	digitization	Interpretation		
5.Farm classification			Farmer group meetings	Farm visits	Qualitative data analysis		Farmer discussions	Problem ranking	Farm visits			
6.Information synthesis and analysis				Review meeting	Analysis of preliminary data and review meeting			Review meeting		Final analysis review meeting and write-up		

Other major stakeholders were the extension agents (both government and non-government) and the local administration in the area interested in improved food production.

3.2 Overview of the methodologies used

The study, which was mainly a diagnostic inquiry was based on different activities with various objectives, tools, actors and outputs. The major activities included background information, stakeholder workshops, farmers meetings, soil classification, farm classification and finally, information synthesis and reporting. Most of the activities were carried out over the whole period of the study as shown in Table 3.1. Details of each of these activities are given in the following paragraphs.

3.2.1 Background information

In the review of background information, the major activities were the review of secondary information and discussions with key informants. The activities undertaken and tools used to collect background information are summarized in Table 3.2.

Table 3.2 An overview of background information

Activities	Tools	Actors involved	Objectives	Out-put
Review back ground information	Literature review, Reconnaissance survey	ICRA team	To get insight of the problem study area & previous work	Current soil mapping methodology and their use to farmers List of research questions
Discussion with key informants	Semi-structured interview	ICRA team, Resource persons, KSS, NDFRC, Extension	To get perceptions of the main stakeholders & resource persons on soil mapping and management	Overview of soil mapping and management issues

In order to get an insight of the study area and previous work, and to familiarize the team with some of the physical and socio-economic features, the team reviewed and analyzed secondary data relevant to the field study topics under investigation based on some general themes. The themes were considered important to understand soil management practices and participatory soil mapping and included: an assessment of soil mapping methodology used by the KSS and the impact of soil maps on farmers' needs; soil management strategies and farmers' knowledge of the problems and the range of available solutions; soil fertility maintenance and water conservation practices by farmers, and an assessment of Farmer-Researcher-Extension linkage (stakeholders analysis). Based on the themes identified, a time frame was prepared and subdivided into study activities, methods and expected out-puts for different phases (Appendix 4).

Key informants offered valuable information to the team on participatory soil mapping (van Engelen, personal communication) and farmers' soil classification and soil management

(Kauffman, personal communication). Additional information was collected after the arrival in Kenya. KSS scientists were interviewed to find out current soil mapping methodologies and their expectations from the team. A discussion took place with Soil and Water Program of Katumani about issues to be considered under soil management. Elders, village heads and the Chief of Kasikeu Location provided valuable information of indigenous soil terminology and land ownership. Difficulties encountered by extension with the current soil maps were discussed with the RELO serving Katumani mandate area. All discussions with key informants were based on checklists.

3.2.3 Stakeholders workshops

The findings that surfaced out at various stages of the field study were shared with stakeholders of the study through an introductory, a mid-term and a final workshop organized in co-operation with KARI, NLO, KSS and NDFRC as shown in Table 3.3.

Table 3.3 Overview of stakeholder workshops

Activities	Tools	Actors involved	Objective	Out-puts
Introductory workshop	Slides, Overheads and Discussion	KSS, NLO, KARI HQ, Naivasha, and Extension.	To introduce the work plan. To get feed back flow	Modified work plan.
Mid-term workshop	Presentation and discussion	Male and female farmers. ICRA team. External reviewer. NLO, KSS & NDFRC scientists, KARI HQ.	To inform the stakeholders progress made. To communicate preliminary findings on soil mapping and management. To finalize action plan for the coming study period.	Feed back from stakeholders. Revised work plan.
Final workshop	Presentation and discussion.	Male and female farmers. ICRA team. NLO, KSS & NDFRC scientists, KARI HQ.	To get feed back from stakeholders for finalizing study report	Revised report

Introductory workshop

After arrival in Kenya, a one-day introductory workshop was organized on April 16, 1998 in Nairobi. The role of ICRA, research themes, study objectives, proposed methodology and the work plan were discussed with major stakeholders including, KSS, NLO, KARI, NAHRC - Naivasha and government extension agents for suggestions and clarification prior to implementation of the field study.

Mid-term workshop

Mid-term workshop was organized in Katumani on May 18, 1998 after initial phase of information collection. A total of 46 participants who included male and female farmers from

Kasikeu, KSS scientists, representative of KARI headquarters, NLO, Katumani scientists and MoALD&M extension staff participated in the workshop.

The main objective of the workshop was to present preliminary findings of the field survey to all stakeholders concerned, get their feedback and to determine further information needs. The major topics in this workshop were: introduction and general study methodology, relationship between KARI and ICRA, farmers' criteria for soil classification, soil mapping methodology and farm typology. The presentation was followed by a discussion in which participants gave feedback. Finally, a plan of action for the remaining period was presented and discussed. The inputs of the participants were used to refine the initial plan for the second phase of information collection.

Final workshop

The final workshop was undertaken on July 2, 1998 in Katumani with the same participants who did attend the mid-term workshop. The main objective of the workshop was to communicate conclusion and recommendation of the research findings of the field study. The topics covered were methodology (principles behind the study), soil mapping methodology and farm typology. It was agreed that the results would form a working document for both KSS and NDFRC.

Table 3.4 Overview of the farmers' meetings

Activities	Tools	Actors involved	Objective	Out-put
Introductory *Baraza*	Previously drown PRA map. Formal meeting	ICRA team, NDFRC resource person, Extension & local administration	To introduce the team to the farmers. To inform farmers the work plans. To develop rapport with farmers.	Rapport developed. Appointments made for further meeting
Concluding *Baraza*	Maps, Matrices, Flip charts, Group discussions.	Farmers, Local administration, ICRA team, KSS & NDFRC resource person, Extension	To inform farmers on outcome of research activities. To share knowledge and research findings with farmers. To offer some recommendations on soil management.	Farmers informed of additional information on soil management. Researchers get feed back on study findings.

3.2.4 Farmers' meetings (*baraza*)

Introductory and concluding farmers' *baraza* were conducted to develop rapport with farmers and to communicate the study findings to farmers respectively. In both meetings, male and female farmers were represented. The major objectives and tools used in the *baraza* are given Table 3.4.

Introductory baraza

The initial meeting was carried out with farmers at sub-location level. The team was introduced to the farmers and the local administration and was able to explain the purpose of the field study. Further, the team introduced the work plan of the study and made appointments for further communication. At the end of the day, a rapport with farmers was developed. Other major stakeholders were the extension agents (both government and non-government) and the local administration in the area interested in improved food production.. The introductory *baraza was* found to be a useful entry point for future activities that the team expected to undertake in Kasikeu.

Concluding baraza

Like the introductory *baraza*, the concluding one was held at the sub-location level. The farmers were reminded of the participatory work they had carried out particularly on the map drawing. Among the issues covered were importance of soils and their conservation, farm typology – both reasons and criteria, problems and opportunities for medium and low management farm types and finally the identified research issues. The team thanked and bade farewell to both farmers and the local administration. Later a concluding party for farmers and the local administration took place.

3.2.5 Soil classification and mapping

Soil classification

In order to understand the farmers knowledge on soils and their management, it was important to hold focussed group farmer meetings involving both male and female farmers. In these meetings, the farmers identified different types of soils in the area by their local names and proximate locations. For each soil type, major uses and management practices as well as the problems associated with management were listed. They extensively described each soil type. The meetings involved discussions with and among the farmers while visualization was carried out by one of the ICRA team members.

Soil mapping and digitisation

Having finished the soil identification and description the next step was to map them. A total of twelve male and female farmers were present during the soil mapping exercise with each gender represented by six farmers. Based on a sub-location map drawn by farmers in a previous PRA each gender drew a soil map. The farmers first demarcated the different village boundaries in the map though with difficulties. The men changed the sub-location boundaries to what they said was the current boundary of the sub-location. Although the women wanted to draw a new map they later decided against it arguing that it may take too much time. The women started by indicating the larger soil units ending with the smaller units while the men did the opposite. After finishing, the groups came together to compare similarities and discuss any differences. In a follow up session, the farmers combined both the women's and men's maps. To do this, the sub-chief was requested to indicate the sub-location boundary on a topographical map obtained from KSS for the farmers to use as a base map. The soil boundaries were indicated by a group composed of both men and women farmers. The three maps (drawn by men, women and the combined one) were sent to KSS for digitisation. The purpose was to translate the farmers' map into a database for future use in producing different types of maps and easy retrieval. These was done by the KSS GIS section in Nairobi.

Transect walks

To enable the verification of collected information and soil sampling, transect walks were done. The first transect walk was done from the mid-slope to the top of Kasikeu Hill and down the other side of the hill. In the next session, the walk started from the mid-slope down to the plains. The transect route was selected by the farmers so as to allow the team to observe as many soil units as possible. The group was made of both young and elderly male and female farmers, government extension staff and the ICRA team. The major aspects for observation were the soil and vegetation types, land use and soil management practices. In these exercises no soil sampling was done.

Soil sampling and analysis

Following the mapping, additional transect walks were done in other areas of the sub-location. In these, a KSS resource person, a few ICRA team members and farmer representatives were involved. As the farmers located the soil units, profile pits were dug and described while survey and fertility analysis samples were collected. A total of 5 fertility and 22 survey samples were collected. The samples were taken to Katumani soil and water laboratory for drying, grinding and sieving. Subsequently, they were taken to the KSS research laboratory for the actual fertility and survey analysis. Interpretation of data from the field and the laboratory analysis was done at KSS by the resource person and other scientists.

Table 3.5 Overview of soil classification

Activity	Objectives	Tools	Actors	Outputs
• Soil classification and mapping	• To learn farmers knowledge on soils and their management. • To learn farmers criteria for identification and characterization of soils. • To get gender specified perceptions on location of soil types. • To verify soil units and their boundaries. • To describe the soils and collect soil samples for laboratory analysis. • To get complimentary analytical information on soil. • To interpret analysis results for soil classification and fertility evaluation. • Translate the farmers map into a data base for future use in producing different types of maps and easy retrieval.	• Group discussion • Visualisation • Transect walk • Base map • Map drawing • Joint observations and discussions • Soil sampling • Physical and chemical laboratory analysis • Interpretations • GIS	• Male and female farmers • ICRA team • Extension staff • External reviewer • KSS & NDFRC resource persons	• Matrix on local soil names, uses, management practises and farmers criteria for identification • Gender specified and combined soil maps • Profile pits dug and described • Soil samples collected for survey and fertility analysis • Scientific classification of soils and fertility status of soils • Digitised map

3.2.6 Farm classification

To obtain differences and similarities among farms under investigation farm classification exercise was undertaken at both sub-location and village levels. Details of the activities are indicated Table 3.6.

Table 3.6 Overview of farm classification

Activities	Tools	Actors involved	Objectives	Out-put
Farm classification & selection at sub-location level	Group discussion, Visualization	Male & female farmers, ICRA team, Extension, NDFRC resource person & External reviewer.	To understand the diversity of farms in respect to soil management. To identify criteria for proper soil management practices. To select farmers for farm visits.	List of criteria for good soil management practices & factors allowing good practices. Farmers identified for farm visits (9 groups)
Farm visits (sub-location level)	Farm observation, Semi-structured interview, Farm sketches	Male & female farmers, ICRA team, Extension, & External reviewer.	To understand and verify soil management practices at farm household level	Farm sketches and detailed information on selected number of farms
Farm classification at village level	Household survey census, Group discussions	Male & female farmers, ICRA team, Extension, NDFRC resource persons.	To get a better representation of diversity among farmers with regard to soil management.	List of criteria for proper soil management. Four classes of farmers identified.
Soil management problem identification and ranking	Pair wise ranking, Group discussion.	Male & female farmers, ICRA team, Extension, NDFRC resource person.	To identify and rank major soil management problems causes & opportunities according to farm classes.	List of prioritised problems, causes and opportunities.
Farm visit at village level	Formal questionnaire.	Male & female farmers, ICRA team, Extension.	To verify farm typology & understand soil management problems.	Quantitative information.

Farmers identified that they are different among each other according to their own ability of proper soil management, such as: good, medium, and low. Based on this classification, farmers were asked to develop criteria for what they would refer to as good soil management practices. Following, they identified important factors that allow good soil management.

Initially fifteen farmers were selected based on topography and interviewed with a pre-tested checklist (Appendix 5) at sub location level to understand the diversity of farms with respect to soil management practices. The farmers first sketched their farm including the different fields and different soil types followed by discussions on terracing, ploughing, manure application, planting and weeding.

However, the household survey at sub-location level did not sufficiently cover the diversity of farmers and did not allow for the selection of representative farmers of soil management. For this reason, a proposal was made to adopt the methodology and select farmers at the village level. Thus, Mavemba village was selected by farmers on the basis of the dominant soil types found in the village and the availability of diversity among farmers with regard to soil management practices. Group discussions with different categories of farmers within the village was conducted for in-depth investigation of the research questions and to understand variation in their perceptions of soil management problems and opportunities. Farmers were asked to identify the major problems and to rank the opportunities. This was supported by the general agreement among participants on the constraints considered the most important. Farmers were first grouped by gender to undertake problem-opportunities exercise. At the end of the exercise each group presented their findings such that, differences and correspondences were discussed. Further, farmers were asked to volunteer for individual household interviews. The aim was to collect quantitative socio-economic information and to verify farm typology. Accordingly, 24 families headed by both men and women were registered and dates for interviews fixed with the agreement of the farmers. The interview was undertaken with a formally structured questionnaire (Appendix 9).

3.2.7 Information synthesis and analysis

Table 3.7 Overview of information synthesis

Activities	Tools	Actors involved	Objectives	Out-put
Information analysis, synthesis and write-up	Group discussions, Matrix, Graphs & Charts, Maps, Review meeting.	ICRA team, External reviewer, KSS resource person.	To bring together the collected information. To interpret the collected information to the study objective. To draw conclusion and recommendation. To summarize research findings & produce report.	Report
Review meetings	Meeting	ICRA team, NLO, External reviewer.	To monitor & evaluate progress of the study regularly. To get feedback for further improvement of the study.	Revised work plan.

Information synthesis was carried out through out the study period although it was most intensive during the last 3 weeks. The major players were the ICRA team and the external reviewer.

Review meetings

This was a new introduction to the monitoring and evaluation process of the study. Three review meetings were held in-between the major stakeholder workshops. They helped further in getting feedback from the major stakeholders.

CHAPTER 4

STUDY FINDINGS

4.1 Soils and their management: Agro-pedological perspective.

4.1.1 Issues in conventional soil classification and mapping.

As outlined in the introduction, Chapter 1.2.1, one of the Kenya Soil Survey (KSS) major objective is to inventory soil and other natural resources countrywide. The outputs should cater for client's information needs in helping them to solve their (rural development) problems (Andriesse and Enserink 1996). Up to 1996, KSS had carried out 22 reconnaissance soil surveys on the basis of the so-called quarter degree topographic map sheets, and lately on a district basis after acquiring a GIS facility. It has also carried out many other surveys at different scales of mapping.

In execution of its work, KSS has been using standard (conventional) methods of soil mapping, which have the following steps.

1. Aerial - photo and satellite image interpretation
2. Fieldwork: checking of soil units and boundaries, soil sampling, description of soil genesis and physical factors etc.
3. Laboratory sample analysis
4. Interpretation of results
5. Drawing of maps (by manual cartography and GIS methods)
6. Report writing
7. Dissemination of report and maps to extension staff and KSS data storage.

The team found that the outputs (reports and maps) produced from the above methodology have interrelated problems which revolve about the type of information presented, the **way** it is presented and the approach to production of the information.

A) Problems in the type of information produced

- Presently, land inventories made by KSS at reconnaissance level produce outputs targeted for multipurpose land use planning; thus they lack a focussed unit for addressing farmer-oriented research needs.
- The reports and maps made by KSS contain in-depth scientific information especially on soil genesis (using technical soil classification names and scientific jargons in the description). They become very difficult to read and understand by non-scientist `outsiders' e.g. extension staff, development officers, land use planners etc.
- KSS expects the extension staff to understand and interpret the contents of their reports and maps. However, without training the extension and laymen on how to interpret the reports and maps, it becomes difficult for them to use those KSS outputs.
- The soil maps are in a very small scale (becoming very generalized) since they cover very large areas, for effective use by the extension staff in addressing the farmers' problems.

B) Problems in the approach to produce the information

- KSS never involved farmers and extension staff in the soil mapping process, until very recently (1995) in Mashuru Division of Kajiado district. Thus, KSS lacks the input and knowledge of the extension and farmers.
- Little collaboration with other KARI Regional Research Centers for an input of farming systems information which is presently lacking in the reports and other outputs.

C) Problems in the way of presentation of the information

- Since the extension staff were never involved in the process of soil mapping, they cannot understand the reports and maps given to them. Note however that, single attribute maps given to them e.g. nitrogen, phosphorus, soil salinity hazard etc. have been more attractive to them.
- The extension are just given the KSS maps and reports for their implementation, which is a top-down approach that lacks the feedback of the extension staff to KSS.

The extension staff, who are the major clients of KSS have the following perceptions on how the soil maps can be improved to make them useful tools for use by the extension:

A) Type of information on soils to be given in soil maps

- The fertility (level of nutrients) of the soils
- Workability of the various soils
- Depth
- Water holding capacity
- Erodibility
- Suitability's e.g. for irrigation, afforestation, pastures, cropping etc.

B) Approach in the production of the information

- Extension and farmers to be involved in the process of making soil maps, so that it is easy to disseminate and accept the technology respectively.

C) Way of presentation of the information

- A simple criteria to identify various soil types e.g. color, texture, management practices and problems etc.
- The maps should preferably be in color since they are easier to read.
- Photographs of soil types should be included in the report for easier identification of the soils.
- The maps should not be generalized i.e. should not cover a very large area.

4.1.2 Farmers' soil classification

A) Farmers' criteria for soil classification

Farmers in Kasikeu base their soil classification system mainly on color, texture and coarseness. They name the soils on the basis of these major criteria or a combination of any two. These criteria are important to the farmer in the sense that they are visible and practical in terms of his management of the soils. In terms of color, farmers in Kasikeu classify their soils according to red, black, brown and white colors with glades of each color to almost similar soils for comparison purposes e.g. very red or very black, but they don't have other names for such soils. In terms of texture, the farmers classify the soil on the basis of the sand and clay composition with a combination of the two (sand and clay). Coarseness is used to further differentiate the red soils.

Farmers in Kasikeu distinguished 9 different soil types viz. Kitune, Kitune na mavia, Ilivi, Ikala, Nthangathi nziu, Nthangathi nzau, Yumba, Malamu and Mavia. The criteria they use in differentiating these soils is presented in Table 4.1 Farmers further describe the soils according to a number of characteristics which are stickiness, hardness, water retention capacity drainage, erodibility, cracking, fertility and when is best to plough them.

B) Soil types

The soils of Kasikeu sub-location may be grouped into three major categories viz: red soils, black soils and sandy soils:

Red soils

These soils are reddish in color and are known as Kitune (red) which is further subdivided according to coarseness (stoniness) into Kitune and Kitune na mavia (red with stones). Generally these soils are found on uplands and higher slopes. They are deep soils, but Kitune na mavia has a stony to gravelly layer near the surface. The texture of these soils is mainly clay and due to the high clay content, these soils become sticky when wet and hard when dry and thus pose some limitations to cultural operations. Ploughing is possible only after on-set of the rains. Kitune na mavia poses problems in ploughing and other cultural operations unless the stony layer is broken and stones are removed. Due to their position on the catena, these soils are well drained and have good water retention. Being highly eroded, these soils do not give good yields unless manure and/or fertilizer is added.

Black soils

These soils are dark brown to black in color and are mostly found in plains and low-lying areas. They are very deep and have pure clay texture, which make them very sticky and slippery when wet. Due to the high clay content particularly of the swell-shrink type, these soils become very hard on drying to the extent of developing big cracks and after excessive rainfall, they become waterlogged. Therefore, cultural operations are possible only under moderate moist conditions. Because of their physiographic position and inherent characteristics, these soils are more fertile than red soils as they are very weedy with plants which farmers recognize as indicator plants for fertility e.g. *Cyperus rotundus* (mbio), *Galinsoga parviflora, Datura stramonium* and *Amaranthus* sp.

Table 4.1: Criteria and characteristics farmers use in classifying soil types in Kasikeu Sub-Location.

	Soil types						
Major criteria for distinguishing	Kitune	Kitune na mavia	Ikala	Ilivi	Nthangathi nzau	Nthangathi nziu	Yumba
Color	Red	Red	Black	Black	Whitish	Brown	Black
Texture	Clay	Clay	Clay	Clay	Sandy	Sandy	Clay
Coarseness	None	Coarse elements	None	None	None	None	None
Characteristics: Stickness	Sticky	As Kitune	Very sticky	Very sticky and slippery	Non-sticky and loose when dry	Very sticky	Very sticky
Hardness	Hard	As Kitune	Very hard	Hard	_	Very hard	_
Water retention capacity	Good	As Kitune	Better than Ilivi	Good	Very low	Less than Kitune	Good
Drainage	Good	As Kitune	Poor	Poor	Good	Good	Poor
Erodibility	Easily eroded on slopes	As Kitune	Easily eroded into gullies	Less erodible than sandy and Kitune soils	High	More than Kitune	_
Cracking	None	As Kitune	Cracks	None	None	None	_
Fertility	More fertile than sandy soils	As Kitune	Good	More fertile then sandy and Kitune soils	Very poor	Less fertile than Kitune	_
Uses and crops grown	1. Cropping maize, and Beans, pigeonpeas, cowpeas Bananas, Mangoes, Oranges, Avocado etc. 2. Brick making 3. Mud houses 4. Building sites 5.Pasture	Same as Kitune	1. Cropping Maize, Beans, sugarcane, cotton, Tobacco, Arrowroots, Dolichos, Cowpeas, Green grams, Gourds, Bananas 2. Pasture	Best for bananas and sugar cane	Cropping: Best for sweet potatoes and to a lesser extent cassava, tomatoes, vegetables	Cropping:: Sorghum, Cassava, Sweetpota to, cowpea, Banana Pumpkin, Pawpaw 2. Pasture	Pot making

Management practices	- Ploughing after rains - Manure application is less frequent than sandy soils (once in 2yrs) - Bench terraces with grass/trash line on slopes.	Same as Kitune but in addition, removal of stones to make stone terraces	- Ploughing after light rains - Generally no manure application - Grass strips/stone lining is needed near river bed	- Digging very deep pits to reach the soil type to plant bananas and sugarcane. - Addition of manure and trash in the pits	- Ploughing after rains - Manure is for vegetables only and is required every year - Grass strips for erosion control - Bucket irrigation for vegetables	- Ploughed after rains - Manure is required every two years - Bench terraces - Minimal tillage - Grass/trash lines required on slopes	–
Position on catena	Mainly on mid-slopes but may be on the plains	Upper slopes	Plains	Plains (near the river but beneath Nthangathi nzau)	Next to rivers	Everywhere	Lower slopes
Constrains	Difficult to plough when too wet or dry	Same as Kitune and also due to stones	Difficult to plough when wet or dry	Buried under sand and thus not suitable for shallow-rooted crops	Very low fertility and low water retention capacity	Difficult to plough when dry	–

Note: 1) The soil types Malamu and Mavia are not used for agricultural practices; therefore, they are not listed on the matrix

2) For representation of soil types on the catena refer to the transect drawing Appendix 1

Depending upon some physical characteristics, the farmers categorize the black soils into Ikala, Ilivi and Yumba. The main differentiating characteristic between Ikala and Ilivi is that Ikala soil develops cracks when dry while Ilivi does not. Further, Ilivi is found mostly along the rivers and streams and is generally buried under sand. Yumba soils are found in some small isolated pockets only, and are non-cracking, very soft clay, shiny, and are primarily used for pottery.

Sandy soils

There are two types of sandy soils in the area and are named on the basis of a combination of texture and color criteria. These are Nthangathi nziu (brownish sandy soils) and Nthangathi nzau (whitish sandy soils) The former soils may be found everywhere along the catena (from top of hills to plains). On hilltops, it is very shallow due to erosion over a long period, mixed with rocks and boulders and coarse textured. On footslopes and plains, it is deep, more clay in texture and better crop yielding after improved management practices. Due to the clay content, it is slightly sticky when wet and hard when dry and can be ploughed only after onset of the rains. On steep slopes, the soil is more erodible than the red soils.

Nthangathi nzau are whitish in color and found mostly near the streams and rivers. They are almost pure sand, poor in water retention capacity and fertility status. Due to the shallowness of ground water, vegetable growing is done here by irrigation and manure applied every year.

C) Gender perceptions on soil types

As mentioned in chapter 3.2.5, the team split the farmers into male and female groups for purposes of capturing gender perceptions on soil types and their spatial distribution in the sub-

C) Gender perceptions on soil types

As mentioned in chapter 3.2.5, the team split the farmers into male and female groups for purposes of capturing gender perceptions on soil types and their spatial distribution in the sub-location on separate maps (Figures 4.1 and 4.2). The farmer's later drew a combined map after discussions and compromising (Figure 4.3). The team analyzed the different farmers' soil maps and came out with the following major differences as outlined in table 4.2.

Table 4.2: Differences between male and female soil maps of Kasikeu Sub-Location.

	Male	Female	Combined
Sub-location boundary	More accurate	Less accurate	Ass. Chief assisted the location of Exact boundary
Soil types	5	9	9
Dominant soil type	Kitune	Nthangathi nziu	Nthangathi nziu
Details on map	Generalized	More detailed	Detailed as in women's
Ikala and Ilivi soil types	Same	Distinct types	Distinct types
Location of Ilivi	Occurs exposed	Occurs exposed	Occurs buried under Nthangathi nzau
Location of Nthangathi nzau	Along river beds	Big units outside the river courses	Along river beds
Location of Yumba	Did not locate	Located	Location close to women's

As concerns the sub-location boundary, the men had a better perception of the newly created changes to the sub-location boundary after the sub-division of the greater Kasikeu Location into three sub-locations. The Assistant Chief assisted the farmers in the drawing of the exact boundary for the combined map. The men also had a better perception of some of the physical features and entities like roads than women.

The men identified 5 soil units while the women identified 9 soil units. The women's map was very detailed even to very small units while the men did not recognize the small units. Upon combining the maps, the groups agreed that there were 9 soil types as identified by the women. Further the men classified Ilivi and Ikala soil types as one and the same while the women distinguished them as two distinct soil types. Upon combination of both genders, the farmers discussed and compromised that Ilivi occurs always buried under sand and even if it is exposed through erosion, it never cracks as Ikala, thus making them two distinct soil types.

The groups also differed in the actual location of some soil types. For example, the men group was more or less accurate on the location and distribution of Nthangathi nzau (builders' sand) along the river beds - maybe because they are involved more than women in the sand harvesting business. The women group was more accurate on the location of Yumba since upon combining, the whole group agreed on the location, which was close to where the women had identified - possibly because Yumba is used in pottery work which, is an activity carried out entirely by women.

The groups also differed on the most dominant soil type, with men group identifying Kitune as the most dominant while women group identified Nthangathi nziu as the most dominant type. Upon combination of the maps, the two groups agreed that Nthangathi nziu is the most dominant type as shown in the following table:

Table 4.3: Spatial distribution (%) of different soil types in Kasikeu Sub-Location

Type of Map	Soil Types								
	Nthangathi Nziu	Nthangathi Nzau	Kitune	Kitune na mavia	Ilivi	Ikala	Yumba	Malamu	Mavia
Male	22.36	13.22	62.74	-	-	1.54	0.13	-	-
Female	54.66	10.04	10.43	6.14	7.27	1.94	1.27	0.64	7.61
Combined	43.60	14.59	16.98	-	5.84	4.88	0.68	2.24	11.18

A reflection on the different gender perceptions can be explained by the different activities each group is involved in. The women are more involved in farm activities like planting, weeding, terrace making (especially women groups) and even to some extent ploughing. Therefore, it is no surprise that they identified more soil units and their spatial location than the men who were general and did not recognize some soil units. Another example is the identification of Yumba for pottery, which is entirely a women affair. During transect walks, the women were also more keen and knowledgeable on natural vegetation which provided food (fruit trees), medicine and fodder for livestock.

The men group on the other hand was more keen on areas where builders' sand is located and areas previously mined for mica. Men are also more involved in politics and other current affairs than the women and as such are well informed of current local issues for example, changes in the sub-location boundary. The local administration comprising D.O., Chief, Assistant Chief and village headmen are all males.

4.1.3 Scientists' soil classification

Kenya Soil Survey classifies soils following the FAO/UNESCO Legend for the Soil Map of the World (scale 1:5 million) for soil classification and soil correlation purposes (Siderius and van der Pouw, 1980). The FAO/UNESCO Legend was designed to accommodate world soils in order to overcome gaps in national soil classification systems and to provide an internationally accepted basis for soil correlation. The classification system uses commonly accepted principles of soil formation (genesis) which are reflected in the nomenclature.

The soil description for classification purpose as done by KSS, is made from soil profile pits and emphasis placed on the sub-soil, usually the B-horizon till depth of 100 cm or to rock, whichever is shallower. These profile descriptions are annotated on the KSS "green form" according to soil color (dry and moist), mottling, texture, structure, consistence (dry, moist and wet), cutans, pores, content of rock and mineral fragments, content of carbonates and soluble salts, features of biological origin like roots, fauna activity; finally the nature of horizon boundary and number of the sample taken for analysis (KSS Staff, 1998)

Farmers in Kasikeu identified five primary soil types which are important in terms of agricultural practices, which were Nthangathi nzau, Kitune, Kitune na mavia, Nthangathi nziu and Ikala. After field descriptions and laboratory analysis of the soil samples taken by KSS scientist, they were described and classified as in Table 4.4.

Table 4.4 : Scientist' soil description and classification of the major soils of Kasikeu Sub-Location

	Soil types				
Local name	Kitune	Kitune na mavia	Nthangathi nziu	Nthangathi nzau	Ikala
Scientific name	Haplic Ferralsol	Haplic Lixisol rudic phase	Haplic Lixisol	Luvic Arenosol	Eutric Vertisol
Characteristics	-Strongly weathered, leached and indistinct horizons -Highly porous and permeable -Stable structure -Chemically poor soils -Good moisture holding capacity	-Generally moderately deep to deep soils -Low base status -Low amounts of organic matter (ASAL areas) -Strong surface sealing/crusting thus susceptible to water erosion	-Well drained and deep -Sandy clay loam topsoil and a clay subsoil	-Coarse textured soils -Well to excessively drained -Low water holding capacity -Low fertility status	-Dark cracking clays -Are imperfectly to poorly drained -Expand and contract (shrink) with changes in moisture content - Heavy clay texture -High chemical fertility (except N &P)
Land use	-Rainfed cultivation of millet, sorghum, sunflower, beans, green grams, maize etc	Arable cropping or extensive grazing depending on climatic conditions.	Cropping and grazing	-Cropping of cassava, maize and mangoes. -Used for animal production (pasture)	-Grazing -Rainfed agriculture (maize, sunflower, beans, chick peas etc)
Limitations	-Low chemical fertility -Addition of manure and fertilizers is therefore necessary -Erosion conservation	-Low surface organic matter content -Sealing and crusting therefore susceptible to water erosion -High degradation hazard (surface cover,	-The CEC is low (9.6-19.0 me/10g). -The organic matte is low (0.42 – 0.91%C). -The nutrient	-Low fertility hence high fertilization required -Easily eroded	-Low permeability (susceptible to water logging and flooding) -Low infiltration -Difficult tillage (optimum moisture for cultivation)

	measures are necessary	land use and climatic conditions), compact clay subsoil's restricts rootability -Stony layers	levels are low due to low CEC and organic matter content.		-Salinity problem when irrigated with poor quality water -Difficult to leach due to low permeability -Prone to erosion especially gully erosion.

1) Kitune

Kitune soils (Haplic Ferralsol) are well drained, deep with diffuse horizon boundaries, dark reddish brown. The soils have a clay texture throughout the profile. They are slightly acid (6-6.3). The soil physical conditions are good in terms of moisture retention, workability and water movement. On the basis of soil physical characteristics, the potential of these soils for deeply rooted crops is very high. These soils are developed from metarmophic rocks (granitoid gneiss). The Cation Exchange Capacity of the soils is low (8.8 - 10.2me/100g). Organic matter of both the topsoil and sub-soil is low (0.48-0.72%C). These deeply weathered soils have low nutrient levels.

2) Kitune na mavia

Kitune na mavia (Haplic Lixisol rudic phase) soils are well-drained, deep, clear and smooth transition, dark red to dark reddish brown. The topsoil is sandy clay loam while that of sub-soil is clay. The soils are very strongly acid to strongly acid (4.9-5.5). The potential of these soils for deeply rooted crops is high, based on good soil physical conditions. These soils are developed on metamorphic granitoid gneiss. The CEC is low (7.3-10.7me/100g). Organic matter is low to medium (0.9-1.09%C). The soils have limited nutrient levels.

3) Nthangathi nziu

Nthangathi nziu (Haplic lixisol) soils are moderately well drained and deep. They have very dark grey topsoil and strong brown to dark brown sub-soil. The soils are sandy clay loam in the topsoil (0-12cm) and clay in the sub-soil. These soils are medium to strongly acid (5.4-5.6). The soils have a reasonably high potential for root growth. The soils are developed on metamorphic granitoid gneiss.

4) Nthangathi nzau

Nthangathi nzau (Luvic Arenosol) soils are excessively drained, deep to very deep, brown to dark brown. The texture, which is the particle size distribution, influences the moisture retention and transmission properties of soils. As a rule, coarse textured soils have low moisture retention and high permeability. Topsoil is sandy while the deep sub-soils are clay loam to clay. These soils are well aerated but have low water holding capacity. These soils are slightly acid (6.1-6.7).

The physical characteristics of these soils show high potential for root growth. These soils are developed as metamorphic rocks (granitoid gneiss) which are acid rocks that give rise generally to poor soils. The Cation Exchange Capacity (CEC) of the soils is generally low (1.7-6.2me/100g soil The organic matter content is generally very low (<0.4%C) 100cm depth and low (0.42-0.72%C) in the deeper sub-soil. Organic matter contributes to soil moisture retention and soil structure formation and structure stability.

5) Ikala

Ikala (Eutric vertisol) soils which are also commonly referred to as 'the black cotton soils' are poorly drained moderately deep, very dark greyish brown to black. These are heavy textured cracking clay soils. They have low water permeability. The soils are slightly acid to neutral (6.05-6.82). On the basis of the soil physical properties, these soils have relatively low potential for deeply rooted crops. The soils are developed on metamorphic granitoid gneiss. The CEC is high (21.1-26.8 me/100g). The organic matter content is medium (1.09-1.82%C).

Ikala (Vertisol) soils are very hard and shrink when dry; very sticky and swell when wet, hence poor workability. The nutrient levels are high considering both soil physical and chemical characteristics.

Fertility status of the soils

The appraisal of the soil fertility is based on the chemical analytical data of composite topsoil (0-30 cm) samples taken from the vicinity of representative profile pits. This appraisal should be regarded as a general one. However it gives a general overview of the soil fertility status in the survey area. The soil pH ranges from moderately acid (5.0-5.9) to near neutral (6.5-6.9). The organic matter content ranges from very low to moderate (1.0-1.8%) and hence nitrogen is also low in all the soils units.

All the soils are sufficiently supplied with Na, Mg and Ca. Potassium and Manganese are sufficiently supplied in all soils except in Nthangathi nziu and Kitune. Phosphorus supply is deficient in all soils except in Nthangathi nziu. Ikala has too low exchangeable acidity to warrant liming. Application for fertilizer containing N, P and K nutrients to correct the deficiencies would be necessary.

Non-acidic fertilizers such as CAN, TSP and SSP should be applied in Ikala to avoid further increase in pH which may further affect the normal plant growth. Farmyard manure, which is a source of major plant nutrients, should be applied in all soils. Humus in soil organic matter adds substantially to the buffering capacity of the soil as well as acting as a reservoir of cationic nutrients. Moreover, organic matter improves soil physical conditions (infiltration, movement and retention of soil water, soil aeration etc) and increases soil micro-organism's activities.

4.1.4. Merging farmers and scientists knowledge in soil classification

In relation to similar work done elsewhere in other parts of the world, farmers have detailed practical knowledge of tillage, management, protection and productivity of the soil, based on generations-long experience with the local soil types and their uses (Kante and Defoer, 1995, Kauffman, 1996). At farm level, the farmer knows in detail the soil types occuring on his farm, their uses and management, as exemplified by farm sketches drawn by the farmers.(Appedix 2 and 3). On the other hand, the soil scientists acquire knowledge of their study areas in a relatively short time through survey, testing and classifying the soil types according to international and national standards.

Farmers recognize different soil layers and the naming of soils is frequently based on topsoil characteristics. This sometimes complicates correlation with the scientific soil name, which focuses on the complete soil profile with an emphasis on the subsoil. For example, farmers classification of Nthangathi nziu and Kitune na mavia are differentiated on the major criteria of color and sand contents, while the scientist classify them as the same (Haplic Lixisol) except the stony phase (Haplic Lixisol rudic phase) in Kitune na mavia. Other major differences and similarities in the farmers and scientists soil classification systems are as in Table 4.5.

Table 4.5: Comparison of farmers' and scientists' soil classification systems

	Farmers Classification	Scientists Classification	
1. Soil types	Local name	Common Name	Scientific Name
	Kitune Kitune na mavia Nthangathi nziu Nthangathi nzau Ikala Iivi Malamu Yumba Mavia	Red soil (without stones) Red soil(with stones) Compact sandy soil Loose white sand Black cotton soil Dark silt loam-silt clay Murram Clay soil Rocks and stones	Haplic Ferralsol Haplic Lixisol rudic phase Haplic Lixisol Luvic Arenosol Eutric Vertisol - - - -
2. Main criteria to distinguish soils	color, texture and coarseness	Parent material	
3. Other characteristics	stickiness, hardness, water retention capacity, drainage, erodibility, cracking, fertility	Diagnostic horizons and properties (drainage,depth color(moist), mottling, consistence (moist) calcareousness, salinity/alkalinity (sodicity), pH, rockiness, stoniness, cracking, texture)	

Soil classification systems by farmers are through soil characteristics or properties important to the farmers. Soil scientists tend to be biased toward classification systems they know and thus separate soils to fit the division breaks of their own system (Tabor, 1993). This practice can overly complicate the soil survey, or worse, disregard separations that are important to the farmer. Local systems can provide clues most limiting to land management and can help the soil scientist identify agricultural interventions that will most economically improve the soil productivity.

The analytical data by the scientist complements the farmers knowledge on aspects that he cannot be able to interpret for example, a farmer may value his land as fertile but does not know the inherent nutrient levels in the soil, and may need to know the analytical information for proper fertilizer application. Survey and analysis of soil samples by KSS for five soil types identified by farmers provided the following information.

Table 4.6: Merging farmers and scientists information

	SOil types									
	Farmers	Scientists	Farmers	Scientists	Farmers	Scientists	Farmers	Scientists	Farmers	Scientists
Soil Names	Kitune	Haplic Ferrasol	Kitune na mavia	Haplic lixisol rudic phase	Nthangathi Nziu	Haplic lixisol	Nthangathi Nzau	Luvic Arenosol	Ikala	Eutric vertisol
Color	Red	Dark reddish brown	Red	Dark red to Dark reddish brown	Brown	Dark Grey topsoil, strong brown to dark brown subsoil	White	Brown to dark brown	Black	Very dark greyish brown to black
Texture	Clay	Clay	Clay	Topsoil- sandy clay loam. Subsoil- clay	Sandy clay	Sandy clay loam (topsoil) Clay (subsoil)	Sandy	Topsoil- sandy Subsoil- clay loam to clay	Clay	Heavy textured clay
Coarseness	None	None	Stony	Stony	Sand particles	Sand particles in topsoil	Pure sand	Coarse sand particles	None	None
Other charac -teristics	-Sticky when wet -Hard when dry -Good water retention -Easily eroded on slopes	-Well drained -Deep -Slightly acid -Good moisture retention -Good workability -Stable structure - Porous and permeable -Strongly weathered - High potential for root growth	Same as Kitune	- well drained - Strongly acid - deep - Low organic matter - Surface sealing cru sting - High potential for root growth	-Slightly sticky when wet -Friable when dry -Less water retention than Kitune -Good drainage - Can be ploughed easily - More erodible than Kitune	-Deep -Medium to strongly acid -High potential for root growth -Low organic matter	-Non-sticky when wet -loose when dry -Very low water retention capacity -Can be ploughed very easily when wet or dry	- Excessively drained -Very deep -High permeabilit y -Well aerated -Low water holding capacity -Slightly acid -Low organic matter -High potential for root growth	-Very Sticky when wet -Very hard when dry -Cracks when dry -Good water retention -Poor drainage -Very weedy -Very difficult to plough when wet or dry	-Poorly drained -Low water permeability -Slightly acid to neutral -Low potential for deep rooted crops -Organic matter content medium shrinks when dry -Very sticky and swell when wet - Poor workability
Fertility	More fertile than sandy soils	Low (Low CEC and low O matter)	Same as Kitune	Low (Low CEC and low- medium O matter)	Less fertile than Kitune	Low (Low CEC and O matter)	Very Poor	Low (Low CEC and very low O matter)	More fertile than sandy soils	High(High CEC and medium O matter content)

Uses	-Cropping (maize. beans. pigeonpea. Cowpea. Bananas. Mango. Oranges. Avocado etc) -Brick making - Mud houses - Building sites -Pasture	-Arable cropping (Millet. Sorghum. sunflower. Beans. Green grams. maize etc)	Same as Kitune	-Arable cropping -Grazing	- Cropping(sorghum. cassava. sweet potato. cowpea. bananas. pumpkin. pawpaw) -Pasture	-	-Cropping (Pigeonpea. cassava. sweet potato. tomato. pumpkins) - Sand harvesting	Cropping (Cassava. maize .mangoes)	-Cropping (maize. beans. sugarcane.cotton. tobacco. Arrow roots. Dolichos. cowpea Gourds etc -Pasture	-Grazing -Rainfed agriculture(Ma sunflower. bea chickpeas etc)
Management practices	-Ploughing after rains -Less manure required than sandy soils -Bench terraces with grass trash lines on slopes	-	Same as Kitune -Also removing of stones	-	-Ploughed after rains -Manure required every 2 years - Bench terraces required on slopes -Minimal tillage on slopes	-	-Ploughing after rainys -Lot of manure required -Manure applied only to vegetables (yearly)	-	-Ploughing after light rains - No manure application - Grass strips/stone lining near river beds	-
Constraints	Low fertility	Low fertility	Low fertility and stones	Low fertility and stones	Compact soil and low fertility		Low water holding capacity and fertility	Low water holding capacity and low fertility		-Poor workabili due to waterlogging

Farmers in Kasikeu felt that some of the data taken by KSS during soil profile description is very necessary to them. Some of the information they felt is important to them is: -

1. The topsoil observations and analysis for fertility should be given emphasis and the type of fertilizer to apply during top-dressing especially for maize.
2. Emphasis on the type of soils to be sampled should be in the major occurring soils e.g. Nthangathi nziu and Kitune since the results will benefit more farmers than Ilivi, of which the results will benefit only a few farmers.
3. Depth - it will indicate the types of crops that can be grown.
4. Color - to differentiate the different soil horizons and can tell the types of soils in one profile.
5. Porosity - to indicate aeration of lower horizons and thus penetration of roots.
6. Salinity tests of the soils - to know whether the soils are saline.
7. Quick feedback of the results (they said they have never seen the results of the earlier soil survey done on some of their farms).

Farmers and scientist knowledge/information and mapping techniques differs. The team analyzed the combined farmers and the scientist's map, earlier drawn by KSS when it was soil mapping the area and observed the following major differences and similarities:

Table 4.7: Major differences and similarities between farmers and scientists soil maps.

	Farmer	Scientist
1. Knowledge/Information		
(i) Soil units recognized	9	11
(ii) Classification names	All	8
(iii) Soil complexes	None	Some
(iv) Basis of classification	Physical characteristics (color and texture)	Parent material and chemical and physical characteristics
(v) Legend content	Simple and easy to understand	According to a certain sequence of soil properties
2. Mapping technique		
(i) Representation of units	Specified all	Generalized the small units because of scale
(ii) Location of soil units	Assisted by physical features or entities e.g. schools, churches	Change of soils characteristics
(iii) Accuracy of sub-location boundary	Aware of recent changes	Used outdated boundary
(iv) Stakeholders involved	Involves more	Scientists only
(v) Need of base map	Yes	Yes
(vi) Use of scale	Not to scale	To scale

4.2 Soils and their management: socio-economic perspectives

4.2.1 Targeting soil management recommendations

Generally, diversity exists in soil management because different soil types often require different management regimes. Also, farmers even if they are in the same area managing same soil types may do so differently because they may be faced with different social and economic conditions. Thus in reality, general or broad soil management recommendations for an average farmer and/or soil types may not be appropriate to the wide range of conditions experienced by farmers or the whole range of farm families.

Proposing suitable soil management strategies for individual farm families may be an ideal way of overcoming the problem of diversity among farmers, since no one farm in reality is identical to the other. However, this may not be feasible particularly, from the economic point view due to limited resources and the fact that it may be laborious and expensive.

A more practical alternative is the typology or classification of farms with similar circumstances (production objectives, resources, management levels, constraints, etc.) into relatively homogeneous groups for whom same or specific research and extension recommendations in soil management could be made. It is believed that recommendations designed in this manner may suit the socio-economic standing of the different categories of farms and are more likely to be adopted.

4.2.2 Farm Typology

4.2.2.1 Sub-location level classification

Section 4.1 above elaborates on the agro-pedological diversity in soil types in the study area. In continuation of this and given the existing topography, farms were first classified at the sub-location level according to their physiographic position (position along the toposequence i.e. hill, slope and plains), since this could determine the type of soils on farms and how their managed by farmers. The purpose of this classification was to understand the diversity on farms with respect to soil management and identify farms with similar soil management practices. Detailed description of the classification is in chapter three.

Discussions were later held with farmers to understand their perception or criteria for proper soil management. According to the farmers, the criteria for proper soil management are first of all, being able to under take such soil management practices as the digging of bench terraces on hilly areas, applying manure, ploughing with oxen, planting early and weeding early.

Some reasons farmers gave for these criteria are that terracing of hills prevents soil and nutrients from being washed away in run-off water. Most of the soils in the area are compact or sandy and have been cultivated for long periods. Thus manure application is important to improve the structure and fertility status of the soils for better yields. Ploughing with oxen hastens land preparation for early planting and taking advantage of the early rains or ensures timeliness. It also gives a better turning over of the soils especially, in incorporating manure. The timeliness of weeding is also important for better crop growth.

Further to that, the farmers commented that practicing proper soil management would require access and control over resources such as adequate land, money for inputs, digging terraces, etc. and cattle for manure production. Adequate land is required for both cropping and grazing. Grazing land is important for rearing or keeping livestock (particularly, cattle) for manure production. Proper soil management also requires oxen and ox-plough for ploughing and weeding early, shovels for digging terrace, hoes for land preparation and weeding as well as adequate labour for undertaking the management practices.

Based on these two sets of criteria, the farmers identified three levels of soil management amongst themselves. These are good, medium and low soil managers. Good soil managers are those practicing at least four of the soil management practices and have most of the important resources such as oxen, cows (manure), ox-plough, land and money. Those in the medium class practice at least three of the management practices and have moderate resources while the low soil managers practice less than three practices and have very little resources.

The team then selected farms according to these three hypothetical levels of management for each of the three physiograpghic positions identified above, for a an appraisal of the diversity that may exist in soil management at the farm level. This resulted in nine hypothetical farm types as follows:

Farm type	Category
Type 1	Hill – good
Type 2	Hill – medium
Type 3	Hill – low
Type 4	Slope – good
Type 5	Slope – medium
Type 6	Slope – low
Type 7	Plain – good
Type 8	Plain – medium
Type 9	Plain – low

A checklist of was prepared on the practices and resources farmers have identified for proper soil management (appendix 5) for a quick semi-structured survey of the selected farms. This was to verify farmers perception of proper soil management and to obtain some qualitative information for better understanding of the diversity among the farms (refer chapter three). A summary of the results of the farm appraisal are in appendices 6-8. Analysis of the information gathered from these nine farm types revealed that some of the major soil types occur anywhere on the toposequence. Thus almost all farms have same soil types. For instance, kitune and nthangathi nziu could occur on the hill as well as the slope and plain. In fact all farms appeared to be on both hilly and flat lands. This proves valid the observation made in section 4.1. It was also observed that soils might be managed differently not necessarily due to differences in physical and chemical characteristics but due to where they are found on the toposequence. Hilly areas are usually terraced and manure applied to the soils due to problems of erosion. Such areas are used for the production of maize, beans, cowpeas, & pigeon peas.

The same soils on plains or foot slopes (which are not normally terraced because they are less prone to erosion) may not be manured (except for vegetable production in more sandy soils). This is because they take advantage of soils and nutrients eroded and deposited from the hills and slopes, hence are more fertile. Such soils may be used for the production of vegetables, sweet potatoes and cassava (for ease of harvesting) in addition to those crops grown on the hilly areas. Thus the hill and slope are managed in a similar manner but differently from the plains with regards to terrace and manure application. This was the most striking difference between farms with respect to topography. All soils are ploughed and weeded (except pure bean and mixed crop stands) with oxen irrespective of where they occur on the topography.

The timeliness of ploughing and weeding with oxen does not depend on topography but rather on the access and control over resources such as an ox and ox-plough, money and labour. In some cases the structure of a soil may influence timeliness in ploughing. A friable soil may be easily ploughed even before the onset of the rains (when dry) irrespective of topography. Such soils could occur on the plains where there are possibilities of sandy or silty loams. They could also be found on the hilly areas depending on how well terraces have been constructed and protected and how well the soils have been manured and properly ploughed over the years.

A closer look at the soil management practices on farms in the three management levels (good, medium and low) show only micro differences within classes in same position. For farms on the hills, there was no information on the low management class. However, there was virtually no difference between the good and medium with respect to the practices. There were only slight differences in terrace maintenance but again this depend on how well the terrace has been constructed and protected and of course the availability of money and labour to do so.

The use of mineral fertilizer is not a common practice in the area. Only few farmers do so for vegetables and maize production. Farmers claim it scorches crops if moisture is inadequate. They also lack money to purchase them and lack adequate knowledge on its use.

The same was true for all classes of farms on the slopes, although the low class was again not well represented. On the plains, terracing and manure are not normally required, except those with farms stretching continuously from some portion of the slope to the plain. No manure is applied on one low management farm on the plain. This may be because it is either not available (because the farmer owns only two goats) or have no money to purchase some (although has terraces). It may also be due to the fact that the greater part of the farm is on the plains (which are not normally manured) or the land is quite new.

The same low management farm on the plain planted after the onset of rains (probably, it is the same for ploughing because both are done simultaneously). This may be explained by the fact that both the oxen and plough are borrowed from neighbours (appendix 8) hence has to wait for neighbours to theirs available. Thus ownership of an oxen and an ox-plough could influence timeliness of ploughing, planting and weeding.

The resource capacity of the different farms (although not quantified), does not seem to vary with topography but rather, with the three level of management (good, medium and low) within farms in the same physiographic position. On the hills the good class has the largest farm sizes, greater than 20 acres, while the medium has up to about 10 acres. The pattern is similar among farms on the slope and plains with the low class having the least farm size, 3 acres and below.

The same may be true for livestock ownership and the amount of labour available on the farm. Due to the qualitative nature of the survey these differences are not very clear. Ownership of ox and ox-plough is quite common among almost all the classes in all the positions. Except one medium farm on the plain (borrows or rents because there is no grazing area for cattle) and one low management farm on the plain (inadequate money to purchase them).

From the foregoing, it can be deduced that topography may not be a good criterion for classifying farms for soil management. The access and control over resources for soil management could probably influence soil management within classes of farm irrespective of position. However, this is not very well illustrated because of inadequate quantitative data to substantiate the few differences observed. Also, there seem to be not much difference between the good and medium classes (except in the area of farm size). In addition, the low management class was not well represented, making it difficult to explain the diversity that may exist between the better off class and the low ones.

It was noted that the poor representation of the low class could be because classification was done at the sub-location level. Most villages in the sub-location are quite distant from the central place for meetings. Thus in most cases, it is mostly the more influential and people living close by who are likely to attend farmer meetings. Moreover, gender differences in soil management were also not clear. For instance, female managed farms found on the slope were not very different from male managed ones in same class of the same position or same class elsewhere.

In view of the above, a village level study was carried out to get a better representation of the classes of farms in the area and identify a number of classes of farms with similar soil management characteristics. The study was also to explore more and understand better the differences in these classes with respect to soil management, this time with emphasis on the influence of the access and control of the resources identified above. The study as to quantify some of these resources to confirm and explain the diversity among farms.

4.2.2.2 Village level classification

Mavemba village, one of the villages in the sub-location was selected for the case study. It was selected in a discussion with farmers. Mavemba village was chosen because it is a medium sized village, easily accessible, has all the major soil types identified in section 4.1 above and has more social cohesion among the people.

In a discussion with farmers in Mavemba village to understand their perception of proper soil management, the farmers identified the criteria for proper soil management to be the use of manure on farms to improve soil fertility, terracing of hilly areas and loosening of the soil early for planting. They also identified the use of mineral fertilizer to improve soil fertility and good income for undertaking farm operations.

Reasons farmers gave to support these criteria are quite similar to those of farmers at the sub-location level. The farmers then grouped themselves into good, medium and low soil managers as groups A, B, & C respectively, based on these criteria. Farms in group A (good) practice four to five of the criteria, those in B (medium) at least three and those in C (low) two and below.

Two groups or classes, medium and low managers emerged. There was no farm in group A or the good class. Each group composed of male and females, thus further classification was done based on gender to obtain four groups. The four groups were considered as four hypothetical farm types. The four farm types are as follows:

Farm Type	Category
I	Medium male managed
II	Medium female managed
III	Low male managed
IV	Low female managed

Each group identified a number of soil management problems, their causes, coping strategies and opportunities they perceived for alleviating these problems. The problems were later ranked to identify the priority ones for research and extension considerations (refer chapter three and section 4.2.3 for details). Farms from each group were then selected for a quantitative appraisal.

A questionnaire was designed based on the criteria farmers have identified so far (both sub-location and village levels) for proper soil management (appendix 9). A quantitative survey was carried out on the selected farms within each category (refer chapter 3).

Tables 4.8-4.11 are summary descriptions or overviews of the farm types with respect to soil management practices and resources required for proper soil management from the view points of management levels B (medium) & C (low) and gender (male and female).

Table 4.8 Soil management characteristics of farms in Kasikeu sub-location

Soil management practice	FARM TYPES			
	Medium male	Medium female	Low male	Low female
Terracing Presence of terrace	100% have	75% have	75% have	100% have
Terrace type	100% Fanyaju	100% Fanyaju	100% Fanyaju	88% fanyaju 12% trash lines
Maintenance	100% yearly	100% yearly	100% yearly	70% yearly
Fertilization Manure use	100% apply	100% apply	50% apply	100% apply
Manure source	Cattle, goats, sheep, Poultry & household waste.	Cattle, goats, sheep, Poultry & household waste.	Cattle, goats, sheep, Poultry & household waste.	Cattle, goats, sheep, poultry, household waste, crop residue.
Manure production & storage	Animals mostly enclosed in shed at night to produce manure but stored in the open.	Animals mostly enclosed in shed at night to produce manure but stored in the open.	Animals mostly enclosed in shed at night to produce manure but stored in the open.	Animals mostly enclosed in shed at night to produce manure but stored in the open
Application method.	Broadcast (spread) & ploughed in.	Broadcast (spread) & ploughed in.	Broadcast (spread) & ploughed in.	Broadcast (spread) & ploughed in.
Part of farm & crop	Hilly area. Mainly maize, beans, pigeon peas.	Hilly area. Mainly maize, beans, pigeon peas.	Hilly area. Mainly maize, beans, pigeon peas.	Hilly area. Mainly maize, beans, pigeon peas.
Mineral fertilizer use	100% none	75% use	25% use	100% none
Time of applying mineral fertilizer	–	67% before planting & 33% after planting	100% before planting	–
Crop(s) fertilized		Maize	Maize	
Ploughing Ploughing with oxen	100%.	100%.	100%	71%
Timeliness of ox-ploughing	83% timely (on-set of rain).	100%timely (on-set of rain).	75% plough late.	60% timely
Weeding Weeding with oxen	67% ox plough weeding for pure maize stand.	100% ox plough weeding for pure maize stand	25% ox plough weeding for pure maize stand	43% ox plough weeding for pure maize stand
Timeliness of ox-weeding	100% timely	100% timely	100% timely	100% timely

Table 4.9 Resources controlling soil management on farms in Kasikeu sub-location

Resource	FARM TYPES			
	Medium male	Medium female	Low male	Low female
Average household size Number on farm	12 11	6.3 5.5	6.3 6.3	7 5
Land ownership (% of farms Family Own	 67% 33 %	 100% 50%	 75% 25 %	 57% 43%
Farm location	Hill & slope	Slope	Hill & slope	Hill, slope & plain
Farm size (acres)	15	6.8	4.8	7.0
Area under crops (acres)	6.7	4.0	2.5	2.5
Area under grazing (acres)	7.5	2.5	0.5	0.5
Average livestock owned (total)	32	16	13.3	11.2
Oxen Cows Goats Sheep Poultry	2 3 9 3 15	1 3 5 2 5	0 0.3 3 1 9	0.2 2 4 0 5
Ownership of oxen & ox-plough (% of farms)	83%	75%	100% none	71% none
Access to oxen for Ploughing Weeding	 100% 67%	 100% 100%	 100% 25%	 71% 43%
Labour source (Av. No.) Family Hired/communal Family (men : women) Hired/communal (men : women)	Family & hired 6 (75%) 2 (25%) 50% : 50% 60 %: 40%	Family & hired 2 (40%) 3 (60%) 15% : 85% 67% : 33%	Family 2.3 (100%) 0 57% : 43% 0 % : 0%	Family, hired, communal 2.3 (37%) 4 (63%) 39% : 61% 0% : 100%
Sources of income(% of farms) On-farm only On and off-farm	 67% 33%	 25% 75%	 75% 25%	 43% 57%
Financial potential (Ksh)	454,402.00	228,447.00	134,106.00	104,449.00

Table 4.10 Soil management characteristics on medium & low vrs male & female managed farms

Soil management practices	Medium soil managers	Low soil managers	Male soil managers	Female soil managers
Terracing (% of farms)				
Presence of terrace	90%	90%	90%	90%
Terrace type	100% fanyajuu	90% fanynjuu 10% trash lines	100% fanyajuu	90% fanynjuu 10% trash lines
Maintenance	100% yearly	70% yearly	100% yearly	70% yearly
Fertilization (% of farms)				
Manure use	100%	82%	80%	100%
Manure source	Cattle, goats, sheep, poultry, household waste.	Cattle, goats, sheep, poultry, household waste, crop residue.	Cattle, goats, sheep, poultry, household waste.	Cattle, goats, sheep, poultry, household waste, crop residue.
Manure production & storage	Animals mostly enclosed in shed at night to produce manure but stored in the open	Animals mostly enclosed in shed at night to produce manure but stored in the open	Animals mostly enclosed in shed at night to produce manure but stored in the open	Animals mostly enclosed in shed at night to produce manure but stored in the open
Application method	Broadcast (spread) & ploughed in.	Broadcast (spread) & ploughed in.	Broadcast (spread) & ploughed in.	Broadcast (spread) & ploughed in.
Mineral fertilizer use	30%	9%	10%	30%
Crops	Maize	Maize	Maize	Maize
Ploughing (% of farms)				
Ox-ploughing	100%	82%	100%	82%
Timeliness of ox-ploughing	90% timely	44%	60% timely	78%
Weeding (% of farms)				
Ox-weeding	80%	36%	50%	64%
Timeliness of ox-weeding	100% timely	100%	100% timely	100%

Table 4.11 Resources controlling soil management on medium & low vrs male & female managed farms

Resources controlling soil management	Medium soil managers	Low soil managers	Male soil managers	Female soil managers
Average household size	9.6	6.46	9.6	6.46
On farm	8.5	5.64	8.8	5.36
Off farm	1.1	0.82	0.8	1.1
Land ownership				
Family	60%	64%	70%	55%
Own	60%	36%	30%	60%
Average farm size (acres)	11.7	6.1	10.9	6.9
Area under crop (acres)	5.6	2.5	5.63	3.25
Area under grazing (acres)	5.5	0.5	5.75	1.5
Total livestock owned(per farm)	25.3	11.6	25	13.6
Oxen	1.6	0.1	1	0.6
Cow	2.9	1.4	2	3
Goats	7.5	3.5	7	4
Sheep	2.3	0.4	2	1
Poultry	11	6.2	13	5
% Ownership of oxen & ox-plough	90%	9%	50%	46%
% Access to oxen				
Ploughing	100%	82%	100%	82%
Weeding	80%	36%	50%	64%
Labour source	Family & hired	Family & hired	Family & hired	Family & hired
Family (Av. No.)	4.4 (66%)	2.3 (50%)	4.6 (79%)	2.09 (39%)
Hired/communal	2.3 (34%)	2.3 (50%)	1.2 (21%)	3.27 (61%)
Family (men : women)	46% :54%	44% : 56%	52% : 48%	29% : 71%
Hired/communal (men : women)	61% : 3.9%	0% : 100%	58% : 42%	18% : 8 2%
Sources of income (% of farms)				
On farm	-	-	-	-
Off farm	50%	45%	30%	65%
Financial potential	365,228.000	179,292.00	327,491.00	215,474.00

Differences in soil management on farms

Terracing

Table 4.12 Terrace and terrace maintenance

Practice	FARM TYPES			
	Medium male	Medium female	Low male	Low female
Presence of terrace	100% have	75% have	75% have	100% have
Terrace type	100% fanya juu	100% fanya juu	100% fanya juu	88% fanya juu 12% trash lines.
Maintenance	100% yearly	100% yearly	100% yearly	70% yearly

Table 4.13 Terrace and terrace maintenance: soil management level & gender

Practice	FARM TYPES			
	Medium	Low	Male	Female
Presence of terrace	90%	90%	90%	90%
Terrace type	100% fanya juu	90% fanya juu 10% trash lines	100% fanya juu	90% fanya juu 10% trash lines.
Maintenance	100% yearly	70% yearly	100% yearly	70% yearly

The fanya juu type of terrace usually maintained yearly is common in all farm types. Only a small percentage (12%) in the low female class or (10 %) in female and low management classes have trash lines. This is due to inadequate labour and money for digging terraces). Farms without any type of terrace (25% medium female & 25% low male management classes) may either be relatively new farmlands, farms on more gentle slopes or it may be due to inadequate money and labour for doing so.

The inability of the 30% farms in the low female class to maintain terraces yearly or regularly could also be due to inadequate money and labour. This class has access to communal labour from about fifteen women in a group (table 4.9). However, this labour is not normally used for terrace maintenance but rather for more priority farm operations like ploughing, planting, weeding, etc. The class also has the lowest financial potential (table 4.9), hence inadequate money for hiring labour for terrace maintenance.

Fertilization

Table 4.14 Manure & mineral fertilizer use

Practice	FARM TYPES			
	Medium male	Medium female	Low male	Low female
Manure use	100% apply	100% apply	50% apply	100% apply
Mineral fertilizer use	100% none	75% use	25% use	100% none
Time of application	–	67% before planting 33% after planting	100% before planting	–
Crop(s) fertilized		Maize	Maize	

Manure is commonly produced from a mixture of fecal material of cattle, goats, sheep, poultry; crop residues and household wastes. The cattle is kept in an enclosure called "boma" overnight. Left over from crop residues fed to cattle mixes up with their dung in the "boma". Goats, poultry and sheep droppings as well as household wastes are added to the mixture. It is normally stored in the open and applied on the farm by broadcasting before ploughing.

50% of the low male management class are unable to apply manure on farms. The major reason is lack of livestock on some farms in this class due to inadequate money to purchase them or no grazing area. Table 4.9, shows only an average of 0.3 cows and no oxen (which are major sources of dung for manure) and 0.5 grazing area per farm in this class. It may also be due to inadequate money to purchase manure from elsewhere.

The use of mineral fertilizer is generally not a common practice in the area, mainly due to inadequate money to purchase and lack of knowledge on its use. However, a higher percentage (75%) of farms in the female medium class apply mineral fertilizer because most of them have access to off farm income (table 4.9) from husbands working out of the farm as well as from petty trading.

Table 4.15 Manure & mineral fertilizer: management level & gender

Practice	FARM TYPES			
	Medium	Low	Male	Female
Manure use	100%	82%	80%	100%
Mineral fertilizer use	30%	9%	10%	30%
Time of application	67% before planting 33% after planting	100% before planting	100% before planting	67% before planting 33% after planting
Crop(s) fertilized	Maize	Maize	Maize	Maize

A higher percentage of farms in the medium class use manure as compared to those in the low management class, although the difference is not much. Again this could be explained by the absence of cattle on some of the low management farms and inadequate financial resources for purchasing cattle or manure (table 4.11). The same may be true for the 20% males who do not use manure on male managed farms.

Comparing mineral fertilizer use between medium and low management classes, only 9% of the low management farms are able to do so. This could be due to fewer farms having off-farm income and a lower financial potential (table 4.11). More female managed farms use mineral fertilizer than male ones. This could be linked more to access to off-farm income by a greater proportion of the females than males.

Ox-ploughing and weeding

Table 4.16 Ox-ploughing and weeding

Practice	FARM TYPES			
	Medium male	Medium female	Low male	Low female
Ploughing with oxen	100%	100%	100%	71%
Timeliness of ox-ploughing	83% timely	100%timely	25% timely	60% timely
Weeding with oxen	67%	100%	25%	43%
Timeliness of ox-weeding	100% timely	100% timely	100% timely	100% timely

Majority of all farms plough with oxen. This is because access to oxen for ploughing is normally not a problem. Table 4.11 above shows a high percentage of all farms having access because those who do not possess it can borrow or rent and either plough earlier or after others can make theirs available.

However, the timeliness of ploughing with oxen is a major problem to a higher proportion of the low management classes, especially the males. Only 25% of the low management farms plough timely with oxen. A higher percentage of low male and female farms own no oxen and ox-plough (table 4.11). The implication is that majority of farms in the medium classes (a greater percentage of whom own oxen and ox-plough) plough early or timely (mostly at onset of the rains) when the soils are easier to be worked and tillage depth is better. Those in the low classes may either have to plough late or plough much earlier when it is dry and the soils are hard and difficult to be worked. This may require more labour and/or result in poor soil tillage, since the depth of tillage is likely to be low.

Access to oxen for weeding seem to be crucial for timeliness in weeding because all farms weeding with oxen do so timely. Most farms start weeding around the same time (three weeks after planting maize and when beans are at two-three leave stage), thus the demand for oxen during the time of weeding may be high. Pure maize stands are normally weeded with ox-plough while maize-beans inter-crops and pure bean stands weeded with hoes. Most farms in the male and female medium classes thus weed early. Majority of those in the low male and female classes would either have to weed much earlier (before the three weeks after planting) to be on time or weed late with the plough or weed with the hand hoe using more time and labour. It is also because they have inadequate money for renting.

Table 4.17 Ox-ploughing and weeding: soil management level & gender

Practice	FARM TYPES			
	Medium	Low	Male	Female
Ploughing with oxen	100%	82%	100%	82%
Timeliness of ox-ploughing	90% timely	44% timely	60% timely	78% timely
Weeding with oxen	80%	36%	50%	64%
Timeliness of ox-weeding	100% timely	100% timely	100% timely	100% timely

Similarly, access to oxen for ploughing is not a major problem whether one is medium or low soil manager or male or female. Again timeliness is a major issue especially for a greater number of the low management farms. Comparing male and female farms, more females plough timely than the males.

Differences in resource potentials on farms

Household size & farm labour

Table 4.18 labour availability for farm operations

Resource	FARM TYPES			
	Medium male	Medium female	Low male	Low female
Av. Household size (total)	12	6.3	6.3	7
On farm	**11**	**5.5**	**6.3**	**5**
Off farm	1	0.8	0	2
Labour source	Family & hired	Family & hired	Family	Family, hired, communal
Total number of people	**8**	**5**	**2.3**	**6.3**
Family	6 (75%)	2 (40%)	2.3 (100%)	2.3 (37%)
Hired / communal	2 (25%)	3 (60%)	0	4 (63%)
Male : female				
Family	50% : 50%	15% : 85%	57% : 43%	39% : 61%
Hired	60% : 40%	67% : 33%	0	0 : 100%

The number of people living on the farm is higher on the medium male farms. This could explain why the medium male farms rely more on family labour. Both male and female household members are equally engaged in farm work.

The medium female farms have less people living on farm. They hire more labour, most of whom are males and some of them are permanent farm hands. As has been mentioned earlier on most of these females have husbands who work outside the farm. They also engage in petty trading off farm. Thus they have extra income for hiring labour and for purchasing other resources.

The low male management farms have the entire households living on farm but have the least labour potential for farm operations. This may be because they have little resources (land, money etc.) at their disposal, thus most often trade-off their labour to the medium class farms for either money or oxen and a plough for land preparation. Most often than not money obtained outside the farm is used in supplementing household expenses and not invested in the farm. With inadequate money, they are also unable to engage hired labour. Moreover, they have no access to any communal labour.

The low female farms have the least number of people living on farm. However, they have a higher labour potential because they have access to communal labour from fifteen-member women group for undertaking some farm operations like ploughing, weeding and harvesting.

Table 4.19 labour availability: management levels & gender

Resource	FARM TYPES			
	Medium	Low	Male	Female
Av. Household size (total)	9.6	6.46	9.6	6.46
On farm	8.5	5.64	8.8	5.36
Off farm	1.1	0.82	0.8	1.1
Labour source	Family & hired	Family & hired	Family & hired	Family & hired
Total number of people	**6.7**	**4.6**	**5.8**	**5.4**
Family	4 4 (66%)	2.3 (50%)	4.6 (79%)	2.1 (39%)
Hired/communal	2.3 (34%)	2.3 (50%)	1.2 (21%)	3.3 (61%)
Male : female				
Family	46% : 54%	44% : 56%	52% : 48%	29% : 71%
Hired	61% : 39%	0 : 100%	48% : 42%	18% : 82%

The labour potential on medium management farms is higher (most of which is family labour) than on the low ones. This could be because they have more people living on the farm. The higher percentage of hired labour on low management farms is as a result of the communal labour from the low female group (because the low males neither hire nor use any communal labour).

Comparing the male managed farms with the female ones, the males have more labour on farm, a greater proportion of which is family labour. The females have about the same labour potential as the males but engage more labour from outside the farm. Again this is due to access to off-farm income and communal labour (low female).

Farm land

4.20 Land ownership & use

Resource	FARM TYPES			
	Medium male	Medium female	Low male	Low female
Ownership (% farms)				
Family	67%	100%	75%	57%
Own	33%	50%	25 %	43%
Farm size (acres)	15	6.8	4.8	7.0
Area under crops	6.7	4.0	2.5	2.5
Area under grazing	7.5	2.5	0.5	0.5

Medium male farms have the largest farm sizes with a greater number of the farmlands being family lands, thus they are able to put more land under cultivation and grazing. It was noted that some of the males in the medium class are in charge of their family lands. Thus they have ready access to a bigger portion of the land. Most medium females have access to family land (either belonging to husbands family or own family) and their own private lands mostly purchased by husbands working off-farm.

The low male farms are the least in sizes but majority of these are family lands. Of course with few having off-farm income and virtually all family members living on farm, it is difficult to earn adequate money to purchase their own lands to supplement the few acres that may be obtained from the extended family (which may have to be shared among several people).

The low females have quite larger farm sizes with quite a good number of them being privately owned lands. However, they are unable to cultivate bigger areas and even have small grazing areas. This could be explained by the fact that some of them have inadequate money for investing into the farm (eg. Widows). It is also because those among them farming family lands can only have access to smaller acreages. In fact some of them have no grazing area at all and would have to graze the few livestock they have on the fields of other family members or that of neighbours in exchange for some service. This is also true for the low male farms.

4.21 Land ownership & use: management levels & gender

Resource	FARM TYPES			
	Medium	Low	Male	Female
Ownership (% farms)				
Family	60%	64%	70%	55%
Own	60%	36%	30%	60%
Farm size (acres)	11.7	6.1	10.9	6.9
Area under crops	5.6	2.5	5.63	3.25
Area under grazing	5.5	0.5	5.75	1.5

Generally, the medium class farm put more land under cultivation and grazing than the lower class probably because they have more land at their disposal. A greater proportion of them have privately owned lands either through purchasing or sub-division and registration (title deeds) of family lands.

A higher percentage of the males farms, farm mainly on family lands while a higher percentage in the females farms have either only privately owned land or both private and family land. This again is due to extra income husbands working outside bring in for purchasing their own lands as compared to the males the majority of whom depend mainly only on farm income. With bigger household sizes on farm, it may be impossible to have sufficient money for purchasing land unless those who have family lands sub-divided with title deeds.

Livestock

Table 4.22 Livestock ownership

Resource	FARM TYPES			
	Medium male	Medium female	Low male	Low female
Average total	**32**	**16**	**13.3**	**11.2**
Oxen	**2**	**1**	**0**	**0.2**
Cows	**3**	**3**	**0.3**	**2**
Goats	9	5	3	4
Sheep	3	2	1	0
Poultry	15	5	9	5

There are more livestock on medium male farms than the others. The number of cattle (cow & oxen) is higher on the male and female medium farms. Of course with better income and larger grazing lands these farms are able to keep more cattle than the low male and female farms. Thus, although it was impossible to quantify or estimate the total amount of manure produced from each farm type because farmers do not normally quantify the manure they apply on their farms, the amount of manure produced from livestock (especially cattle) is likely to be higher in the medium class than the low ones.
Availability of oxen in medium classes also means ploughing and weeding may be done early while the low classes may be at a disadvantage in this regard.

Table 4.23: Livestock ownership: management levels & gender

Resource	FARM TYPES			
	Medium	Low	Male	Female
Average total	25.3	11.6	25	13.6
Oxen	**1.6**	**0.1**	**1**	**0.6**
Cows	**2.9**	**1.4**	**2**	**3**
Goats	7.5	3.5	7	4
Sheep	2.3	0.4	2	1
Poultry	11	6.2	13	5

The average number of livestock owned per farm is higher in the medium class than the low management. Possible reasons are similar to those mentioned for the four management classes above. The male farms have more livestock in total but fewer cattle than the female managed farms. This is because some low males have no cattle on the farm for obvious reasons of limited resources on such farms.

Oxen & Ox-plough

Table 4.24: Ownership & access to oxen & ox-plough

Resource	FARM TYPES			
	Medium male	Medium female	Low male	Low female
Ownership	83%	75%	100% none	71% none
Access for				
Ploughing	100%	100%	100%	71%
Weeding	67%	100%	25%	43%

As has been stated above access to oxen for ploughing is generally not a problem because even the majority of the low male and female farms who do not own an ox and ox-plough have them for ploughing. Timeliness of ploughing may be the problem which most of the low male and female farm would have to contend with since they have to rely on the medium classes

Access to oxen for weeding is crucial for timeliness in weeding. Table 4.16 shows that all those who have access to oxen for weeding weed timely. Lack of oxen and ox-plough in majority of the low male and female management farms is the main reason why only a small percentage of such farms have access to them for weeding compared to those in the medium male and female ones (who own them).

Table 4.25: Ownership & access to oxen & ox-plough: management levels & gender

Resource	FARM TYPES			
	Medium	Low	Male	Female
Ownership	90%	9%	50%	46%
Access for				
Ploughing	100%	82%	100%	82%
Weeding	80%	36%	50%	64%

The problem of access to oxen for weeding is again observed in the low management farms because very few of them own an ox and ox-plough. The differences between male and female managed farms is not very pronounced in this regard, although more females seem to have access to oxen for weeding than the males.

Financial capacity

4.26: Income source & financial potential

Resource	FARM TYPES			
	Medium male	Medium female	Low male	Low female
Income source On farm only	67%	25%	75%	43%
Both on- farm & off farm	**33%**	**75%**	**25%**	**57%**
Financial potential	**454,402.00**	**228,447.00**	**134,106.00**	**104,449.00**

A greater percentage of the medium female farms have access to off farm income. The reason as has been stated earlier on is because of husbands working off the farm and petty trading in the local market or kiosks. The off farm income sources of the males are from the making of mud bricks and stone harvesting for sale; masoning and casual labour.

The financial potential of the male medium class is the highest because they are better endowed with resources such as land, labour livestock, ox-plough; etc.

4.27: Income source & financial potential: management levels & gender

Resource	FARM TYPES			
	Medium	Low	Male	Female
Income source (% of farms) On farm only	50%	55%	70%	35%
Both on farm & off farm	**50%**	**45%**	**30%**	**65%**
Financial potential	365,228.000	179,292.00	327,491.00	215,474.00

More farms in the medium class have off-farm income than those in the low class. However, more female managed farms have off-farm income than the male ones. The reasons being as stated in the previous paragrapgh.

The financial potentials of the medium classes are higher than that of the low ones. This could be because the medium classes have more land, livestock, ox-plough and labour on the farm. Similarly, the financial potentials of males are higher than that of the females. Again the reason is that the males have more land, livestock and labour.

It can be deduced from the foregoing that classification of farms for soil management based on soil management levels (medium and low managers) is quite appropriate for explaining diversity among farms. The distinction between the medium and low classes are more governed by their resource capacities. It is evident from the study that proper soil management requires access and control over some of the resources discussed above. Thus the medium class farms with better resource endowments seem to better soil managers than the low class farms.

Resources controlling proper soil management may be some of the most critical factors that need to be considered in soil management on farms. These may include land especially for grazing, ownership of oxen and ox-plough for timeliness in ploughing and weeding, labour availability on the farm for priority farm operations in soil management such as terracing, manure application, ploughing and weeding. Others are livestock, particularly, cattle for manure production, off-farm income and adequate finances for investments in soil maintenance and conservation.

4.2.3 Problems in Soil Management

Soil management problems, their causes, coping strategies and opportunities to tackle them were identified in a participatory manner as per the four farm types described under section 4.2.2 and have been presented in appendices 23-26. These problems and their causes were analyzed and developed into problem-causal trees (Fig. 4.4 - 4.7) according to different farm types and are described below.

Medium management class

Medium male farmers

The male farmers of medium management class identified low soil fertility, soil erosion, hard soils and scarcity of money as the key problems in soil management (Fig. 4.4).

The causes of low soil fertility were soil erosion and inadequate use of manure and fertilizers. Soil erosion was mainly because of inadequacy of terraces, over grazing and bare soils. Hard soils were ascribed to the inherent property of some soil types and continuous shallow cultivation while scarcity of money was mainly because of lack of credit facilities in the area.

To deal with the problem of low soil fertility farmers use little manure available at their farm. To control soil erosion, ploughing along the contour is practiced. For hard soils, farmers wait for the rains. To cope up with the scarcity of money, some farmers sell the crop or livestock products.

Medium female farmers

According to female farmers of the medium management class, low soil fertility, soil erosion, hard soils and lack of oxen and plough were the main problems in soil management (Fig. 4.5).

The causes of low soil fertility were identified as inadequacy of manure, scarcity of money to buy manure and lack of knowledge on mineral fertilizer use. Soil erosion was said to be because of inadequate erosion control measures, over grazing, bare soils and steep slopes. The lack of plough and oxen was mainly because of scarcity of money.

To tackle the problem of low soil fertility, farmers use "*boma*" manure. Some of the farmers add a little fertilizer either at planting or as top dressing. To control soil erosion, some dig terraces, some plant grass strips, use trash and stone linings while some of them adopt agro-forestry. Reduced grazing on cultivated land was also mentioned as one of the measures to reduce soil erosion.

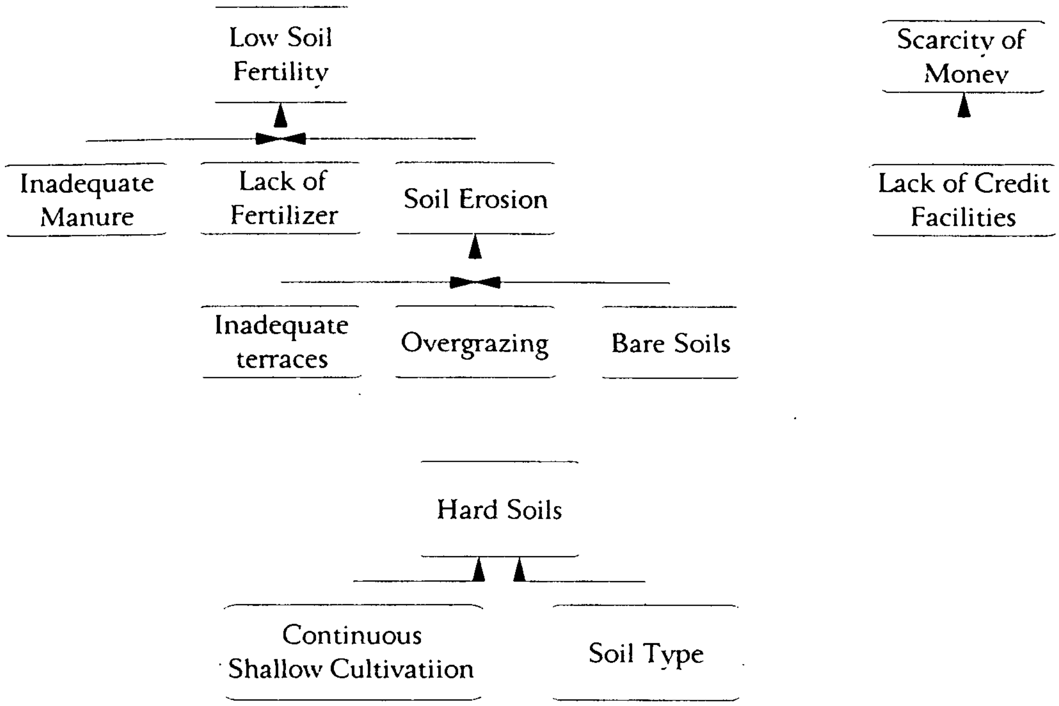


Fig. 4.4 Problem-causal trees as per male farmers of medium management class

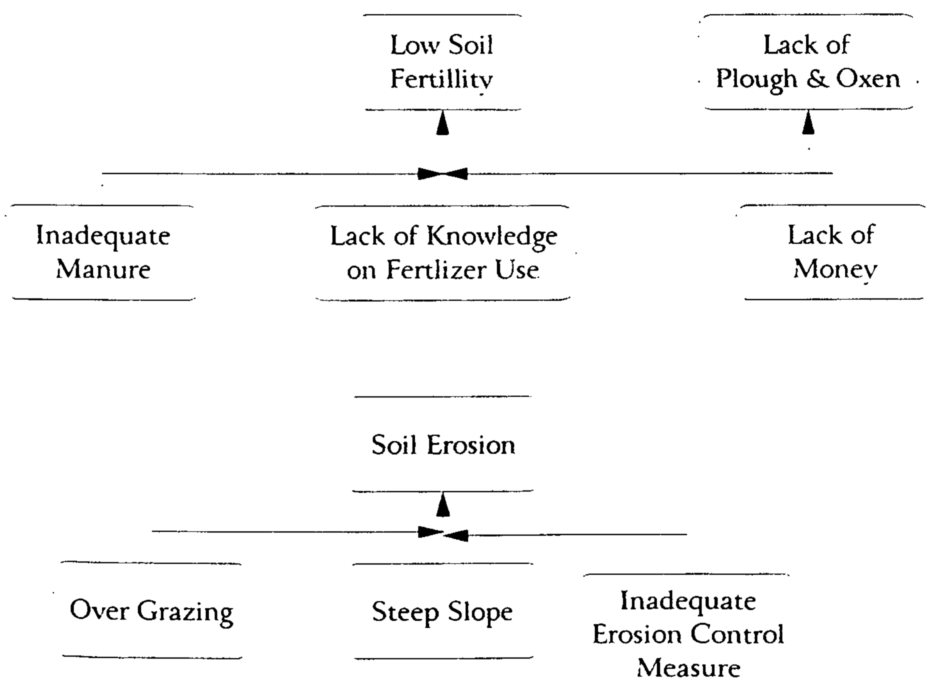


Fig. 4.5 Problem-causal trees as per female farmers of medium management class

Low management class

Low male farmers

The male farmers of low management group identified low soil fertility, gully erosion, scarcity of labor, and water logging as the major problems in soil management (Fig. 4.6).

According to them soil erosion and continuous cultivation for long time without sufficient use of manure and fertilizers were the main causes of low soil fertility. The cause of gully erosion was runoff water from steep slopes. This may again be attributed to inadequacy of terraces because of scarcity of labor, money and implements to dig the terraces. For water logging specific type of soils located in flat/ plain areas and under ground seepage water were identified as the main cause.

To cope with the problem of low soil fertility farmers add little manure if available, dig terraces to control the erosion and consequent loss of nutrients and cultivate on and around anthills if available. A few farmers use little fertilizers also. To control gully erosion, farmers place boulders, sand bags and twigs in the gullies. Planting of napier grass, sisal and *Euphorbia* sp. in the gullies is also done.

To cope with the scarcity of labor for digging terraces, farmers spread the digging of terraces over time. In place of terraces, some of the farmers plant grass strips, use trash and stone lines and leave about one foot uncultivated land along the contour. To solve the problem of water logging, farmers have no option except waiting for water to drain off naturally.

Low female farmers

According to the female farmers of low management group (Fig. 4.7), inadequacy of manure, compact soils, inadequacy of terraces and low soil fertility were the main problems in soil management.

The inadequacy of manure was attributed to few number of animals while compact soils were said to be because of continuous shallow cultivation. The scarcity of labor and money led to inadequate number of terraces to control soil erosion. For low soil fertility, continuous cultivation because of small land holdings in conjunction with inadequate use of manure to replenish the plant nutrients was ascribed as the main cause.

The strategies used to cope with the problem of inadequate manure, farmers spread the manure application on their farm over the time. For compact soils they wait until the soils are wet as a result of rains. To deal with the low soil fertility inter-cropping is practiced. To control soil erosion in absence of terraces, planting of grass strip is adopted.

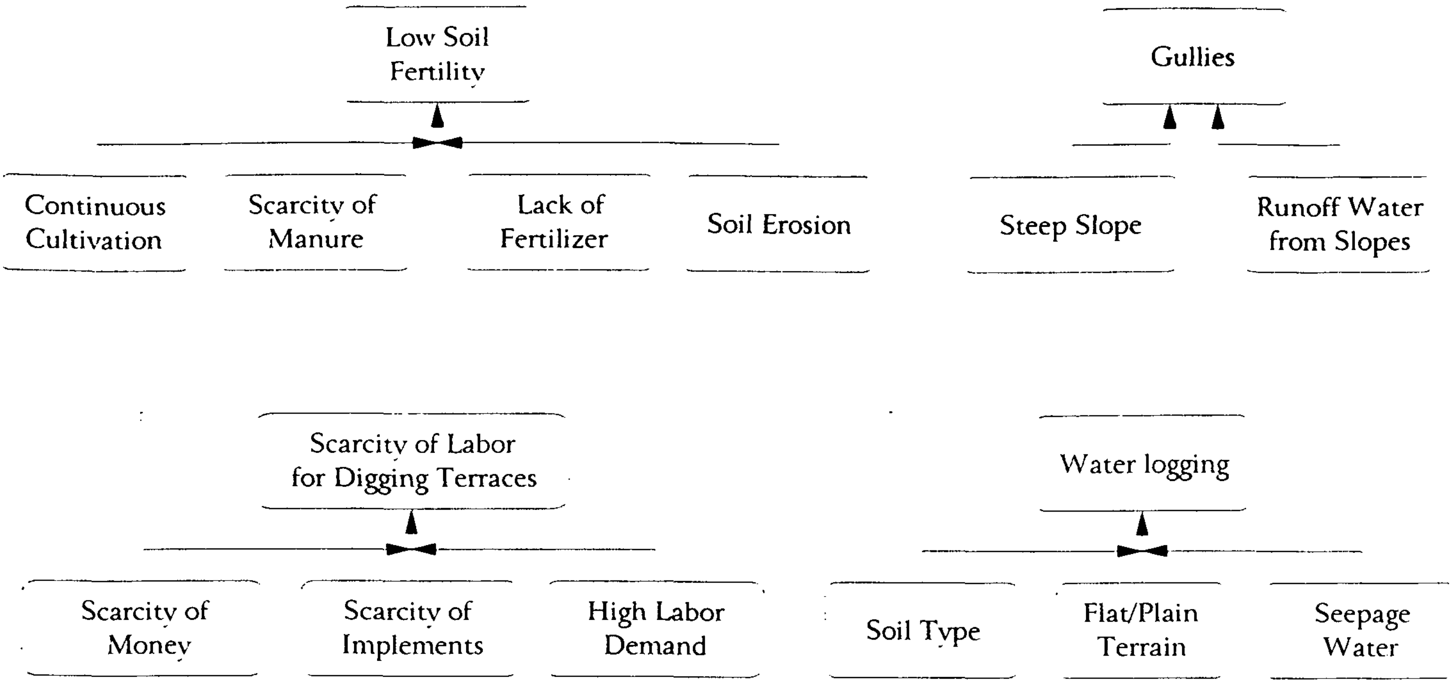


Fig. 4.6 Problem - causal trees as per male farmers of low management class

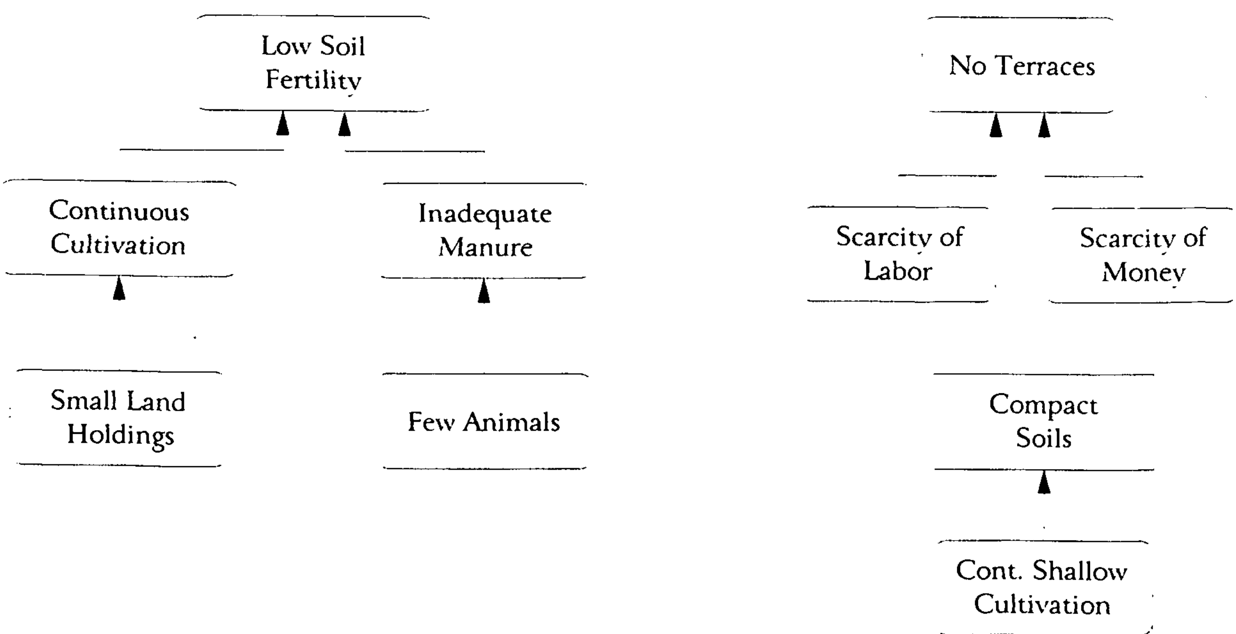


Fig. 4.7 Problem - causal trees as per female farmers of low management class

The above results indicate that although the perception on soil management problems and their causes varied among the four different class of farms, the differences were more pronounced between the two management levels (medium and low) than between male and female managed farms. In other words, most of the problems and causes for males and females in each management level were related. This could be attributed more to the differences in the socio-economic standing of these two classes of farms.

It was observed in section 4.2.2 that the level of soil management on farms was more or less dependent on their resources capacities. Thus, one would expect some differences in soil management constraints between the two management levels, medium and low but more similarities among farms in each management level. For instance, the only differences between problems and causes identified by males and females in the medium class were compact or hard soils by males and lack of oxen and ox-plough by females. Similarly, water logging by males and compact soils by females were the only differences found between problems and causes of the low management class.

Following from this observation, the problems and causes of each management level were combined and developed into problem-causal trees for comprehension of the relationships existing among them. (Figs. 4.8 & 4.9). Further analysis of these sets of diagrams revealed several common grounds in problems and causes. Major differences in problems identified by the medium and low classes were lack of knowledge in mineral fertilizer use and lack of oxen & ox-plough by the medium class as compared to water logging and lack of labour for digging terraces by the low management class. Again, problem-casual diagrams were drawn to have an overview of the relationships between soil management problems and their causes in the study area (Figs. 4.10 & 4.11).

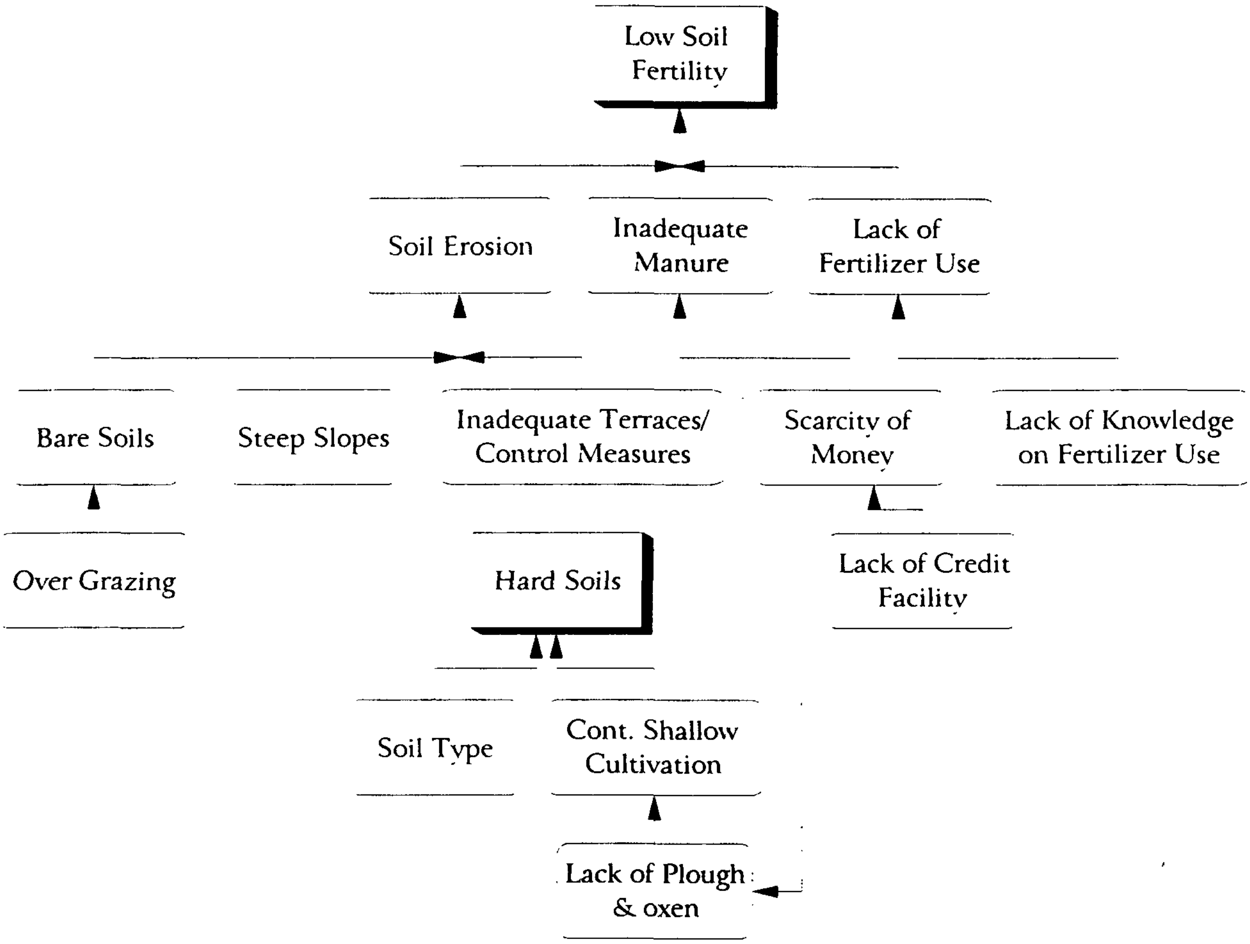


Fig. 4.8 Problem - causal tree for medium management class of farmers of Kasikeu

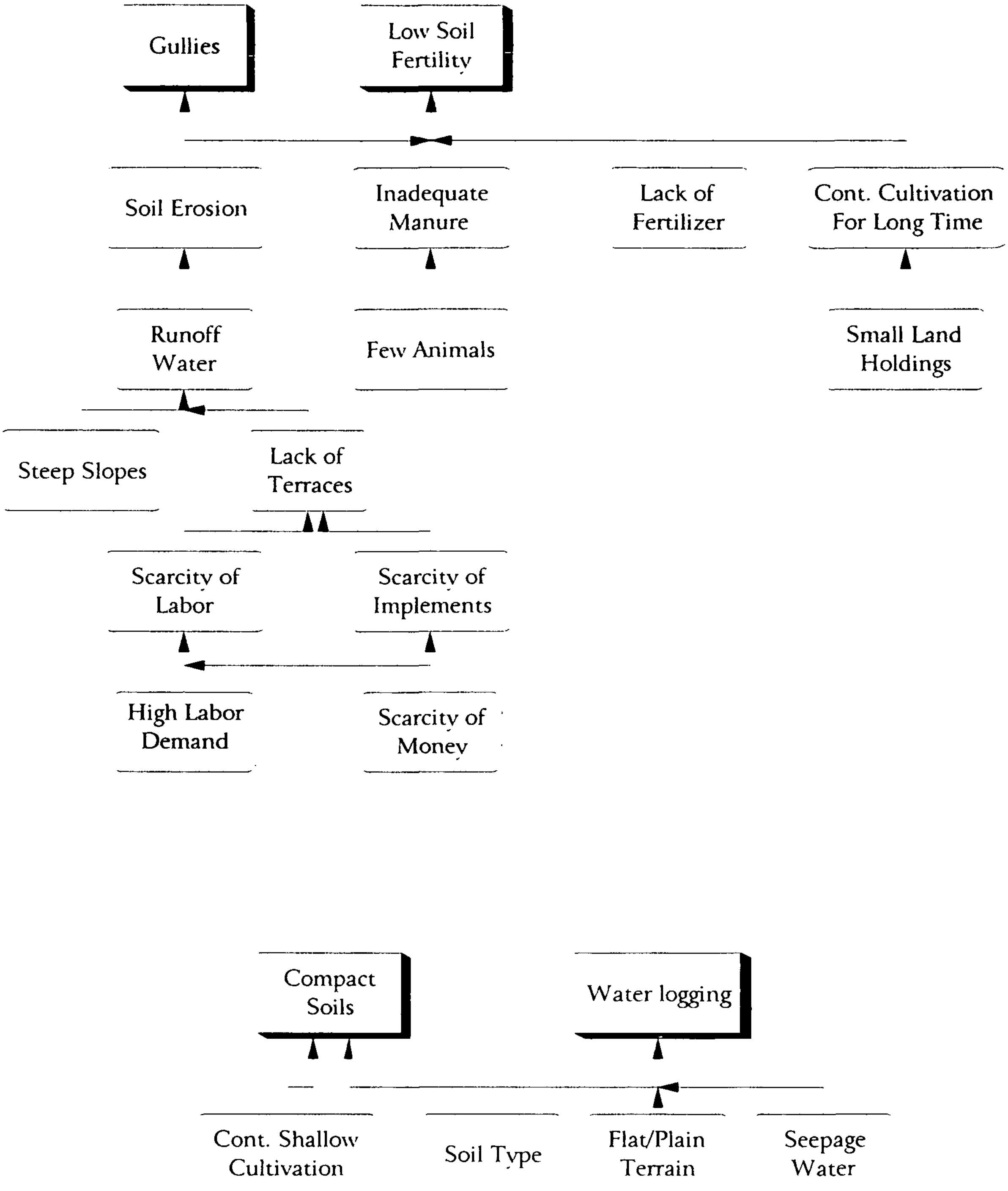


Fig. 4.9 Problem - causal tree for low management group of farmers of Kasikeu

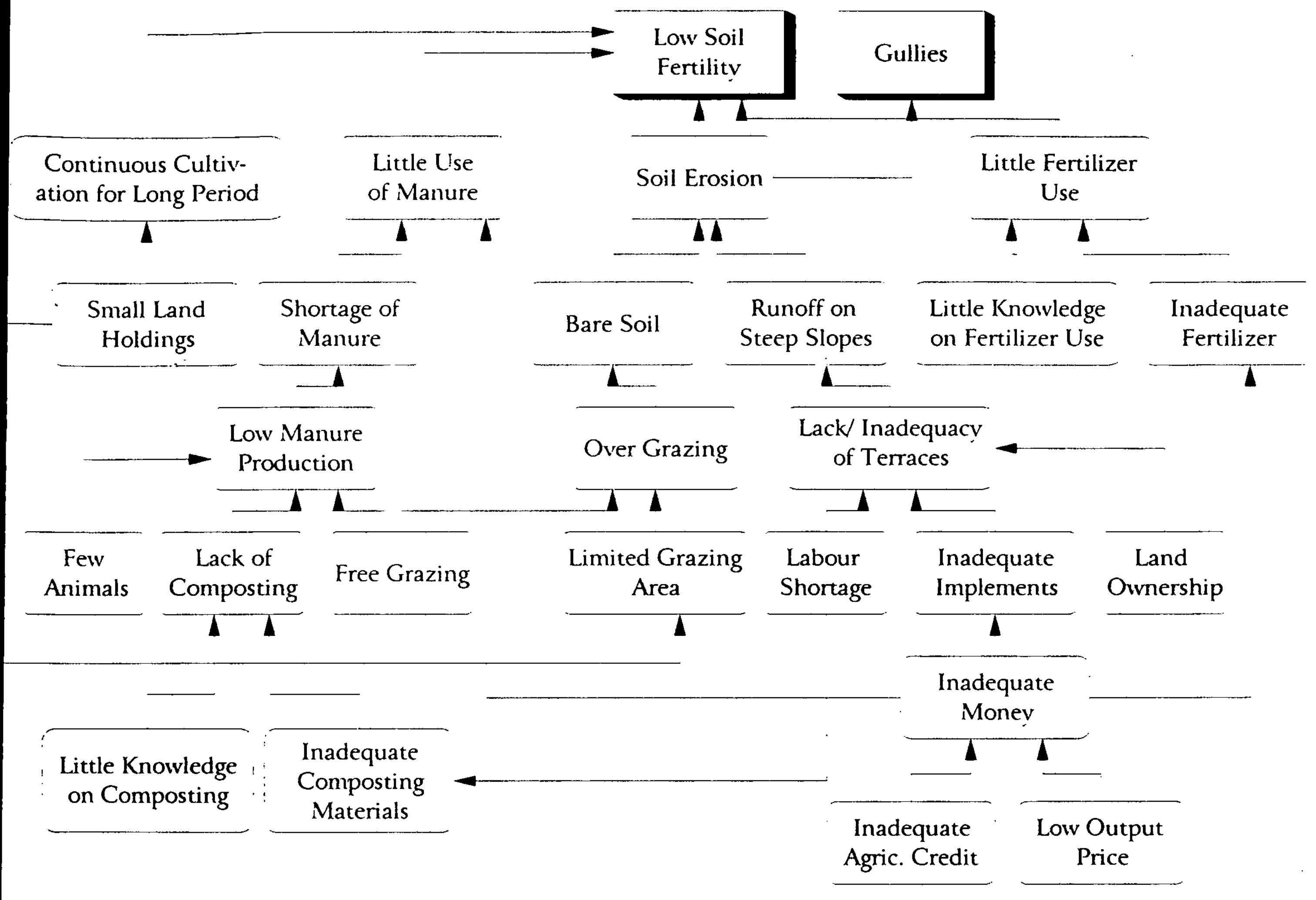


Fig 4.10 Problem Causal Tree for Low Soil Fertility and Gulley Erosion in Kasikeu Sub- Location

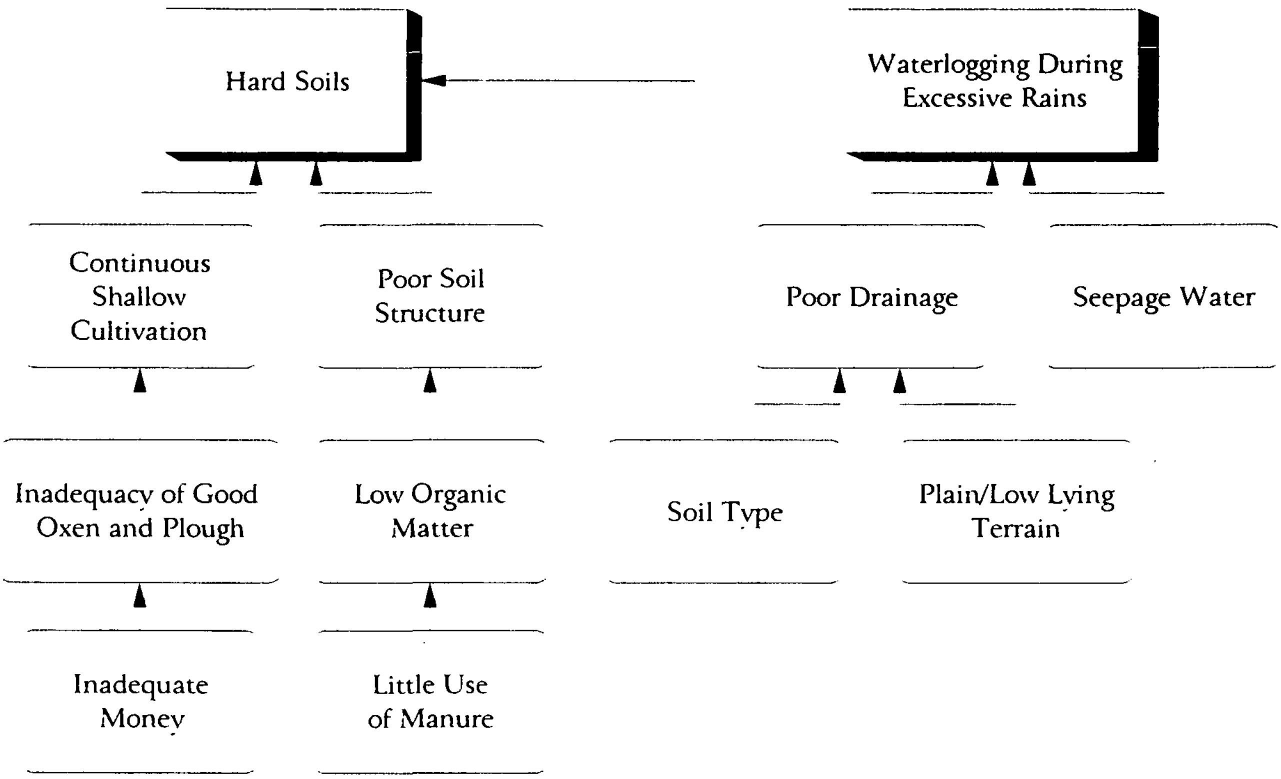


Fig.4.11Problelm Causal Tree for Hard Soils and Waterlogging in Kasikeu Sub-Location

Problem ranking

As discussed above, due to the very little differences in the perception of male and female farmers, the problems identified by them were grouped together and ranked for prioritization as per the two management levels. The pair-wise matrix ranking method was employed in the ranking of the problems. The criteria for ranking was the relative importance of each set of two problems with respect to proper soil management. The resulting matrices are presented in appendix 27. Tables 4.28 & 4.29 are list of problems ranked by the low and medium management classes.

Low management class

Table 4.28 Problem ranking by low management class

Problem	Rank
Inadequate labor	1
Soil erosion	2
Inadequate manure	3
Lack of finance	4
Compact soils	5
Lack of fertilizer	6
Water logging	7

It is evident from table 4.28 that farmers of the low management group, recognized inadequacy of labor especially in digging terraces as the most important problem as they ranked it highest. This may be in line with the observations made in 4.2.2 above that the low class has less labour available on the farm and are not able to engage hired labour due to limited finance (terrace digging is quite expensive in the area).

Soil erosion was the next most important problem. This can also be explained by the fact that low management farms are usually smaller in size and thus continuous cultivation and grazing over long periods without fallow and adequate terracing for soil conservation and fertility improvement would obviously make bare the soil surface and exposed to erosion especially run-off water.

Inadequate manure was next priority problem. Again, from 4.2.2 low management farms were observed to be characterized by limited grazing areas and few livestock, particularly, cattle the major source of manure in the area. To aggravate the problem is inadequate money for purchasing manure from elsewhere.

Lack of finance was ranked fourth. The farmers argued that although adequate money is a major resource for undertaking proper soil management, its availability from external sources is difficult to come by. It was therefore better to look for problems that could easily be solved without much dependence on money.

The fifth priority problem was compact soils. Generally most soils in the area are compact by nature. Suitable implements for loosening these soils and adequate quality manure for improving the structure. Lack of fertilizer was the next. The low management class did not see it as very important because in the first place most of them do not have money for purchasing. The few people who use it complained that it scorches crops due to lack of knowledge of use. Water logging was ranked lowest because it only became a problem on the plains (which are important cropping in normal areas seasons) during the *'el nino'* or unusual period of excessive rains.

Medium management class

Table 4.29. Problem ranking by medium management class

Problem	Rank
Soil erosion	1
Lack of oxen and plough	2
Lack of knowledge of fertilizer use	3
Inadequacy of manure	4
Lack of finance	5
Lack of fertilizer	6
Hard soils	7

According to the medium management group of farmers soil erosion was the most important problem. This is because it is the major cause of low soil fertility, especially on hilly areas. Most terraces are poorly constructed and crop field are intensively grazed during the dry season when fodder is scarce stripping the soil surface bare. The little manure that is applied get easily washed down onto plains and rivers during periods of intensive rain.

Most farms in the medium class own oxen and ox-plough. However, lack of oxen and ox-plough was the second most severe problem. According to the farmers they are the most important resources for soil management, hence ownership of such resource is much more important than even financial assistance in fiscal cash. They argued that cash can easily be spent or diverted for other uses than improving soil fertility whereas an oxen and ox-plough are capital asserts which can be rented out for extra income in addition to its invaluable use in soil management.

Lack of knowledge on mineral fertilizer use is the third important problem to the medium class. It can be recalled from 4.2.2 that only few farms generally use manure in Kasikeu. According to the farmers mineral fertilizer is important for supplementing the limited and poor quality "boma" manure available for improving soil fertility. However a major constraint to its use has been scorching of crops on application as a result of improper knowledge on what type to use, amount to use and when to use.

Inadequacy of manure was ranked fourth. Most farmers in the medium class own cattle, the major source of manure. However, the amount applied is inadequate. Only certain small portions of the farm can be fertilized at a time. With erosion being a serious problem in the area it is difficult to build up fertility at one place at a time or rotate application on terraces.

Farms in the medium class have better financial potential than those in the low class. It is not therefore surprising that lack of finance was ranked fifth. Of course as has been indicated above they put less emphasis on financial support in fiscal cash.

Lack of mineral fertilizer was ranked sixth. The farmers claim fertilizer is not easily available in the community but could be purchased from bigger towns like Machakos or cities like Nairobi which are quite far from Kasikeu. Of more importance is knowledge on efficient use the mineral fertilizer for better crop yields.

Hard soils were ranked lowest by this group. They argued that it is natural phenomenon in the area, although deeper tillage and application of sufficient manure could improve the structure of the soil. Also, most of the people in this class apply manure and own oxen and ox-plough, hence are able to plough early and a time when the oxen is quite strong or has not been overworked.

4.2.4 Opportunities

Tables 4.30 & 4.31 show a list of prioritized problems and their corresponding opportunities for alleviation identified by farmers in the medium and low management classes respectively. The opportunities were analyzed in relation to the problem – causal trees for each of the classes. The key problems which emerged from the sets of prioritized problems for redress were poor soil fertility, inadequate manure, soil erosion, compact soils and lack or inadequate finance. Objective trees of possible solutions for alleviating these key problems ranked by farmers were drawn and is presented as follows:

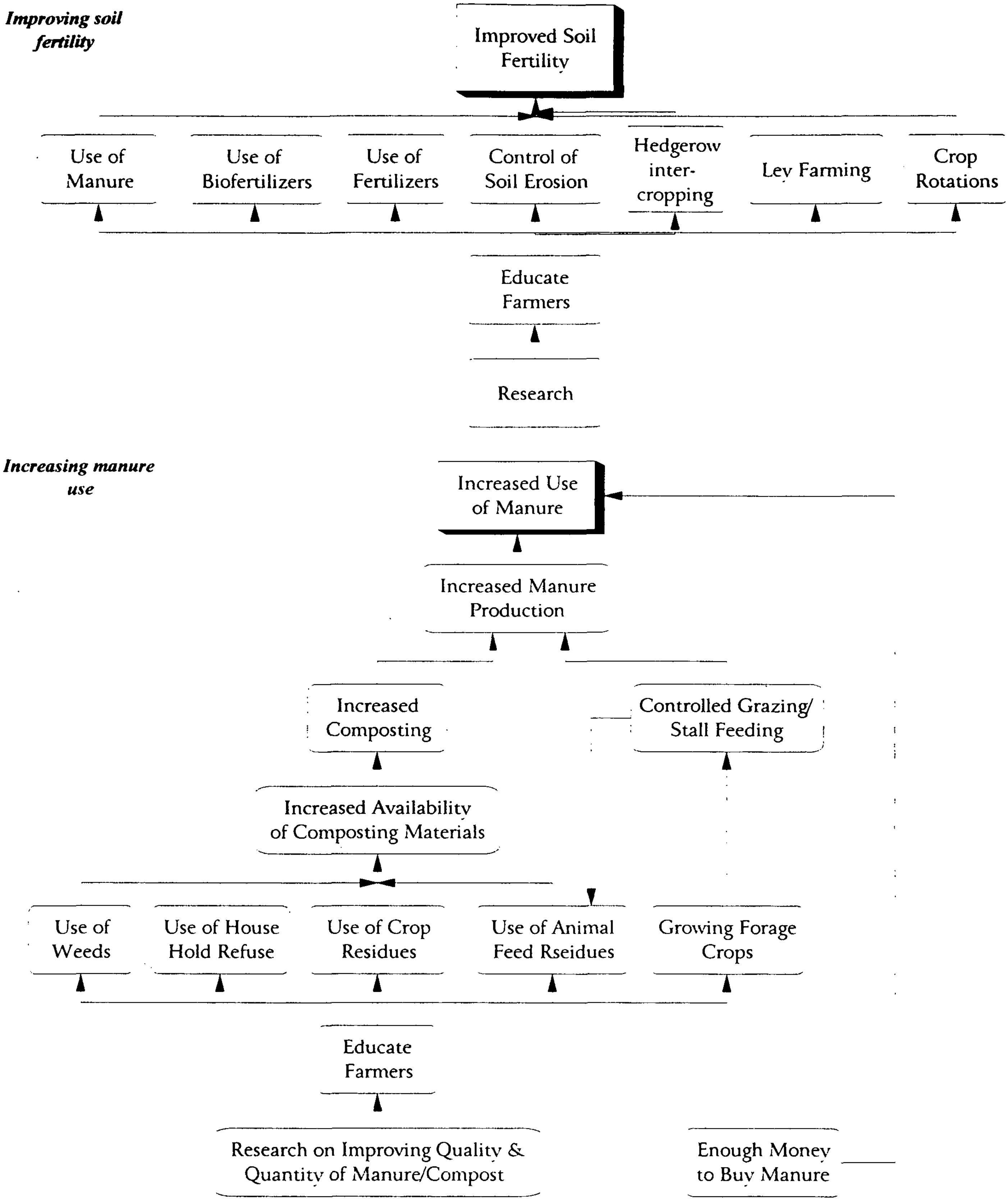


Fig.4.12 Objective trees for improving soil fertility and manure production in Kasikeu Sub- Location.

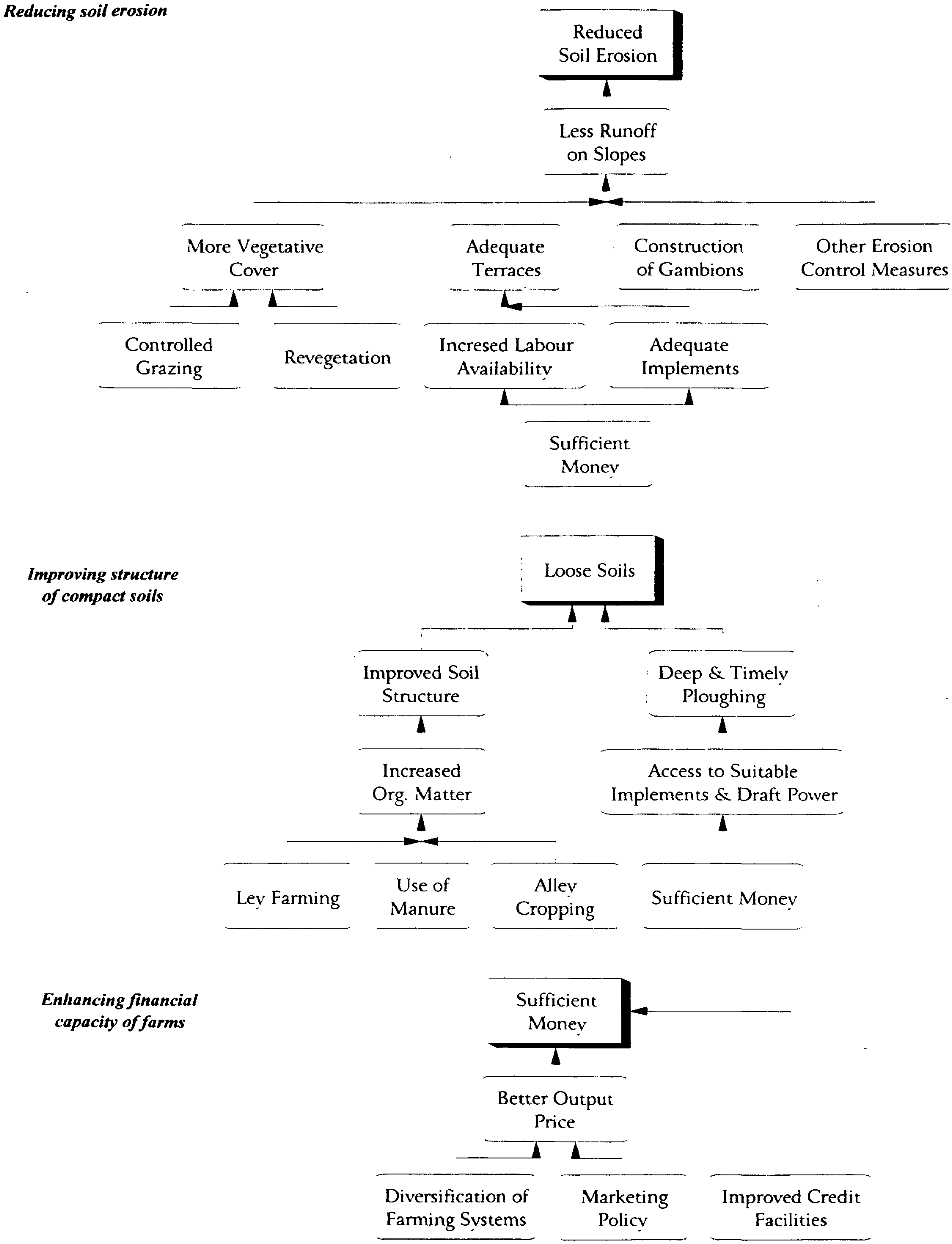


Fig.4.13 Objective trees for soil erosion control, loose soils and money issues in Kasikeu Sub-Location

Each of these options was further analyzed against the bio-physical characteristics of the study area and the socio-economic conditions of the different soil management levels (medium and low) mainly to assess their feasibility in the area. Each of the feasible options or solutions were further adjudged whether it could contributes to environmental sustainability, ensures economic and social improvements of farms and households in each management level. The result of this analysis have been discussed in detail and presented as recommendations or issues for consideration by especially research to improve soil management in the study area in section 5.2. The emerging research issues are as follows:

- Evaluation of hedgerows of fodder grass and leguminous trees and plants on terrace banks and along the contours of the farm to fortify terraces, improve soil fertility, provide fodder, check erosion on farms with no terraces.

- Evaluation of improved follow (ley farming) systems mainly to improve soil fertility, provide fodder, check erosion on bare soils and break cycles of pest and diseases on the farm.

- Increasing the quality and quantity of manure/compost.

- Use of bio-fertilizers, particularly, treating the seeds of beans, cowpeas and pigeon peas to improve nitrogen fixation and enhance soil fertility.

- Efficient use of mineral fertilizers, mainly, time and rates of application as well types to use.

- Suitable crop rotation in relation to soil types to improve fertility and break pest and disease cycles.

- Integrated nutrient management for improving soil fertility. A combination the use of hedgerows of fodder grass and leguminous plants and trees, improved fallow systems, use of organic manure, use of mineral fertilizer, crop rotation and choice of crops are some possibilities that could be explored.

- Evaluation of methods of reducing labour requirements in making terraces to enhance terrace construction on farms for checking the devastating effects of erosion by run-off water in the area.

- Introduction and testing of suitable implements for water harvesting and deeper tillage to improve on soil structure and moisture holding capacity as well as availability of water for the farm household.

- Diversification of the farming system particularly to improve financial capacity of farms. Poultry, fruit trees and dual purpose goats are possible options.

4.3 Stakeholders and Linkages

4.3.1 Stakeholders

Participants in soil management were found to be the farmers, researchers, the extension agents and the local administration (Table 4.3). The farmers include both men and women, whose interest in soil management were found to be mainly maintenance of land value and food production respectively. In either case the farmers were interested in maintaining and rehabilitating their soils both individually and communally. Their role was found to be provision of local technology and farmers besides being the adapters of any developed technology. To enable them do these they have farms and local knowledge.

In research, a whole spectrum of actors all with some relationship to KARI could be identified. They included the KSS, NDFRC, NLO and the ICRA team itself. KSS, one of the major clients for study expected to get am soil mapping methodology that makes soil maps more relevant to their clients – the farmer and the extension service. They have a role to produce relevant soil maps. The need for more client - oriented products is made even more important by the fact that KSS has for some time now been trying to commercialize its activities in search of sustainability. They utilize their technical know-how, laboratory facilities and databases. NDFRC on the other hand wanted soil management problems and possible opportunities to tackle them identified. This is because their they have a role to develop relevant technologies for improved soil management. At their disposal they have qualified personnel, databases on dryland farming and laboratory facilities.

The NLO not only facilitated the study but also wanted to have farmers engaged in seeking solutions to soil management problems taking into consideration the different perspectives of both male and female farmers. Further this office stressed the need for better environmental conservation. The NLO had financial resources. For their part, the ICRA team wanted to diagnose soil management problems and opportunities in a systems approach.

The extension agents wanted relevant technologies in soil management developed particularly in the area of soil conservation. They have a role to mediate relevant technologies for improved soil management. The extension service is aided in so doing by their direct interaction with the farmers. The local administration would like to see farmers using technologies which would boost food production especially because Kasikeu is in the ASAL and in most cases not able to produce enough food. Further, they would like to see an improvement in environmental conservation. Their role in improved soil management was found to be in their ability to organize farmers. Their authority and ability to convene meetings is an important asset.

4.3.2 Linkages

Linkages are forged to in situations where collaboration is required to achieve a goal. Improvement of soil management practices is a complex venture that is likely to require collaboration of the various actors. Effective linkages between the different players would help to avoid

Table 4.3 The roles, interests, importance and resources of various stakeholders in improved soil management.

Stakeholder	Role	Interest	Importance			Resources
			Diagnostic	Possible solutions	Implementation	
KSS	• Produce relevant soil maps	• Better understanding of soils	H	H	L	• Technical know-how • Laboratory facilities • Database
NDFRC	• Develop relevant technologies for improved soil management	• Relevant research issues	H	H	H	• Personnel • Database on dry-land farming • Laboratory
Extension	• Transfer relevant technologies in soil management	• Involvement in technology development and transfer	L	L	H	• Direct interaction with farmers
Farmers	• Provide local technology and farms	• Improved soil management practices	H	H	H	• Farm • Local knowledge
Local Adm.	• Facilitate organisation farmer	• Food security and environmental conservation	L	L	M	• Authority • Ability to convene meetings
Church	• Encourage farmers	• Social welfare	L	L	L	• Communication
Donors	• Funding and stressing other issues of interest	• Publicity • Influence development	M	L	H	• Finance

duplication of efforts and therefore improve the efficiency of service delivery, which can be achieved through complementation rather than competition of both research and extension efforts.

Knowledge of activities to be carried out is important to allow for sharing of roles and responsibilities. The major requirements for achieving improved soil management were identified as :

- An understanding of the soils, management practices, problems coping strategies and opportunities.
- New ideas and practices to be adapted to farmer circumstances.
- Availability of the necessary farm resources.

Three major linkages found to be in play were research–extension, extension-farmer and research-farmer linkage. However, as is clear in Figure 4.3 the weak links mainly between KSS and other actors need to be strengthened.

Research - extension linkage

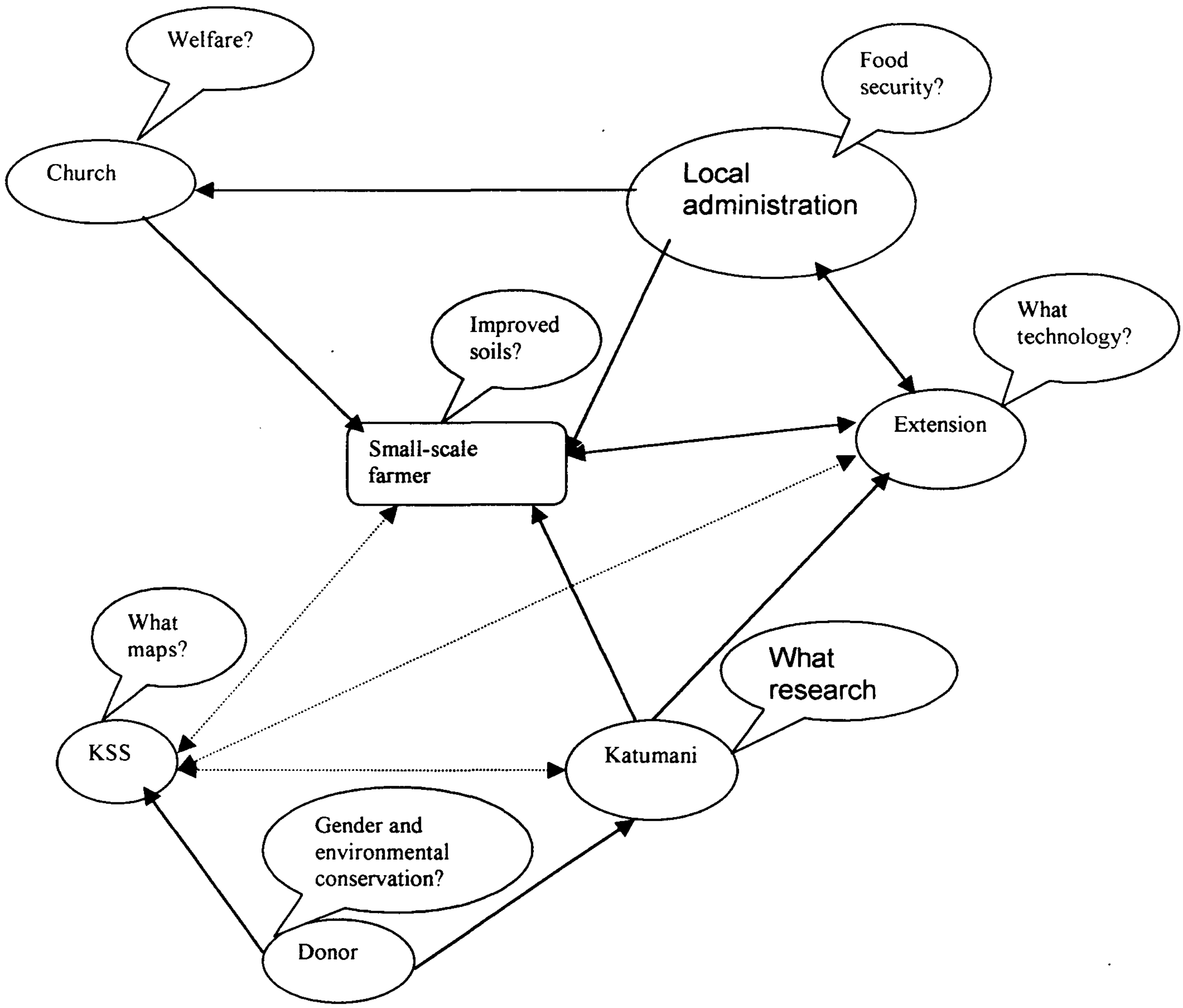
Agricultural R&E services in Kenya are faced by major challenges arising mainly from a rapidly increasing population, declining soil fertility, destruction of environment areas, increasing costs of agricultural inputs, the ever changing world economic structure and the negative impacts of the structural adjustments (MOALD&M, 1993). To meet these challenges the R&E agencies are endeavoring to lay emphasis on efficiency and flexibility in responding to national development goals and objectives. To this end the major providers of these services, MOALD&M on one hand and KARI on the other have signed a memorandum of understanding (MOU) to facilitate fruitful linkage in the their activities. According to the MOU the research and extension officers are expected to jointly generate, test and ensure adoption of technology.

For improvement of soil management practices the extension agents still expect to be disseminators of technology whereas researchers are supposed to be the technology innovators making joint activities irrelevant. As such achieving the anticipated aspirations has been difficult thus making the well intentioned MOU not very effective. Several factors contribute to these: the players do not seem to treat each other as equal partners and suspicion between them is rife. Further, research and extension services are funded by different donors with different interests and inflexible approaches which affect linkages negatively. The advocated monitoring and evaluation process emphasizes supervision of the junior staff by the senior staff. This erodes the responsibilities of the junior staff and reduces their ability for self monitoring and evaluation.

Extension - farmer linkage

A direct link between the farmer and the extension agents is expected through the frontline extension workers (FEW) although location extension officers, divisional extension coordinators and district extension officers also come to direct contact with the farmer either individually or jointly at different times. In the current R&E layout the extension agents are expected to the link between the farmers and researchers: to get ready made technological packages from the researchers and delivering them to the farmers on hand and getting feedback from farmers to researchers on the other. No wonder extension officers reported that they had not been getting extension messages from researchers and were consequently unable to advise the farmers effectively. Their confidence and willingness to meet the farmers has therefore been eroded. As a result reduced respect for the extension staff by the farmers was apparent. This has undermined the ability of the extension staff to work with farmers. Other factors blamed for the state of affairs are the reduced number of FEW per farmer as a result of the on going civil service retrenchment program, farmers high expectation

Figure 4.3. The linkage map for improved soil management in Kasikeu Sub-Location.



especially in form of handouts which the extension agents cannot provide and farmers lack of necessary finance required for some technology adoption.

Research - farmer linkage
In the current R&E direct links between researchers and farmers are viewed as exceptions rather than the norms. That notwithstanding the onset of participatory agricultural research has of necessity brought farmers and researchers together. In the study, farmers were engaged as active players providing invaluable location specific information on soils and their management practices, their problems, causes and opportunities. The farmers essentially shared with researchers their technical knowledge which would otherwise not be available, in the process earning lots of respect from the researchers. The researchers on their part were able to share with the farmers more general and less localized information. The sharing of the information and appreciation of each others knowledge underscored the fact that both farmers and researchers need each other. However there are several obstacles still mitigating against complete integration of farmers - researcher activities.

Direct contact between researchers and farmers is an expensive venture both in time and monetary terms that may be difficult for the public sector sustain whereas extension agents view direct researcher - farmer contacts as an encroachment on their domain of technology transfer. Researchers, as was found out in the study, are known to have started activities on farmers' fields which they forget as soon as they walked out of the farms leading to mistrust by the farmers while excessive farm visits with little or no tangible output may lead to 'visit fatigue'. High expectations from researchers by farmers (handouts) and local politics are some of the other militating factors.

4.3.3 Lessons from current linkage mechanisms
The linkages between researchers, extension agents and farmers are necessary for improved soil management. To improve on the existing linkages it is important to identify the roles and responsibilities for each player (Table 4.3). These would improve the transparency in sharing of roles and hopefully reduce the suspicion between for instance researchers and extension agents. Farmers should be involved farmers in technology development not as passive beneficiaries but as clients, by not only giving to them but also receiving from them. The extension can form a good link between farmers, researchers and other interested parties. Throughout the study, the importance and influence of donors to agricultural innovations was apparent. These warrants a better definition of their relationships with the local extension and research agents if linkages are to sustained.

An important observation was that for improved soil management to occur various types of inputs were required. These require money which neither the research nor extension agents are in a position to offer while the farmers have limited income sources and are uncomfortable with formal credit sources. However, there exists several informal sources of credit but farmers have little or no knowledge about them. It may be worthwhile to consider introducing external micro-financiers to the farmers. For instance some NGO's which may be interested in these should be appreciated and allowed to play complementary roles. Finally a process for monitoring and evaluation which respects the abilities of the actual change agents and therefore encourages them to monitor and evaluate themselves should be put in place.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Participatory soil mapping

Before commencement of any future participatory soil mapping, it is important for KSS to reflect on the underlying objectives and principles of carrying out the soil mapping:

Objectives

1. Reflect on the client who has requested the job and the **type of information** requested more - often it will be a field practitioner who has or intending to do on-farm research or extension with farmers. The information to be given by KSS should be practical in terms of management practices of the soils. The soil mapping should start with the farmer perception and knowledge and complemented by the scientist's knowledge.
2. KSS should also reflect on the **way to present** the information in a better format inform of maps, matrices etc. The description of the information must be in an easily understandable language to the extension and the farmer.
3. A reflection on **the approach** to reach the final outputs in terms of involvement of research, extension, and farmers at different stages. Soil mapping with the participation of farmers and extension enable the research scientist to gather all stakeholders' perceptions and knowledge on the soil, its management, potential and constraints for sustainable land use. The process makes it possible to come up with more responsive research and extension activities to address farmer's needs, who are the main clients of agricultural research.

Principles

1. The **level of mapping** is an important consideration, since all the stakeholders should be involved in the generation of soil related information. Participatory tools will be used so as to combine the farmer, extension, and research perceptions to generate cost and time effective outputs. The participation of the farmer helps the scientist to capture information related to all the soils in the area and the soil characteristics that are most limiting to the soils management and hence a better product from KSS. To satisfy these objectives the team proposes that the sub-location will be the ideal administrative unit for a participatory soil mapping with farmers and extension because:

    i) The farmers are able to identify the various soil types occurring in the sub-location by their local names and spatial distribution and,
    ii) It is the lowest level of operation by the extension staff.
    iii) The research practitioner interacts with the farmers during on-farm research, field days, rural appraisal etc.

Soil mapping at the level that is higher than the sub-location (e.g. at divisional and district level) can be done using the conventional methodology. However, a link must be made between the scientific soil classification and farmers' soil classification. For each soil type(s) identified, the corresponding soil type(s) according to farmers' classification should be noted; this may include several farmer classification systems.

2. The planning and implementation of the **mapping process** will include a number of steps where the objectives, tools, expected outputs, who will be involved and the expected time for each activity will be planned before hand as in Table 5.1.

Table 5.1: Activities in the participatory soil mapping process

Activity	Objectives	Tools	Expected outputs	Who involved	Time (person days)
1. Meeting with Research and Extension	-Planning - Formation of team - Division of roles	Discussions	- Action plan - Team formed - define roles	KSS RRC Extension	3
2. Collect background information	- To collect and review background information of the area	- Reconnaissance - Literature review - PRA - Aerial photo interpretation	- Report on background information	KSS RRC Extension	10
3. Farmers meetings 3(a) General meeting 3(b) Focussed group meetings	- To sensitize the farmers - To create a rapport - Set appointments for selected groups - Description of farmers soil classification system - Set appointments for next activity	- Baraza - Discussions - Meeting - Discussions - Visualization	- Rapport created - Appointments made - Matrices - Appointments	KSS RRC Extension, Farmers , Local Administration KSS RRC Extension , Farmers	2 1
4. Participatory soil mapping 4(a) KSS mapping 4(b) Farmers mapping	Generation of a base map of the sub-location - Farmers to complete the base map by adding features and entities - To demarcate village boundaries - To capture gender perceptions on soils	- GIS - Sketching on gender basis	- Sub-location map - Separate male and female group maps - Combined map	KSS Assistant chief KSS RRC Extension Male and Female groups	

5. Field observations	- Verify the soil units and their boundaries - Soil sampling (Fertility and survey) Exchange of information between stakeholders	Transect walks	- Soil samples - Soil information	KSS RRC Extension, Farmers representatives	6
6. Soil analysis and interpretations	- To analyze for analytical information - To make interpretations of the results and present in understandable formats - To write the report on the findings and recommendations	- Laboratory analysis - Interpretations - Matrices	Report	KSS RRC Extension	21
7. Digitization of the maps	- Enter information in GIS database - Easy manipulable database - Drawing of maps in color	-GIS - Computer	- Stored database - Maps	KSS	10
8. Feedback to the community 8(a) Concluding baraza 8(b) Brief training of extension	- Feedback to farmers on complementary scientific information - Train extension on the use of maps and report - Thank them for cooperation	- Concluding baraza - Discussions - Brief training of extension	- Better informed farmers -Usable technology by extension	KSS RRC Extension Farmers Administration	4

Description of the activities in detail is as follows:

1. Planning meeting

The main purpose of the meeting will be to discuss with representatives of the Regional Research Center (RRC) who may have requested for the soil mapping and the extension staff. The meeting will brainstorm the task at hand, plan the execution, form the team (interdisciplinary) and set roles of who is to do what. The meeting will be expected to develop an action plan for the execution of the work. It is expected that the meeting will take three person days (including one for making appointment).

2. Background information

The purpose of this activity is to collect and review the background information of the sub-location in connection with physical and biophysical information, farming systems information etc. The activity will be done through a reconnaissance of the area, PRA and literature review including aerial photo interpretation and it is expected the activity will be done in at least ten days. A report on background information will be the expected output.

3. Farmers meetings

3 (a) **General meeting:** This is will be in the form of a community baraza (meeting) which will be arranged through the local administration and extension. The purpose of this meeting will be to sensitize the farmers and create a rapport with them after introduction to community. The activity is expected to takes two days (including one for making appointments).

3(b) **Focussed group meetings:** These will be held together with selected farmers from the bigger group. The purpose of the meetings will be for the description of the farmers local soil classification system through: local names of soil, criteria for distinguishing soils, characteristics of the soils, use and management of the soils that occur in the sub-location. The information generated to be presented in the form of a matrix summarizing farmer's knowledge and practices for each of the soil types identified. The visualization with the farmers will make them to be in agreement with all information generated. It is expected that KSS, RRC, Extension and farmers will be involved and one day will be enough for the exercise whereby appointments for the next activity will be agreed upon by all.

4. Participatory soil mapping

4(a) **KSS mapping**: KSS makes a rudimentary (base) map of the sub-location, using the information available in their GIS and indicating the boundaries and major physical features such as roads, rivers, hills, markets centers. The sub-location boundary should be verified together with the Assistant chief of the sub-location. It is expected the activity will take three days (including one day for the verification with the Assistant Chief).

4(b) **Farmers mapping:** Farmers complete the rudimentary map, by adding specific features and entities that are of importance to them and that make the map more recognizable, such as schools, churches, springs, boreholes etc; also amendments are made if necessary subsequently the village boundaries inside the sub-location territory are demarcated, whereby the village headmen can assist in knowing the exact village boundaries.

- The farmers than split into two groups-men and women. Each group makes its won map with a legend of the soil types to get a perception of gender on soil types.
- Subsequently a combined map is made compromising the views of men and women and,
- Several transect routes are setout on the combined map, covering all soil types situated at the different positions of the catenas.

At the end of the activity, there will be three maps generated and it is expected the activity will be completed within two days (including one day for combining the maps).

5. Field observations

Transect walks together with research, extension staff and a representative group of farmers is made. For each soil type identified by the farmers, a soil profile is made and soil samples (fertility and survey) taken for analysis at KSS. If researchers are of the opinion that a soil type recognized by farmers represents more than one type according to the researcher classification, soil samples should be taken accordingly. More sampling should be emphasized on the majority occurring soils, as the information will benefit more farmers. Exchange of information among stakeholders during the exercise will enhance understanding of the soil information for the benefit of all.

6. Soil analysis and interpretations

- The soil samples will be analyzed at KSS, and the profiles described. The field and analytical information will be interpreted and presented in simple and understandable formats e.g. matrices and descriptions. The information will complement the information matrix earlier generated by farmers (step 3(b)). The complementary information should include:
- Corresponding scientific names of the soils; sometimes one soil type of farmers' classification system may correspond to several soil types classified according to the FAO or USDA systems.
- Analytical data with respect to the chemistry of the soil - pH, CEC, major nutrient contents (M, P, K, Ca and Mg) minor nutrients (Fe, Mn, Cu and Zn) and the nutrient reserves at different horizons. Other data including texture of the soil, exchangeable bases, EC and Carbon.
- Recommendations in form of a report for specific management practices based on the soil test report and other information and directed towards more sustainable land use practices e.g. type and amount of fertilizer/farm yard manure to be applied to achieve optimal yields.

The report write-up should have input from KSS, RRC and the Extension and it is expected the write-up will be completed within three weeks.

7. Digitization of map

KSS makes the soil map of the sub-location through digitization of the soil maps made by farmers and additional information obtained through the transect walks, soil analysis, soil profiles and aerial photographs. Specific maps on soil suitability and other maps (e.g. erosion hazard map) from different interpretations should be made through the GIS facility to accompany the soil map. This activity will be expected to be completed within ten days.

8. Feedback to community

8(a) **Concluding baraza:** This will be in the form of a community meeting where all stakeholders (KSS, RRC, Extension, Farmers and Administration) will be present. The purpose of the baraza will be to present complementary information in form of maps, matrices and reports to the community of the sub-location. This activity will be expected to take two days (including one for making an appointment).

8(b) **Training of extension:** KSS will briefly train the extension staff in the use of the maps. Since they will have been involved in most stages of the soil mapping, they will be expected to understand the contents and appreciate the technology as a tool for their use in solving farmer's problems. This activity will be expected to take two days.

5.2 Research issues in soil management

The study has identified a number of soil management problems in the study area as outlined in sections 4.2.3 and 4.2.4. Some possible research opportunities for addressing these problems are as described below.

Evaluation of hedge rows of fodder grass and leguminous threes and plants on terrace bunds and along the contours of the farm.

A combination of trees and grass on terrace bunds and along contours of farms would fortify terraces, protecting them from frequent damage by run-off water and washing away of soil nutrients. The life span of the terraces would be prolonged and labour costs in terrace maintenance saved. It would also be useful for alleviating labour requirements in terrace digging and particularly for the low management class who have inadequate money for doing so.

It could provide fodder for livestock and also contribute to solving the lack of animal feed during the dry periods. It would also help to solve the problem of limited grazing area of the low soil management class with limited and could be used by the medium management class to support zero grazing to control over grazing and to enhance the quantity of manure produced.

The leguminous plants would contribute to the low soil fertility through nitrogen fixation and deposition leaf litter or biomass to improve the organic matter content of the soil over time. This would help alleviate the problem of general low soil fertility in the area and would be of great advantage to the low management class with small landholdings.

The leguminous trees would also provide some firewood in the area especially for the farmers with very low acreage.

Evaluation of improved fallow (ley farming) systems.

This would involve testing and adopting systems of growing a legume/grass mixture on farms under fallow for at least two years intervals. The system would contribute to improving the soil organic matter content and structure. It could be a good source of fodder for livestock and assist in breaking pest and disease cycle of some of the crops. Ley farming could be good for the medium management class, with bigger farm sizes and are likely to put some land area under fallow.

Increasing the quality and quantity of manure/compost.

Manure is commonly used in Kasikeu to improve soil fertility. However, the quantity applied on most farms is inadequate and the quality is poor (manure normally stored in the open over a long period before being transferred to the farm, reducing the ammonia content). Hence, having adequate, good quality manure would be necessary in the area and would go a along way to increase crop production. Knowledge on compost making is also inadequate in the area. Some farmers complained of scarcity of water in the area, the labourious nature and high costs in compost making.

The NDFRC has already done some research in the use of *boma* manure in the ASAL areas. Hence, it would be necessary for the NDFRC to review this work and adapt it to Kasikeu. Particularly, ways of increasing the quantity of manure as well as simple and less expensive compost technologies for semi-arid environments.

Use of Biofertilizers

Farmers in Kasikeu sub-location grow a lot of leguminous crops (beans, cowpeas, pigeon peas) either as crop mixtures with cereals or as sole crops. From literature is known that treating the seeds of these crops with the appropriate bacteria cultures increases the chances of these crops fixing more nitrogen, which would contribute to reducing the low soil fertility problem in the area.

Efficient Use of Mineral Fertilizers

The use of mineral fertilizers in alleviating soil fertility problems in Kasikeu is low. Farmers cite lack of knowledge in fertilizer use as the main bottlenecks. NDFRC-Katumani can liaise with the extension staff in holding demonstrations and training the farmers on issues related to fertilizer use. NDFRC would also be able to dispel the belief in farmers that mineral fertilizer use has a negative effect on the soil with consequent lower crop production through scorching. The farmers are particularly interested in the appropriate types to use (for which soils and crops), application rates and time of application in relation to the rainfall pattern.

Suitable crop rotation

In Kasikeu it was noted that some farmers plant certain crop species on particular portions of their farms year after year. Suitable crop rotations in relation to the soil types on the farm are needed. These would help improve soil nutrient management or distribution on the farm and avoid the build up of pests and diseases associated with certain crop species.

Integrated Nutrient Management

This would involve a combination of several systems to alleviate the soil fertility problem. The following systems can be looked at, use of hedgerows of fodder grass and leguminous plants and trees, improved fallow systems, use of organic manure, use of mineral fertilizer, crop rotation and choice of crops. Due to the socio-economics situation of the farmers in kasikeu it would be necessary to look at which combinations would best suit the different classes of farms. In the long ran using an integrated approach to nutrient management would be sustainable for soil fertility management than using only one system.

Introduction and testing of suitable implements for water harvesting and deeper tillage

Farmers in kasikeu complain of hard (compact) soils and also of inadequate moisture during crop growth. The compact soils are attributed to soil type and shallow ploughing. This problem can be handled through use of manure and complimented with an implement that will break up the hard layer. An implement that will plough deeper and can also make tied ridging would go a long in solving this problem make tied ridging would go a long in solving this problem. The tied ridging would give a bigger surface area for water retention and per location, reducing runoff and thus minimizing soil erosion and loss of nutrients. The breaking of the hard pan will give a better soil tilth for root penetration and aeration. The same implement would also contribute to reduced labour demand for making tied ridges commonly done with manual techniques of water conservation and the use of hand hoe in the breaking of hard pans.

Evaluation of methods of reducing labour requirements in making terraces

Terraces are very important for soil conservation against water erosion and the consequent loss of soil and nutrients. For successful farming proper terracing is needed. The major constraint in inadequate terracing cited by farmers is lack of labour. Digging terraces is difficult and time consuming. Terrace digging and repair are done mostly in the dry period of the year. This period which starts from the end of the rainy season to the start of the next rainy season is short, hence inadequate time for a farmer to dig good terraces and do other activities in land preparations. Methods that can lead to efficient making of terraces and with a lower labour requirement will help in the construction of better terraces on the farms.

Diversification of farming systems

From the study and from farmers admission, one resource limiting better soil management practices is capital. To increase and improve agricultural production there is a need to increase the on-farm income. This could be achieved by either extra income to the farm and/or reducing use of the little on-farm income. Income generating activities are essential in this regard. Possible areas for consideration are poultry, fruit crops and dual purpose goats.

Poultry
Poultry keeping has been practiced in the area. However, the efficiency of this poultry farming is questionable. Some of the issues to be considered include feeding, chick mortality, increasing growth rates of the chicks, achieving high live weight per bird, reducing or efficiently managing poultry diseases.

Fruit trees
The farmers in the area, grow fruits trees that are good sources of income. The current fruit trees have a few problems that can be addressed like very large trees which take more space and difficult to manage in terms of disease and the fruits have a short shelf life and a short season when in production.

Introducing suitable fruit tree varieties that are short (easy to manage in terms of pests and diseases) early maturing and are in fruit for a longer time in the year may be appropriate. The fruits must have longer shelf life and should be marketable. Fruits like citrus (orange), mangoes and papaya thrive very in the area.

Dual purpose goats
With the sub-division of farm lands, reduction of grazing areas and the need for more milk (consumption and sale), efficient utilization of available feeds has become important. It has also become necessary to move away from raising cattle to keeping dual purpose goats. These eat less feed compared to cows, give more milk and can be sold for both meat and milk.

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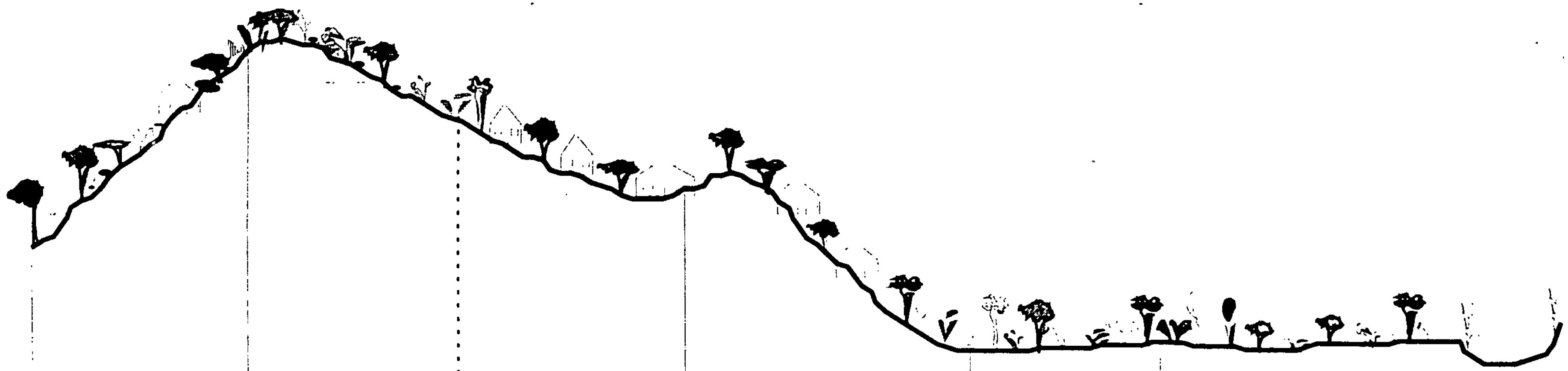
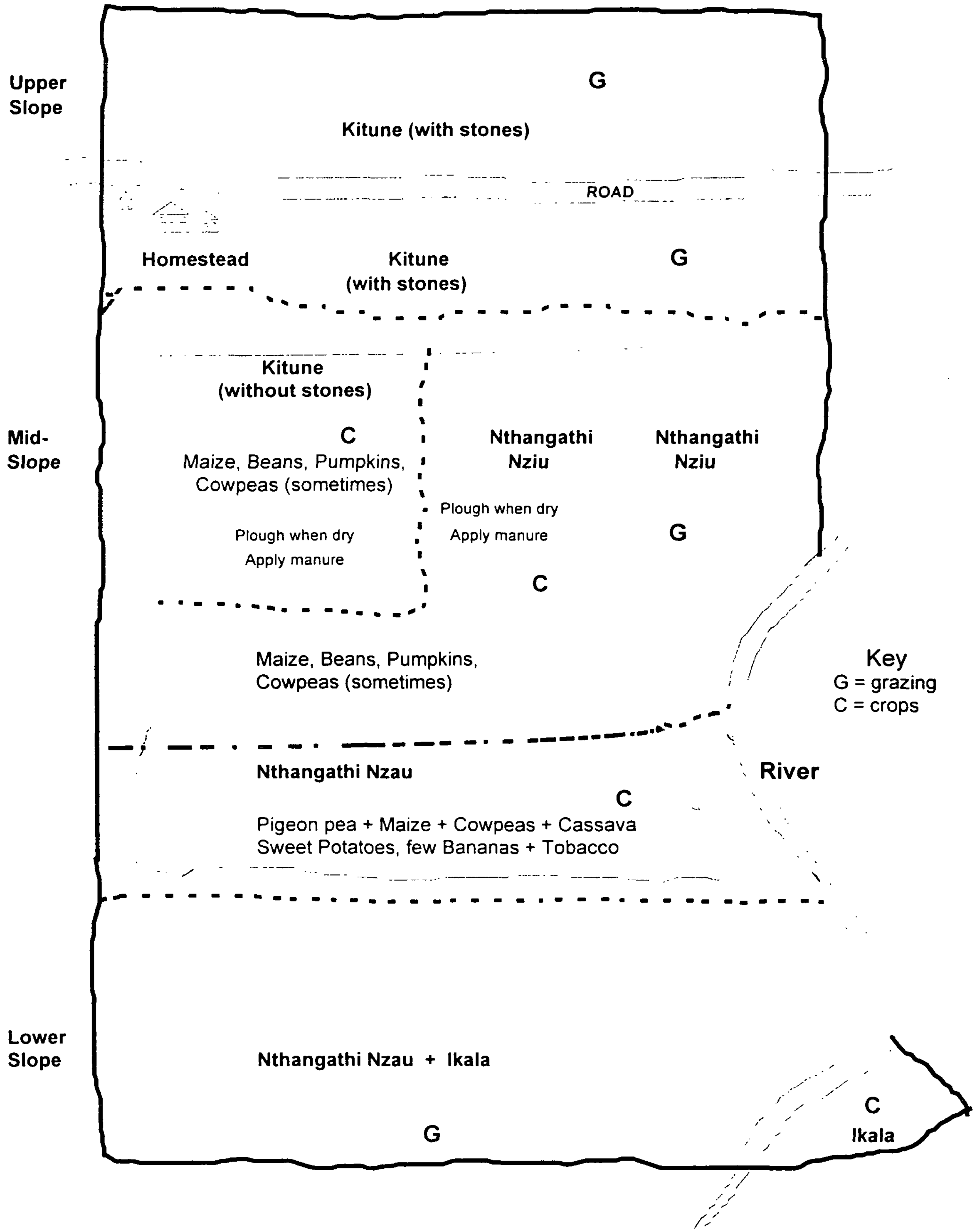
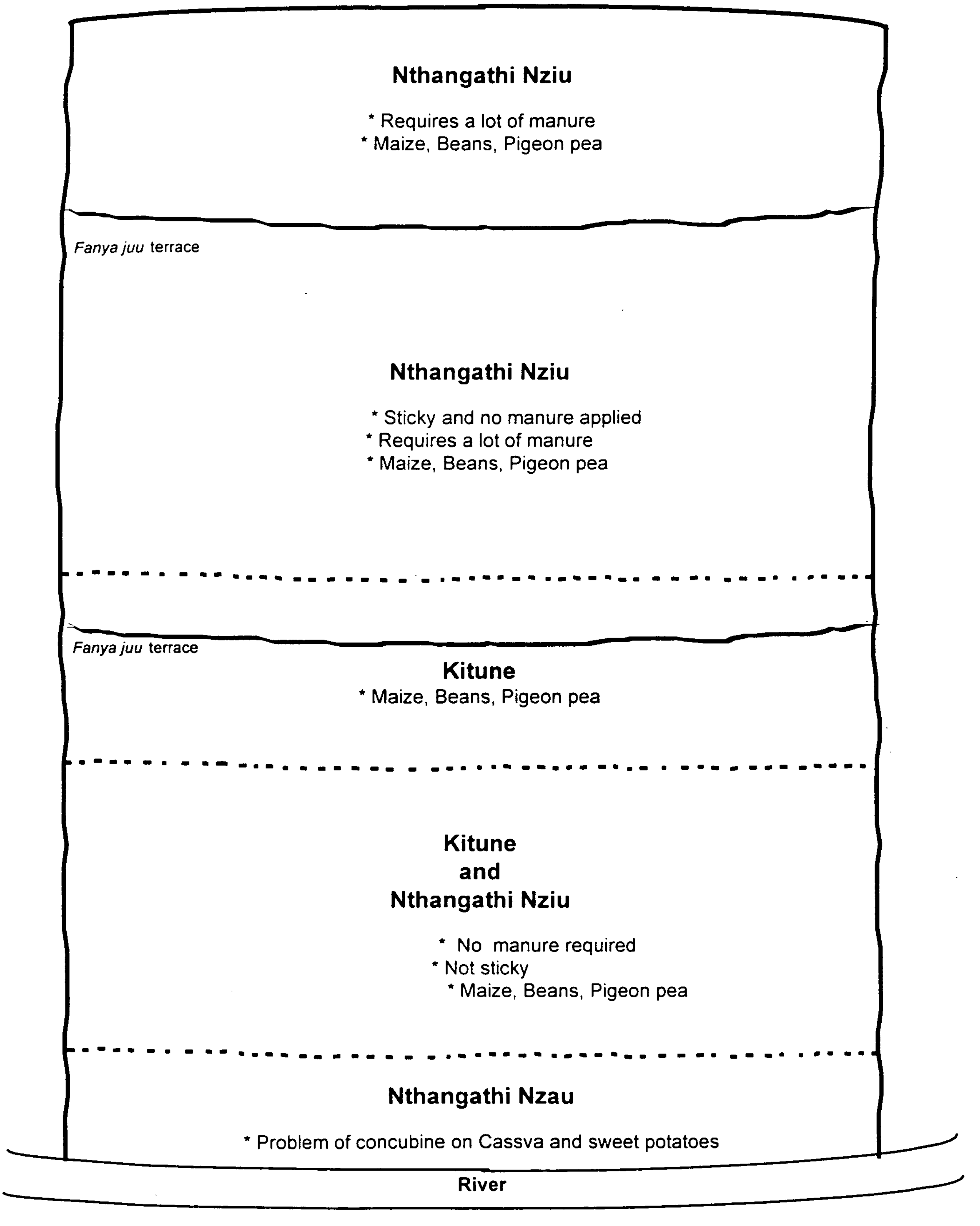


SOILS	Kitune (with stones)	Nthangathi nziu (with rocks & boulders)	Nthangathi nziu (without rocks & boulders)	Kitune (without stones)	Ikala	Nthangathi nzau Ilivi (Beneath Nthangathi nzau)	
VEGETATION	*Croton dichogamus, Gnidia latifolia, Lantana camara, Ocimum bac-illicum, Ipomea* sp., *Sansevieria intermedia, Aloe* sp.	*Croton dichogamus, Gnidia latifolia, Acacia brevispica, Aspilia mosambicensis, Aloe* sp.	*Acacia brevispica, Gnidia latifolia, Croton dichogamus, Grewia mollis, Amaranthus* sp. *Aspilia mosambicensis, Datura stramonium*	*Acacia seyal, A. tortilis, A. senegal, A. brevispica, Balanites glabra, Gnidia latifolia, Lantana camara, Ipomea* sp., *Aloe* sp.	*Acacia polyacantha, Ficus sycomorus, Cyperus* sp.	*Acacia polycantha, Ficus sycomorus, Mangifera indica, Lantana camara*	
LAND USE	Cropping, grazing, selling stones & hard-core, building sites	Grazing, selling stones and hard-core, fire wood collection	Cropping, grazing	Cropping, brick making, building sites	Cropping, grazing	Cropping	
CROPS	Maize, Beans, Avocado, Cowpea, Bananas, Pigeonpea		Maize, Millet, Beans, Cowpea, Pigeonpea, Cassava, Sorghum	Maize, Beans, Cowpea, Pigeonpea, Oranges, Pumpkins, Bananas, Avocado	Maize, Beans, Cowpea, Greengrams, Cotton, Sugarcane, Dolichos, Arrowroots	Cassava, Vegetables, Sweet potatoes, Guava, Bananas, Pumpkins	
SOIL MANAGEMENT PRACTICES	* Bench terraces with grass/trash lines * Ploughing after rains * Manure application		* Bench terraces with grass/trash lines * Minimum cultural operations on slopes * Ploughing after rains * Manure application	* Bench terraces with grass/trash lines * Ploughing after rains * Manure application	* Poughing after light rains. * No manure application	* Grass strips/stone lining near river beds * Ploughing after rains * Bucket irrigation in vegetables * Application of manure in holes for vegetable crops * Very deep pits for bananas * Lots of manure required but applied only in vegetables	
PROBLEMS	* Cultural operations difficult due to stones * Problems of erosion * Hard when dry * Low fertility status	* Overgrazing * Severe erosion * Cutting of woody vegetation	* Problem of erosion * Low soil fertility * Hard when dry if mixed with black clay soil	* Hard when dry * Problem of erosion on slopes * Low fertility status	* Very sticky when wet * Very hard when dry * Problem of water-logging during excessive rains	* Very low soil fertility * Very low moisture retention in upper layers * Easily eroded * Flooding during heavy rains	

Appendix 1. Transect map of Kasikeu sub-location



Appendix 2. Farm Sketch for Mwau Musongo - Kasikeu sub-location



Appendix 3. Farm Sketch for Mary Kyengo - Kasikeu sub-location

Appendix 4 . 1998 ICRA-Kenya field study work plan

WHEN		WHAT (ACTIVITY)	WHERE	HOW	OUTPUT
WEEK	DATE				
1 (14-17 APRIL)	14 (Tue)	Introduction to KARI & NARL	KARI HQ NARL (Nairobi)	Courtesy calls	Team introduced to KARI &NARL
	15 (wed)	Workshop prep.	"	Group work	
	16 (Thus)	Presentation workshop	NARL	Workshop	1st workshop held
	17 (Fri.)	Secondary info. Collection Interview of any stakeholders			Secondary data collected Interviews conducted
	18-19	Weed end	Nairobi		
2 (20-24 APRIL)	20 (Mon.)	Go to Katumani, meet Director	Katumani	Travel/court-esy calls	Team introduced to management
		Interview S&W -Katumani & literature		Interviews	Info. On soil & water program collected
	21 (Tue)	Travel to Makueni to see D.A.O & D.C	Makueni HQ	Travel /courtesy calls	Team introduced to Heads of Depts.
		Night at Katumani or sultan Hamud			
	22 & 23 Wed/Thus	Travel to Kasikeu to see D.O, chief, sub-chief & extension	Kasikeu	Travel /courtesy calls	Team introduced to local administration & extension
		Arrange accommodation at Sultan Hamud	Sultan Hamud	Arrangements	Accommodation arranged
		Arrange Baraza (farmer's meeting)	Kasikeu	Arrangements	Farmer baraza arranged
		Reconnaissance & team introduction to site			Site familiarization done
	24 (Fri.)	Interview KSS	Nairobi	Interview	KSS interviewed
		Plan following week	Nairobi	Group work	Plan for following week made
	25-26	Week end	Kasikeu/ Katumani		
3 APRIL 27-30	27-30 Mon. -Thurs.	Analysis of secondary info. On major topics (participatory methodologies, Soil management practices, gen. Agroecosystem, farm system. socio-economies, knowledge & info	Kasikeu	Review lit. Review interviews Analyze info.	Summary report of information synthesis Gaps in secondary info on all subjects identified

		systems, etc.) Identify gaps in secondary info on all subjects. If sufficient info do farm typology Attend farmer's launching baraza at Kasikeu Plan following week	 Kasikeu Kasikeu	 Baraza Group discussion	 Farmers informed and terms worked Plan of action
	1-3	Week end	Kasikeu/ Katumani		
4 (4-8 MAY)	4-8 Mon.-Fri.	Field data collection -agro-ecosystems -typology -socio-economics, etc. as in TOR Daily review of day's work & summarize data at end of week	Kasikeu Kasikeu	PRA methods -semi-structured interviews -Group interviews -key informants interviews -transect walks (soil classification, soil mgt. Problems, etc.)	Relevant systems identified Typology made Data gathered as in TOR Daily reviews Week data summary
	9-10 10 Sun.	Weekend Debriefing external reviewer			
5 11-15 MAY	11-14 Mon.-wed 14-15 Thurs.-Fri	Data collection Identifying problems & opportunities Problem causal trees	Kasikeu Kasikeu	PRA methods Data analysis	Data gathered Problems & opportunities identified Problem causal tree diagram
	16-17	Weekend Screen options Preparation of mid-term workshop	Katumani	Group discussion & using appropriate tools Group work	Options identified Mid-term workshop materials ready
6 18-22 MAY	18 Mon. 19 Tue 20 21 Wed-Thurs. 22 –24	Mid-term workshop Discussion with external reviewer Incorporate comments Plan phase 2 Week end	Katumani Katumani Katumani/ NARL Katumani	Workshop Discussion	Mid-term workshop held Preliminary report & other issues discussed Comment incorporated 2^{nd} phase plan
	25 Mon.	Prepare detailed report outline.	Katumani	Group work	Detailed report outline

7 25-29 MAY	26-28 Tue-Thur 29 Fri.	Collect & analyse complementary info Start refining options	Katumani Katumani	Focussed PRA Group work	Complementary information collected Options refining started
	30, 31 May - 2 June	Week end / Relaxation trip	Mt Kenya to Nakuru, Kabarnet and others	Travel	Members rejuvenated
8 3-5 JUNE	3-5 Tue.-wed 6-7	Continue refining options Analyse previous R&D experiences Week end	Katumani Katumani	Group work	Options refined Previous R&D activities analysed
9 8-12 JUNE	8-12 Mon.-Fri. 13-14	Report writing Week end	Katumani Katumani	Group work	Write-up of the report
10 15-19 JUNE	15-17 Mon.-wed 18-19 Thurs.-Fri 15-19	Continue report writing Clarify research questions Debriefing external reviewer	Katumani	Group work Group work	Write-up of the report Research questions Clarified
	20-21	Week end	Katumani		
11 22-26 JUNE	22-23 Mon.-Tue 24-25 Wed-Thurs 26 Fri. 27-28	Incorporate clarified research questions & finish report Prepare final workshop Circulate final draft Week end	Katumani	Group work Group work Communication	Research questions incorporated in the report. Final report draft. Final workshop preparations made. Final report draft circulated
12 29 JUNE-JULY 3	29-30 Mon-Tue 1 Wed. afternoon 2 Thurs. 3 Fri. 4-5	Relax, travel, shop Review workshop presentation, arrangements & equipment Final workshop Incorporate feedback Week end	Coast Katumani NARL	Travel Group work Workshop	Team rejuvenated Final workshop presentation reviewed Final workshop held
13 6-10 JULY	6-7 Mon.-Tue 8 Wed. 9 & 10 Thurs.-Fri 11 Sat.	Incorporate feedback Leave draft copy & Say farewell, leave for Nairobi Free Back to Wageningen	Katumani Katumani/Nairobi Nairobi	Group work Travel	Feedback incorporated. Final report draft finalised Draft copy each at Katumani and NARL. Leave Kenya.

Appendix 5 Checklist for sub-location interviews

Name of farmer
Size of farm
Location of farm on toposequence – Hill, slope, plain

Soil management practices

What soil types do you have on your farm?
*(Ask farmer to sketch farm and show resources especially, soils)

<u>Bench terraces</u>

Do you make bench terraces?
If yes
- What type – stones, thrash lines, fanyajuu, others and why
- What protection measures – grass sweet potatoes, etc?
- Utilization of terraces – for water harvesting, etc.
- Width of terrace
- Life of terrace
- How often terrace is maintained and how

If no, why? – Lack of money, lack of labour, lack of knowledge, others

<u>Ploughing with oxen</u>

When do you do your first ploughing ?
On what soil types and why
How – own / hired

<u>Manure application</u>

Do you apply manure? Yes/No
If yes

- Source of manure-type of livestock
  -Own or purchased
- How much
- Method of application –broadcast, point placed, mixing
- How often
- On what area- location
  -Size of farm
- On what soil types
- For which crops

If no, why? -Lack of money to purchase manure, lack of cattle, others

<u>Early planting</u>
- When do you start your first planting? Before rains/ onset of rains/ after rains
- On which soil types do you first plant and for which crops and why

If no, why? – Lack of money, lack of labour, lack of oxen, lack of plough, others

Early weeding

Do you do early weeding?
If yes,
When do you start weeding?
How – hand / implements

If no, why? – Lack of money, lack of labour, lack of implements, others

Resources controlling soil management

Land ownership
Family land
Own
Leased
Share cropping
Others
How do these influence soil management?

Draft power
Oxen – own / hired
Plough - own / hired
How do these influence soil management?

Farm implements
Hand hoe - own / hired
Shovel - own / hired
Plough- own / hired
How do these influence soil management?

Labour
Family – partly / fully (how many men & women)
Hired
How do these influence soil management?

Money
What proportion total income is farm income?
What proportion total income is off-farm income?
How do these influence soil management?

Storage of farm produce
How

Bidii (motivation for hard working)
What is the underlying reason for this

***Most important resources: Cows, oxen for ploughing, plough, manure, hand hoes**

Appendix 6 Soil management characteristics of farms on hills in Kasikeu sub-location

Soil management practices	Good soil manager	Medium soil manager	Low soil manager
Soil types	Kitune Nhangathi nziu	Kitune Nhangathi nziu Ilivi	
Terrace Maintenance Protection Utilization	Yes Fanyajuu Often after each rainy season Napier grass + cut-off drain Water harvesting Fodder for cattle	Fanyajuu As & when required Napier grass Water harvesting for banana	
Time of ploughing How On which soils	Early Oxen Kitune, Nthangathi nziu	Early- before rains (kitune). kitune, Nthangathi nziu	
Manure use Source Quantity Application method Frequency Crops Soils	100% apply Cattle + goats Not quantified Broadcast & ploughed Yearly Maize, beans, c.pea, pumpkin Kitune, Nthangathi nziu	100% apply 4 Cattle + goats Not quantified Broadcast & ploughed Yearly Maize, beans Kitune	
Mineral fertilizer use Which crops Which soils	No	Yes - Sole maize Nthangathi	
Time of planting Which soils Which crops	Early, before rains Kitune, Nthangathi nziu All crops	Early Before rains – kitune After rains – Nthangathi	
Time of weeding How	Early (3 weeks after planting) Oxen – pure maize Hand hoe – pure beans & mixed crops	Early (3 weeks after planting) Oxen – pure maize Hand hoe – pure beans & mixed crops	
Resources controlling soil management Land ownership	 Own &/family	 Own & family	
Farm size (acres)	54	10	
Area cropped (acres)	15-20	6	
Draft power (oxen & ox plough)	Own	Own	
Other farm implements Hand hoes (jembes) Shovel Matchet (panga) Axe	 Own Own Own Own	 Own Own Own Own	
Labour Source	Mostly family	Family & hired	
Source of income	Mainly on farm Off-farm (remittance)	On farm Off –farm (salary)	

Appendix 7 Soil management characteristics of farms on slopes in Kasikeu sub-location

Soil management practices	Good soil manager	Medium soil manager	Low soil manager
Soil types	Kitune, Nhangathi nziu Nthangathi nzau Nthangathi mwiu, Ikala	Kitune, Nhangathi nziu Ikala, Ilivi	Kitune+ Nthangathi Nthangathi nziu Ikala
Terrace Type Maintenance Protection Utilization	Yes Fanyajuu Whenever damaged Napier / nandi grass + cut-off drain Water harvesting for banana Fodder for cattle	Yes Fanyajuu As & when required Castor, *Panicum maximum*. *Cenchros ciliaris* .cut-off drain Fodder, roof thatch	Yes Fanya juu No protection No use
Time of ploughing How On which soils	Early (onset of rains) Oxen plough All soils	Early (before rains / onset of rains) Oxen plough All soils	Onset of rains Nthangathi then Kitune, Ikala Oxen plough
Manure use Source Quantity Application method Frequency Crops Soils	100% apply Own cattle + goats Not quantified Broadcast & ploughed Yearly Maize, beans, c.pea, pumpkin, banana Kitune, Nthangathi nziu	100% apply Own cattle + goats Not quantified Broadcast & ploughed Yearly / every 2 years Maize, beans, vegetables Kitune	100% apply Own cows (3) - Broadcast Maize, beans
Mineral fertilizer use	No	No	No
Time of planting Which soils Which crops	Early (onset of rains) All soils All crops	Early (just before/onset of rains) All soils All crops	Onset of rains
Time of weeding How	Early (3 weeks after planting) Oxen – pure maize Hand hoe – pure beans & mixed crops	Early (3 weeks after planting) Oxen – pure maize Hand hoe – pure beans & mixed crops	Early (3 weeks after planting) Oxen – pure maize Hand hoe – pure beans & mixed crops
Resources controlling soil management Land ownership	Own &/family	67%Own 33% family	Family
Farm size (acres)	20-25	5-8	2
Area cropped (acres)	15-20	6	2
Draft power (oxen & ox plough)	Own	Own	Own
Other farm implements Hand hoes (jembes) Shovel Matchet (panga) Axe	 Own Own Own Own	 Own Own Own Own	 Own Own Own -
Labour Source	Mostly family Hired	Family & hired	Family & hired
Source of income	Mainly on farm Off-farm (remittance)	On farm Off –farm	On farm

Appendix 8 Soil management characteristics of farms on plains in Kasikeu sub-location

Soil management practices	Good soil manager	Medium soil manager	Low soil manager
Soil types		Kitune, Nhangathi nziu Nthangathi nzau Ilivi	Kitune+ Nthangathi Nthangathi nziu Ikala, Ilivi
Terrace Type Maintenance Protection Utilization		50%Yes 50% none (on very flat plain) Fanyajuu Whenever damaged Nandi grass Water harvesting for banana	50%Yes 50% none (on very flat plain) Fanya juu When damaged - -
Time of ploughing How On which soils		Early (before rains in sandy soils / onset of rains others Oxen plough All soils	50% just before of rains 50% after onset of rains Oxen plough All soils
Manure use Source Quantity Application method Frequency Crops Soils		100% apply 50% own cattle + goats & 50% cow dung purchase Not quantified Broadcast & ploughed on terrace but point placed on plains for vegetables Yearly Maize, beans, bananas, vegetables Nthangathi nziu, Nthangathi nzau + Ilivi	50% apply & 50% none Own cows (3), goats, chickens - Point placed Every 2 months Vegetables Nthangathi + Ikala
Mineral fertilizer use		Yes for only vegetables (top dressing)	No
Time of planting Which soils Which crops		Early (just before/onset of rains) All soils All crops	50% just before of rains 50% after onset of rains All soils
Time of weeding How		Early (3 weeks after planting) Oxen – pure maize Hand hoe – pure beans & mixed crops	50% early (3 weeks after planting) 50% 1week after palnting Oxen – pure maize Hand hoe – pure beans & mixed crops
Resources controlling soil management Land ownership		100 % own 50% family	100% own
Farm size (acres)		5-7	3
Area cropped (acres)		4-5	1.5 - 3
Draft power (oxen & ox plough)		50% own 50% borrowed (due to no grazing area)	50% own 50% borrowed
Other farm implements Hand hoes (jembes) Shovel Matchet (panga) Axe		 Own Own Own Own	 Own Own Own -
Labour Source		Family & hired	Family & hired
Source of income		On farm Off –farm (on farm less than off farm)	On farm Off farm(bricks, remittances)

Appendix 9 household interview questionnaire

1. Name--Village--------------------------------------

2. Family size: On Farm Out of Farm Total

3. Location of farm: Hill Slope
Plain

4. Size of farm (acre):

5. Land use (acre): Cropping Grazing Others

6. Ownership of land : Own Family Leased

7. Access to oxen for ploughing: Yes No

8. If yes, when: Timely Late

9. Access to oxen for weeding: Yes No

10. If yes, when: Timely Late

11. Labor: Family Hired Both

12. If both, how many of: Family Hired

13. If family, how many: Men Women Children

14. If hired, how many of: Men Women Children

15. No . of animals: Cattle Goats Sheep
Others

16. Stay of animals in night: In open In shed

17. How manure is stored: In open Covered

18. Type of manure: Cattle Compost Household None

19. How do you apply manure: Point Spread

20. Do you apply fertilizer: Yes No

21. If yes, how: Before planting After planting

22. In which crops: Cereals Legumes Root crops
Others

23. Type of terraces: Fanyaju Rocks Trash line
None

24. Maintenance how often: Regularly Yearly Once in 3 years
Never

25. Source of income: On farm Off farm Both

26. If both, how much of each: F=O F>O F<O

27. Gender activity profile:

27. Gender activity profile:

Terracing, Terrace maintenance Manure application Fert. Appl.

Ploughing Planting Weeding Harvesting Threshing

28. Access and control profile of households:

Major Production Factors	Access		Control	
	Male	Female	Male	Female
Land				
Labour				
Money				
Manure				
Fertilizer				
Oxen				
Ox-plough				
Hand hoe				
Shovel				
Extension advice				
Agric. credit				

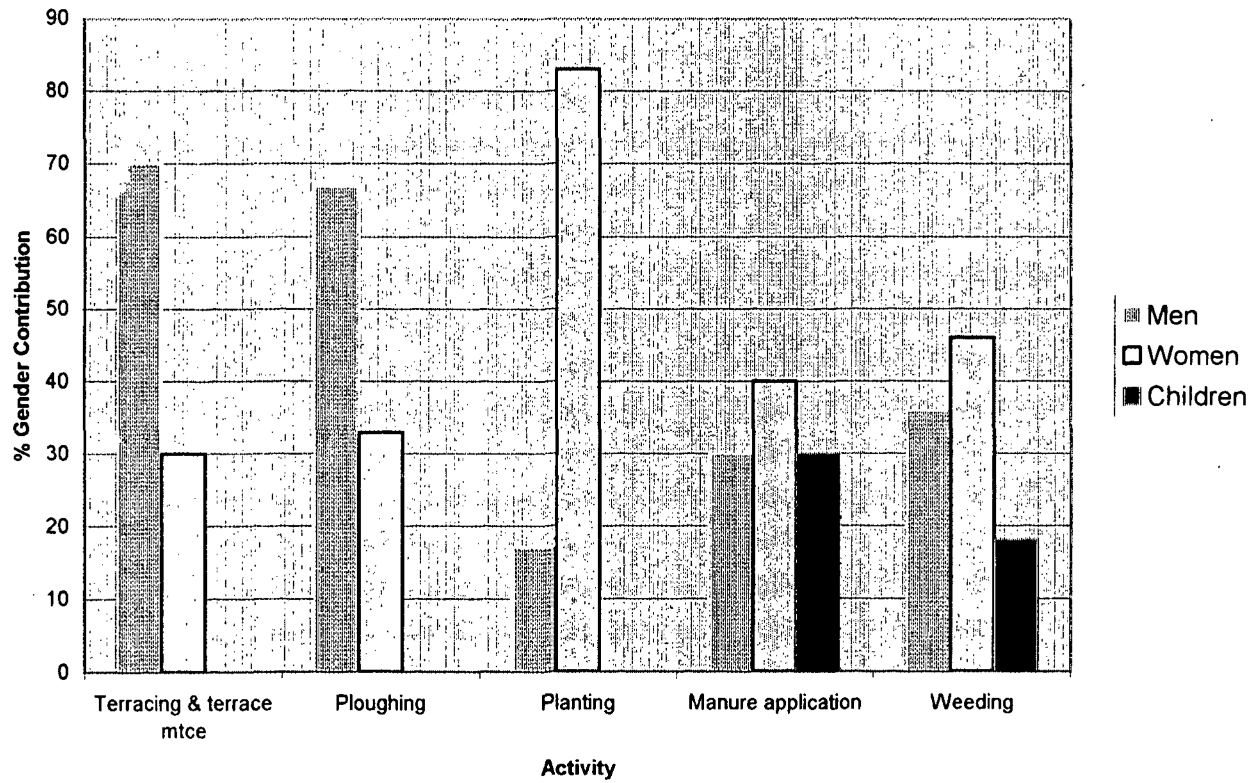
Appendix 10. Financial potentials of farms in Kasikeu sub-location

Farm asset	**Farm types**			
	Medium male	**Medium female**	**Low male**	**Low female**
Land	388,000	175,500	123,500	78,000
Oxen	18,300	12,500	0	1,430
Cow	21,360	26,000	2,000	16,000
Goats	18,660	9,500	5,000	8,000
Sheep	5,000	4,000	2,000	0
Poultry	2,465	772	1,381	790
Ox-plough	-	-	-	-
Labour on farm	617	175	225	229
Total value (financial potential) (ksh)	**454,402**	**228,447**	**134,106**	**104,449**

Farm asset	**Farm types**			
	Medium	**Low**	**Male**	**Female**
Land	304,200	158,600	283,400	179,400
Oxen	16,000	910	11,000	5,450
Cow	23,200	10,912	13,600	19,640
Goats	15,000	6,910	13,200	8,546
Sheep	4,600	728	3,800	1446
Poultry	1788	1,005	2031	783
Ox-plough	-	-	-	-
Labour on farm	440	227	460	209
Total value (financial potential) (ksh)	**365,228**	**179,292**	**327,491**	**215,474**

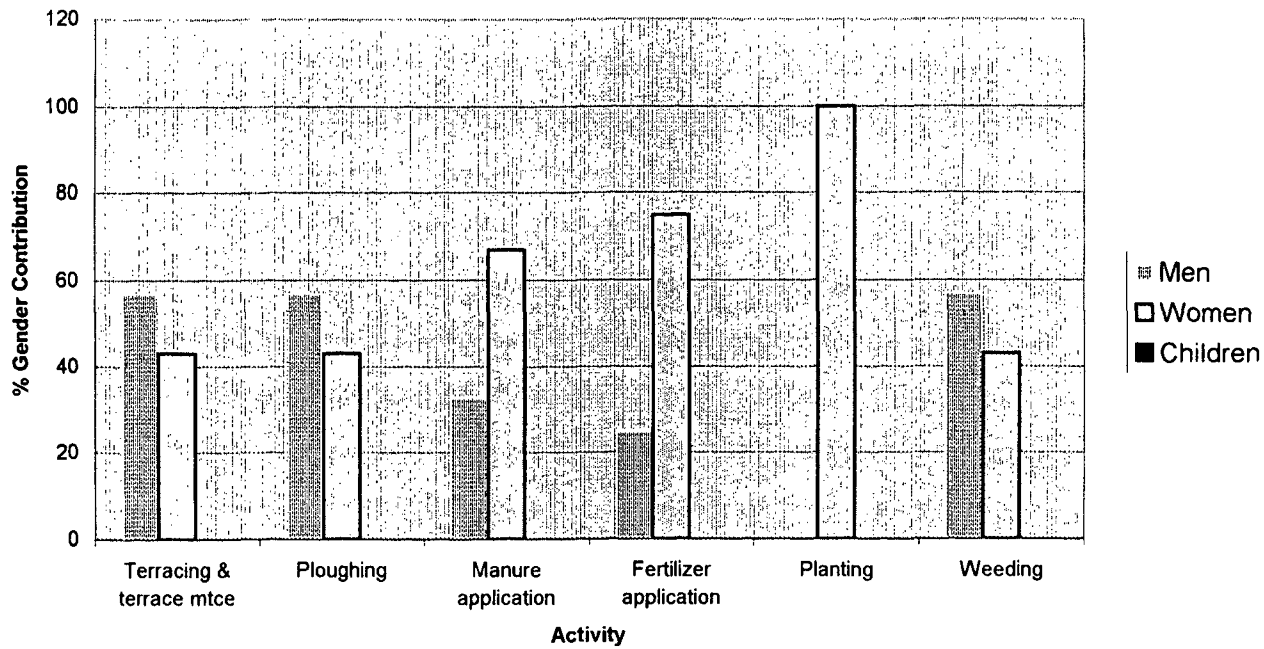
Appendix 11 Gender Activity Profile for Soil management

Medium Male Farm



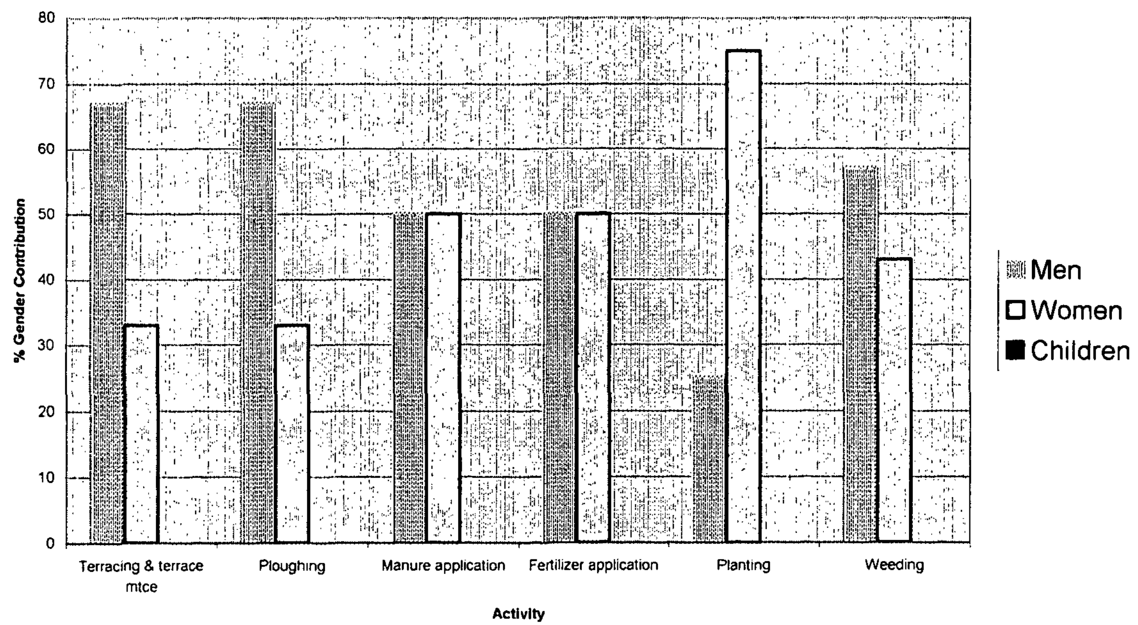
Appendix 12 Gender Activity Profile for Soil Management

Medium Female Farm



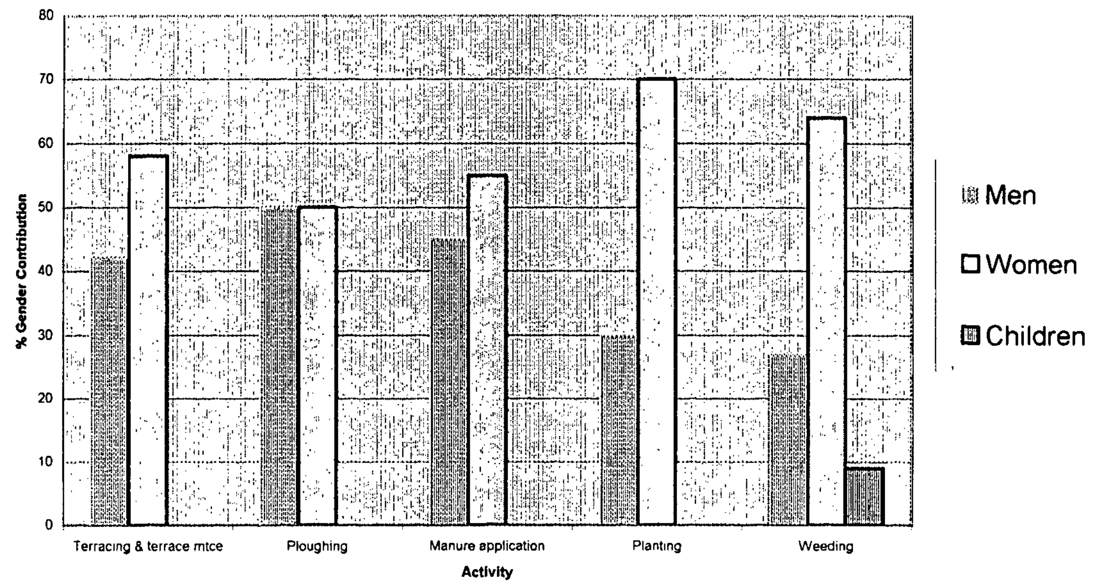
Appendix 13 Gender Activity Profile for Soil Management

Low Male Farm



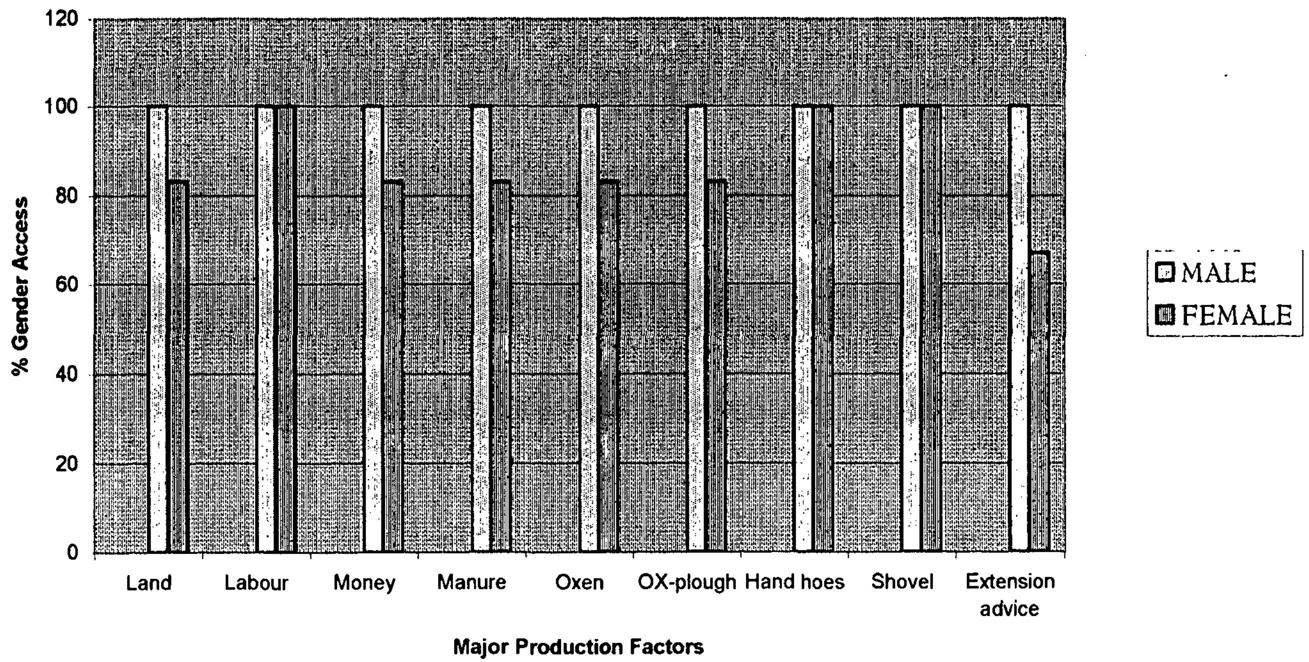
Appendix 14 Gender Activity Profile for Soil Management

Low Female Farm



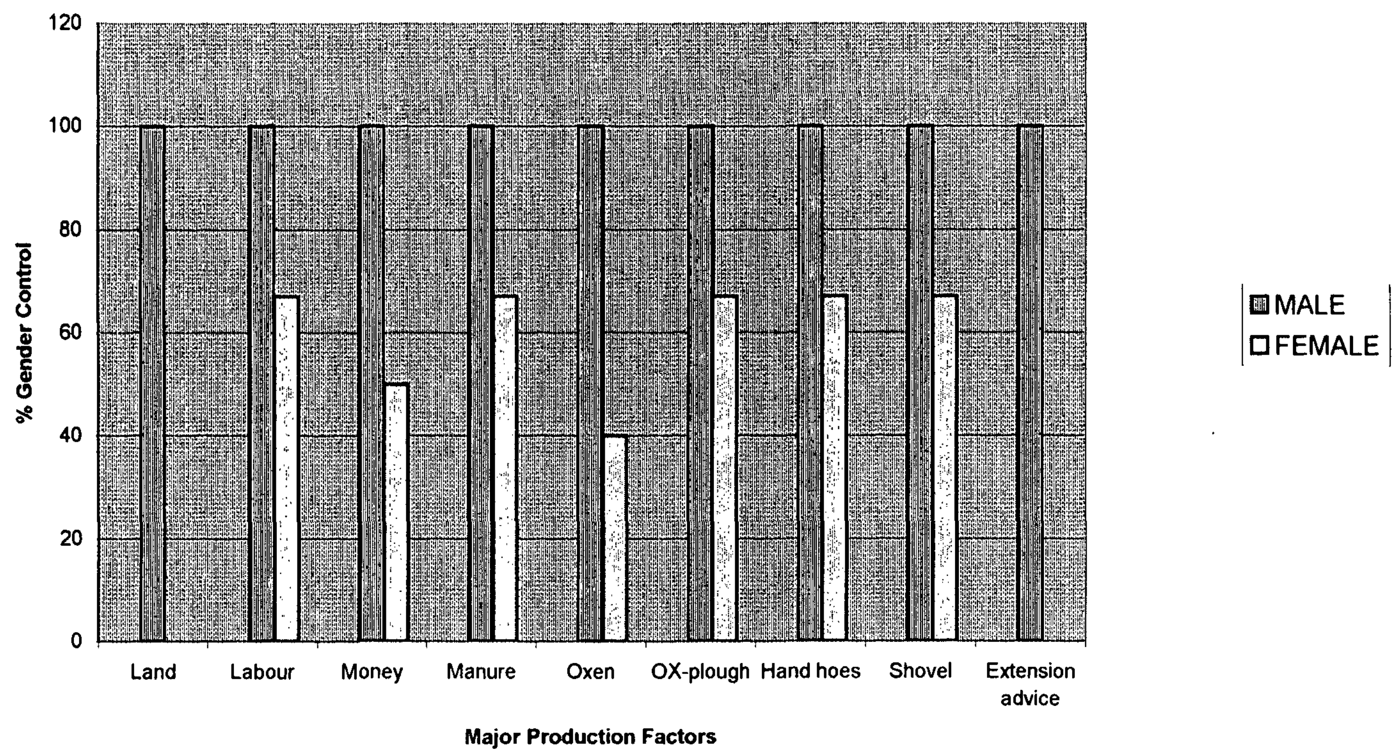
Appendix 15 Gender Access to Major Production Factors

Medium Male Farm



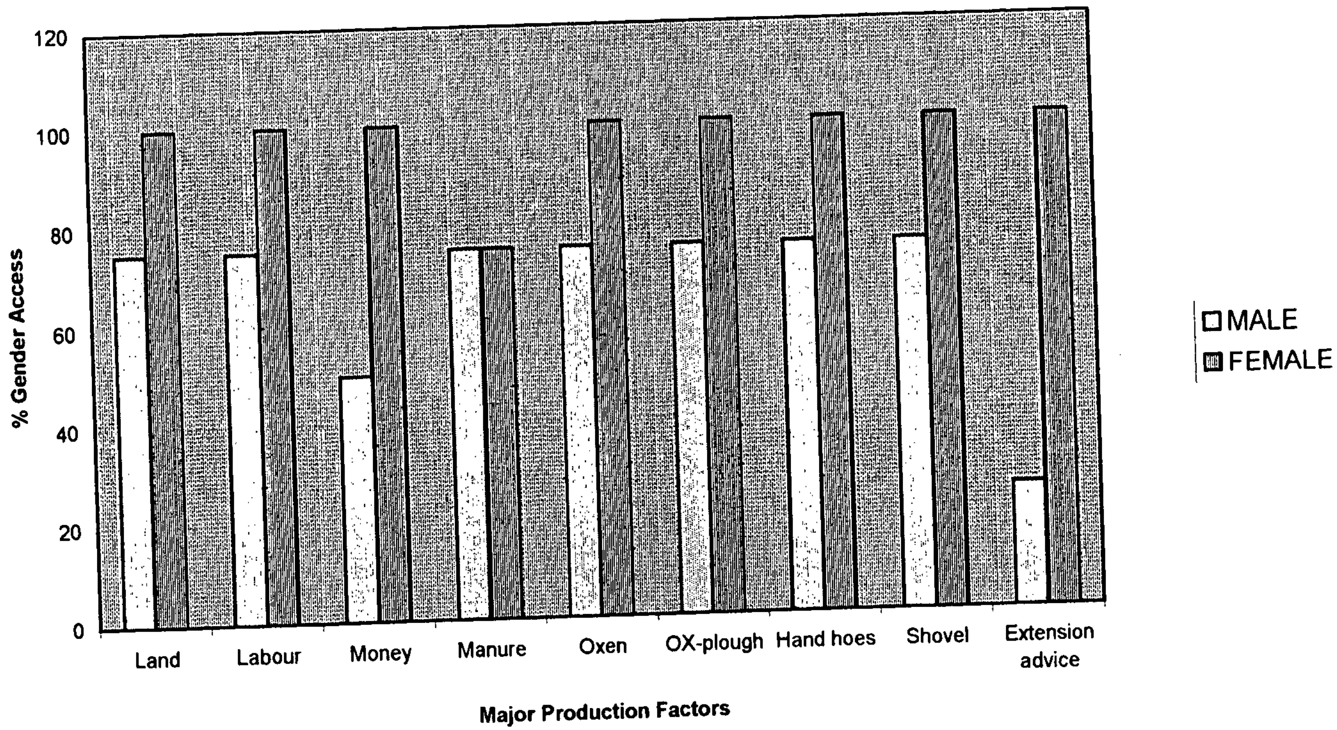
Appendix 16 Gender Control over Major Production Factors

Medium Male Farm



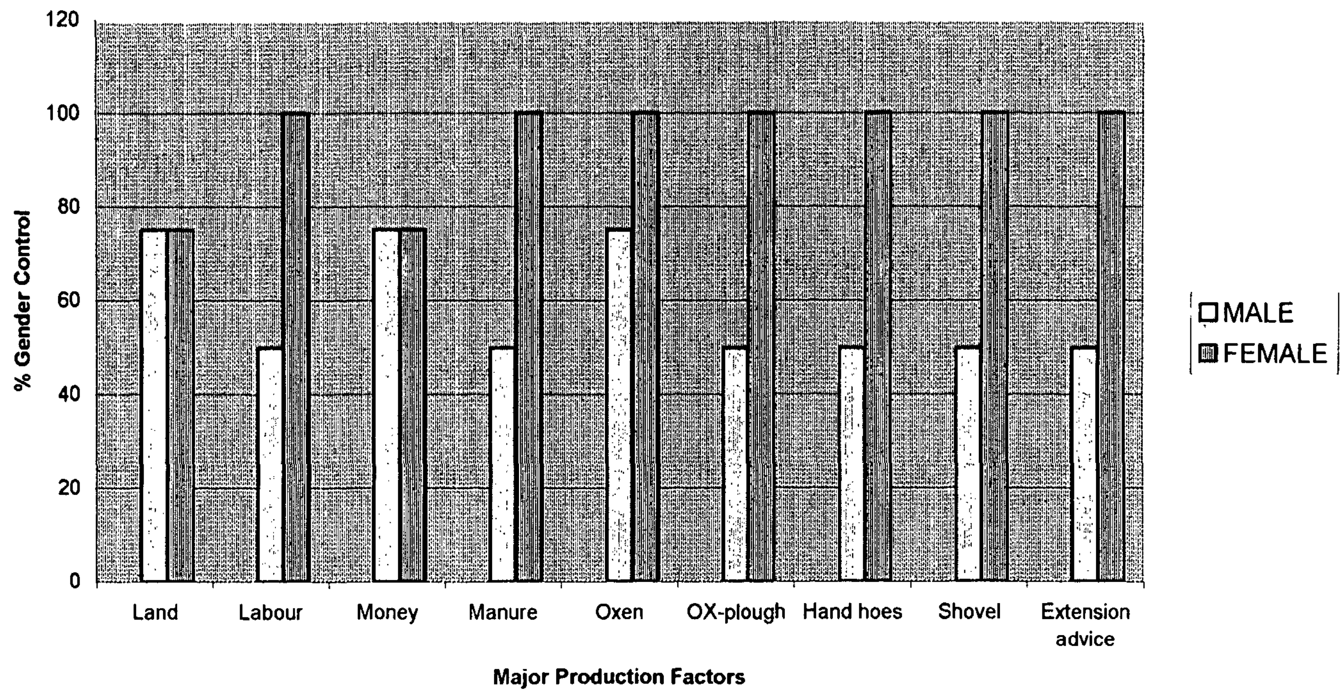
Appendix 17 Gender Access to Major Production Factors

Medium Female Farm



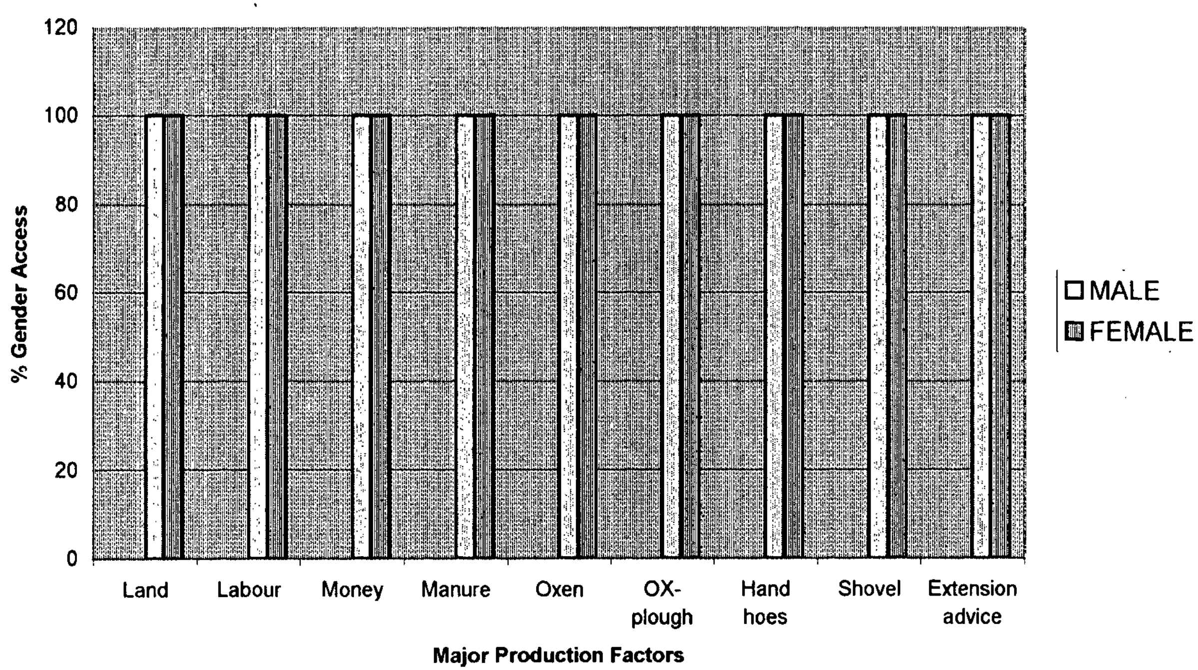
Appendix 18 Gender Control over Major Production Factors

Medium Female Farm



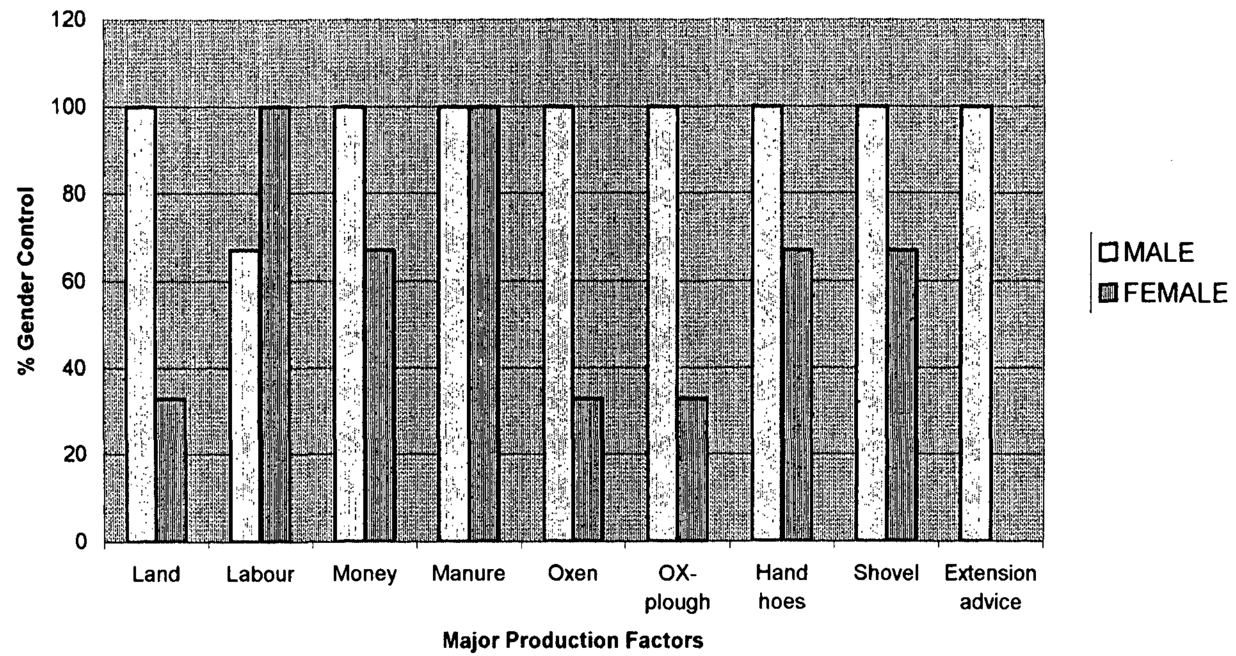
Appendix 19 Gender Access to Major Production Factors

Low Male Farm



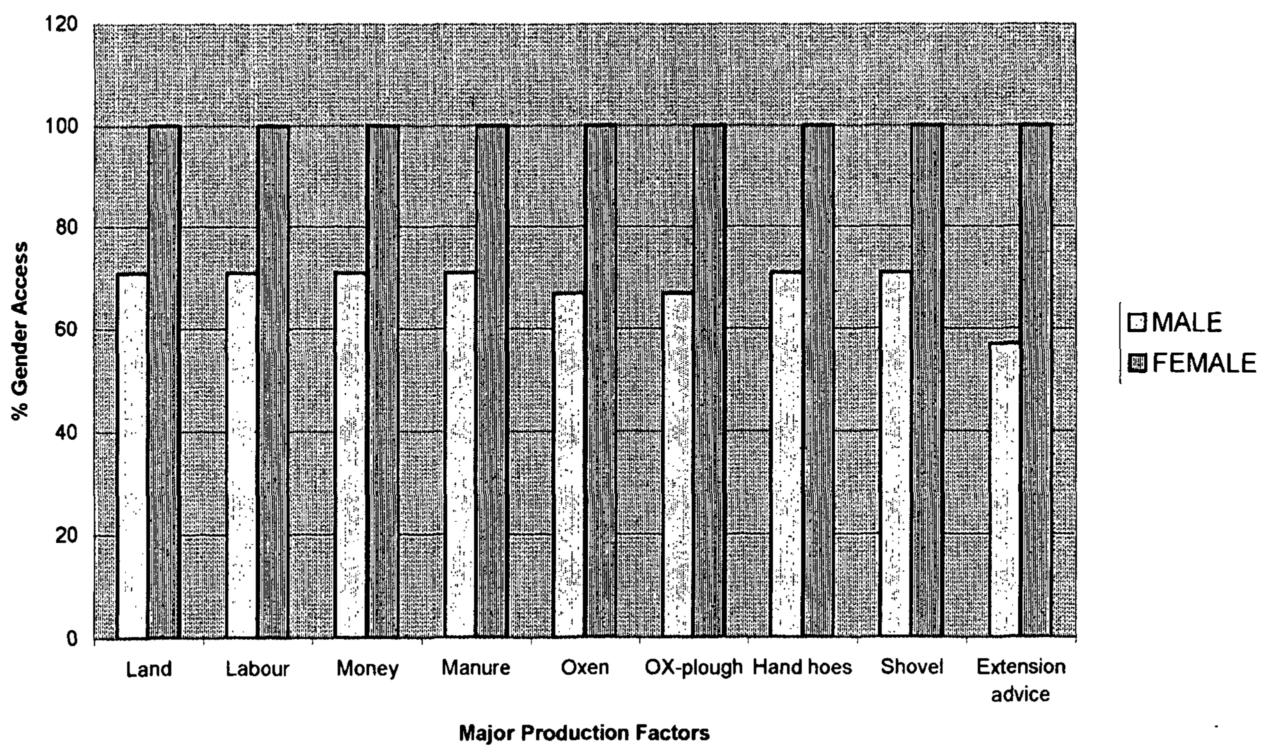
Appendix 20 Gender Control over Major Production Factors

Low Male Farm

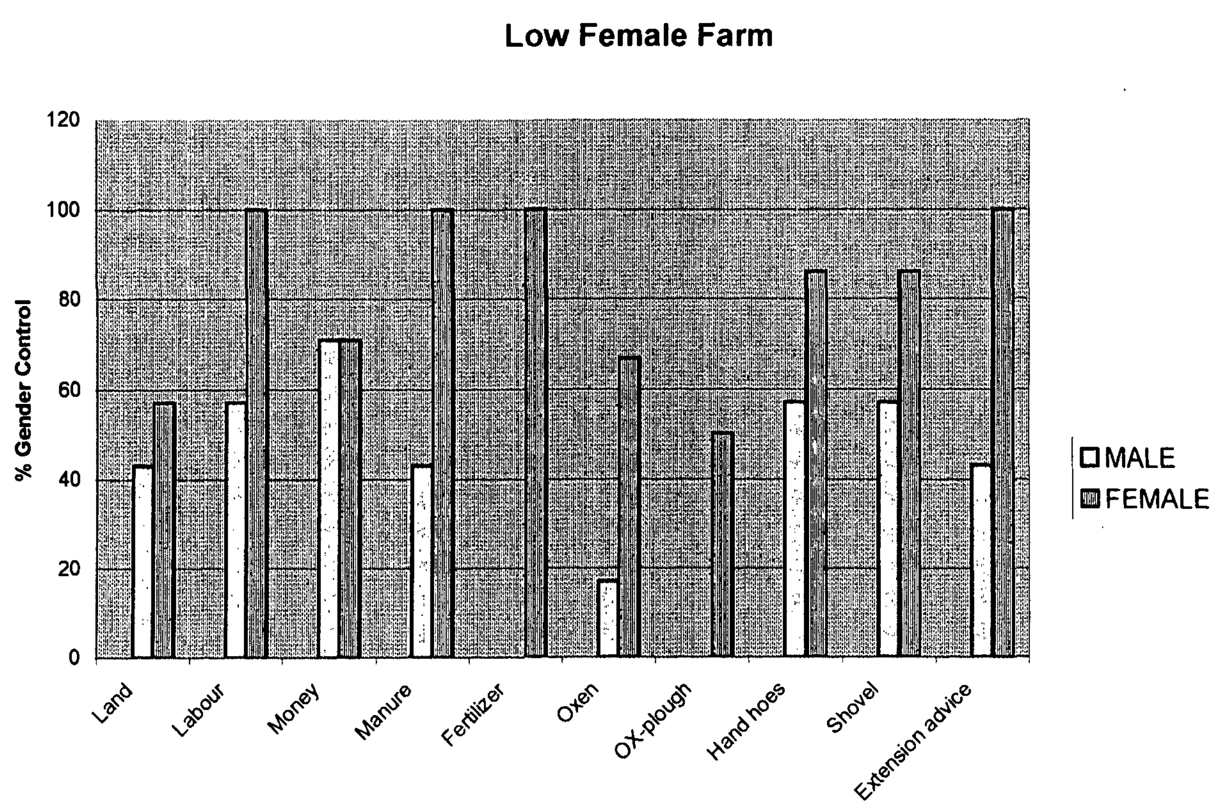


Appendix 21 Gender Access to Major Production Factors

Low Female Farm



Appendix 22 Gender Control over Major Production Factors



Appendix 23. Problems, causes, coping strategies and opportunities as identified by male farmers of low management group

Problems	Causes	Coping Strategies	Opportunities
• Water-logging	• Sol type • Plain/flat terrain • Underground water seepage	• Wait for water to drain	• Provision of drainage
• Shortage of labor for digging terraces	• Lack of money • Lack of implements • High labor demand just before the onset of the rains	• Spread the digging of terraces over time • Planting of grass strips • Trash and stone lines • Leaving a foot wide without planting	• Alternate sources of money • Arrangements for suitable implements
• Low soil fertility	• Continuous cultivation for a long time • Soil erosion • Inadequacy of manure • Lack of fertilizer	• Add manure if available • A few farmers use fertilizers • Digging of terraces • Cultivation on and around anthills if available	• Digging adequate terraces • Producing more manure
• Gullies	• Runoff water from hilltops • Very steep slopes	• Put boulders and twigs in the gully • Plant sisal, napier and Euphorbia sp. • Use of sand bags	• Construction of gabbions • On rock surface build cement walls

Appendix 24. Problems, causes, coping strategies and opportunities as identified by female farmers of low management group

Problems	Causes	Coping strategies	Opportunities
• Inadequate manure	• Few animals for manure production	• Spread the manure application over time	• Making compost
• Compacted soils	• Continuous shallow cultivation	• Wait until the soils are wet	• Suitable implements and draft power
• Low soil fertility	• Continuous cultivation due to small land holdings	• Inter-cropping of all crops	• Application of manure and fertilizer
• No terraces	• Inadequate labor	• Planting of grass strips	• Formation of "labor groups"

Appendix 25. Problems, causes, coping strategies and opportunities as identified by male farmers of medium management group

Problems	Causes	Coping strategies	Opportunities
• Low soil fertility	• Inadequate manure • Lack of money to buy manure • Lack of knowledge on fertilizer use	• Few farmers add compost or boma manure • A few add little fertilizer either at planting or as top dress	• Composting • Add waste materials to boma • Improve terraces • Get knowledge on fertilizer use
• Soil erosion	• Inadequate terraces/control measures • Overgrazing • Bare land • Steep slopes	• Some dig terraces • Use of trash and stone lines • Planting of grass strips • Few adopt agroforestry	• Zero-grazing and destocking • Construction of gabbions
• Lack of plough and oxen	• Lack of finance	• Use hand hoe • Borrow oxen and plough from friends • Hire plough and oxen	• Raise finance through sale of farm produce

Appendix 26. Problems, causes, coping strategies and opportunities as identified by female farmers of medium management group

Problems	Causes	Coping strategies	Opportunities
• Low soil fertility	• Soil erosion • Inadequacy of manure • Lack of fertilizer	• Use of little available manure	• Increase manure production • Increase fertilizer use
• Soil erosion	• Inadequacy of terraces • Overgrazing • Leaving soil bare	• Ploughing along the contour	• Terracing and planting grass on the terraces • Planting grass strips on the contour
• Hard soils	• Continuous shallow cultivation • Soil type	• Wait for rains to plough	• Use manure • Plough early after harvesting
• Scarcity of money	• No credit facilities	• Sell farm and livestock produce	• Form cooperative societies

Appendix 27 Problem ranking by low management farmers

PROBLEM	INADEQUATE MANURE	LACK OF FERTILIZER	SOIL EROSION	COMPACT SOILS	INADEQUATE LABOUR	LACK OF FINANCE	WATER LOGGING	SCORE	RANK
INADEQUATE MANURE		INADEQUATE MANURE	SOIL EROSION	INADEQUA -TE MANURE	INADEQUATE LABOUR	INADEQUATE MANURE	INADEQUA -TE MANURE	4	3
LACK OF FERTILIZER			SOIL EROSION	COMPACT SOILS	INADEQUATE LABOUR	LACK OF FERTILIZER	LACK OF FERTILIZE R	2	6
SOIL EROSION				SOIL EROSION	INADEQUATE LABOUR	LACK OF FINANCE	SOIL EROSION	4	2
COMPACT SOILS					INADEQUATE LABOUR	LACK OF FINANCE	COMPACT SOILS	2	5
INADEQUATE LABOUR						INADEQUATE LABOUR	INADEQUA TE LABOUR	6	1
LACK OF FINANCE							LACK OF FINANCE	3	4
WATER LOGGING								0	7

Appendix 28 Problem ranking by farmers medium management group

PROBLEM	LACK OF MANURE	LACK OF FERTILIZER	SOIL EROSION	HARD SOIL	LACK OF FINANCE	LACK OF OXEN & PLOUGH	LACK OF KNOWLEDGE ON FERTILIZER USE	SCORE	RANK
LACK OF MANURE		LACK OF MANURE	SOIL EROSION	LACK OF MANURE	LACK OF FINANCE	LACK OF OXEN & PLOUGH	LACK OF MANURE	3	4
LACK OF FERTILIZER			SOIL EROSION	LACK OF FERTILIZER	LACK OF FINANCE	LACK OF OXEN & PLOUGH	LACK OF KNOWLEDGE ON FERTILIZER USE	1	6
SOIL EROSION				SOIL EROSION	SOIL EROSION	SOIL EROSION	SOIL EROSION	6	1
HARD SOIL					LACK OF FINANCE	LACK OF OXEN AND PLOUGH	LACK OF KNOWLEDGE	0	7
LACK OF FINANCE						LACK OF OXEN AND PLOUGH	LACK OF KNOWLEDGE	3	5
LACK OF OXEN AND PLOUGH							LACK OF OXEN AND PLOUGH	5	2
LACK OF KNOWLEDGE ON FERTILIZER USE								3	3

Appendix 29 The diffusion action plan for learnt participatory methodologies by the Kenyan ICRA team members to other KARI scientists.

Activity	Who	When	How
Report distribution	Peter*, Ben and David	2nd Week of August	Transportation Hand delivery
Enlargement of soil maps and delivery to Kasikeu.	Peter*, Ben and David	2nd Week of August	GIS and transportation
Seminars for Naivasha on DORA procedure	Peter, Ben* and David	1st Week September	Seminar at Naivasha
Seminars for KSS on DORA procedure and participatory soil mapping	Peter, Ben and David*	2nd Week September	Seminar at KSS
Seminars for Katumani on DORA procedure and soil management issues	Peter, Ben and David*	3rd Week September	Seminar at Katumani

* Organiser

TERMS OF REFERENCE ICRA FIELD STUDY KSS/NDFRC KATUMANI, APRIL-JULY 1998

Introduction

In the context of the collaborative agreement between KARI, KIT and ICRA, an ICRA team is invited to carry out a field study for Kenya Soil Survey (KSS) and National Dryland Farming Research Centre (NDFRC), Katumani. From the point of view of the Netherlands support to KARI, this collaboration is to realize the following outputs:

- three KARI participants are trained in an interdisciplinary team approach to farming systems research;
- a baseline document that includes points of action for research and extension for the further development of participatory research method is developed;
- an extra impulse will be given to the development of the on-farm participatory farming systems research in the Regional Research Programme (RRP) by exposure of the research and extension staff to the ICRA interdisciplinary team approach;
- the collaboration with the partners in the region will be strengthened by the inter-institutional activities of the ICRA team.

To realize the above output, regular interaction with the ICRA team will ensure adequate participation of the interested partners.

Period

The field study will be realised from April to July 1998.

Location

In collaboration with the NDFRC Katumani and the KSS based in National Agricultural Research laboratories (NARL), Nairobi, Kasikeu sub-location in the lowlands of Makueni district is selected as the area to be studied. Kasikeu is a cluster research sites where on-farm research is ongoing and where a general PRA (Participatory Rural Appraisal) has been carried out recently.

Objectives

The objectives of the study are:

- to develop a methodology to make soil maps more comprehensible and relevant to farmers and extension staff;
- to communicate to the NDFRC Katumani the priority problems in soil management as perceived by the farmers (mal, female) in various farm types and recommend the possible orientation of its on-farm research programme in the field of soil management.

Activities

The following activities will be carried out, making use of participatory methods, involving both male and female farmers:

- identification of various farm types in a farming systems perspective (based on soil management practices);
- description of these farm types (size of farm, size of households, assets, area under cultivation, cropping pattern, livestock enterprises, inputs, outputs, gross margin per enterprise, net profits, level of technology, activity profile (gender differentiated), access and control profile (gender differentiated), crop-livestock interaction, off-farm income, household income;
- description of the prevailing soiltypes as identified by the farmers (male, female), their local names, characteristics, means of identification;
- relate soiltypes, distinguished by farmers, and their vernacular names to the international classification presently used by KSS in their various soil maps
- identification of the present land use and production potential of the different soil types (crops (intercrop, rotation), yields, inputs used, gross margins, technology);
- establish trends in land use;
- hold a workshop for KSS and NDFRC Katumani researchers and interested parties on the intermediate findings;
- identification of the present soil management from a farming system perspective for each farm type and gender specific;
- problems and opportunities for the various farm types as identified by the farmers (male, female);
- developing in a participatory manner criteria for soil map presentation;
- description of the methodology followed for further use by KSS;
- inform NDFRC Katumani on soil related research topics for their consideration;
- hold a workshop at the end of the fieldwork to present the results to the KSS and NDFRC Katumani researchers and other interested parties;
- developing an action plan for the KARI members of the ICRA team to follow up the diffusion of the learned participatory methodologies and findings of the study in KARI, in particular the KSS staff, NDFRC Katumani and NAPRC Naivasha.

The KARI members will avail to the ICRA team background information on the area of study which is presently being collected.

KIT/ICRA will support the team by making available a resource person from KIT, specialised in the field of participatory soil mapping. This resource person will introduce the required participatory methodologies during the preparations in Wageningen and will be with the team in the field to during the first stages of the farm typology and identification of soil types with farmers and during the writing up of the methodology for participatory soil mapping.

Reporting

A draft report will be made available to the partners at least one week before the final workshop.

Procedures

During the fieldwork, there will be a feed-back meeting with the major partners once every two weeks. The team will present the progress, planning and issues that can benefit from contributions of the partners.

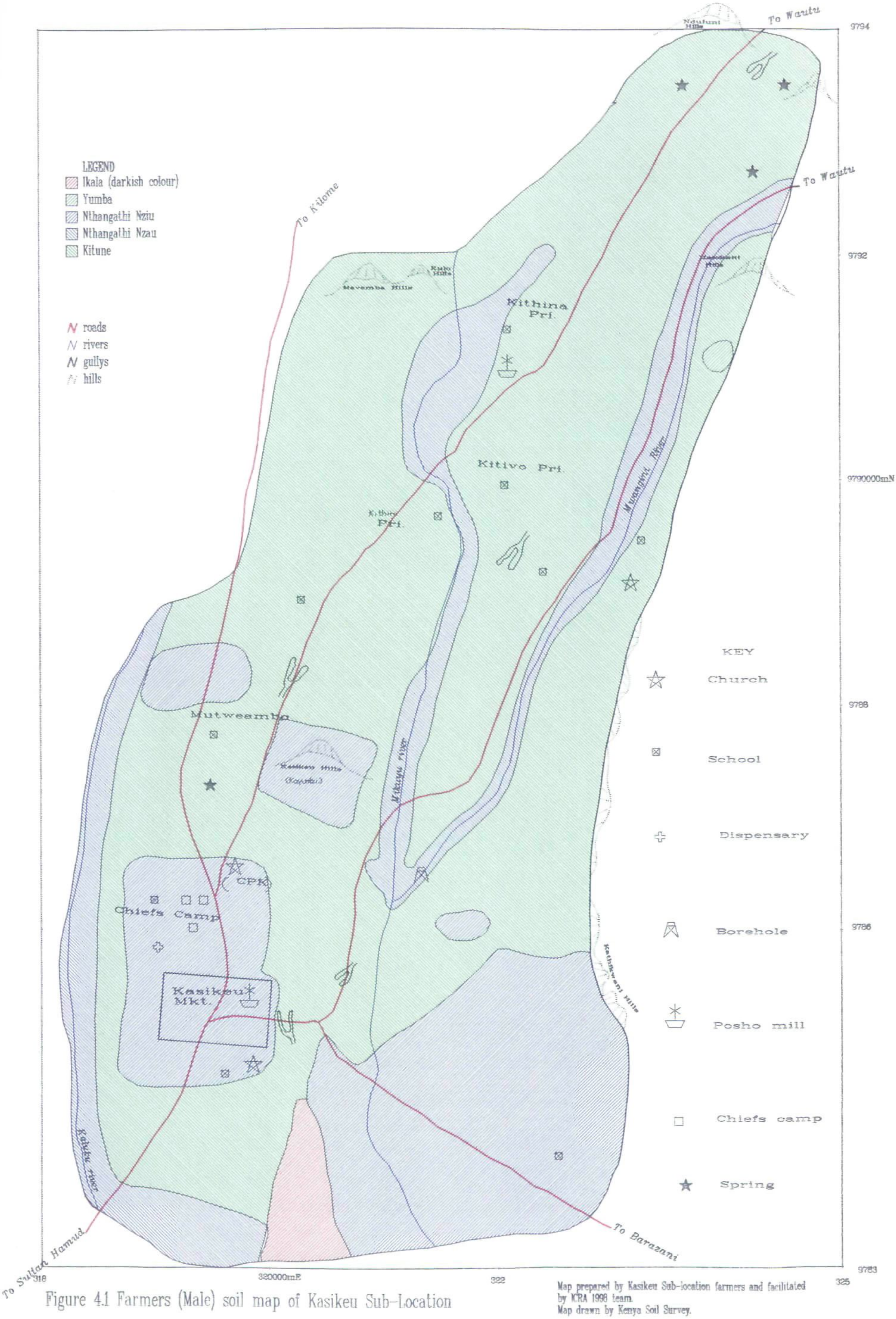


Figure 4.1 Farmers (Male) soil map of Kasikeu Sub-Location

Map prepared by Kasikeu Sub-location farmers and facilitated by ICRA 1998 team.
Map drawn by Kenya Soil Survey.

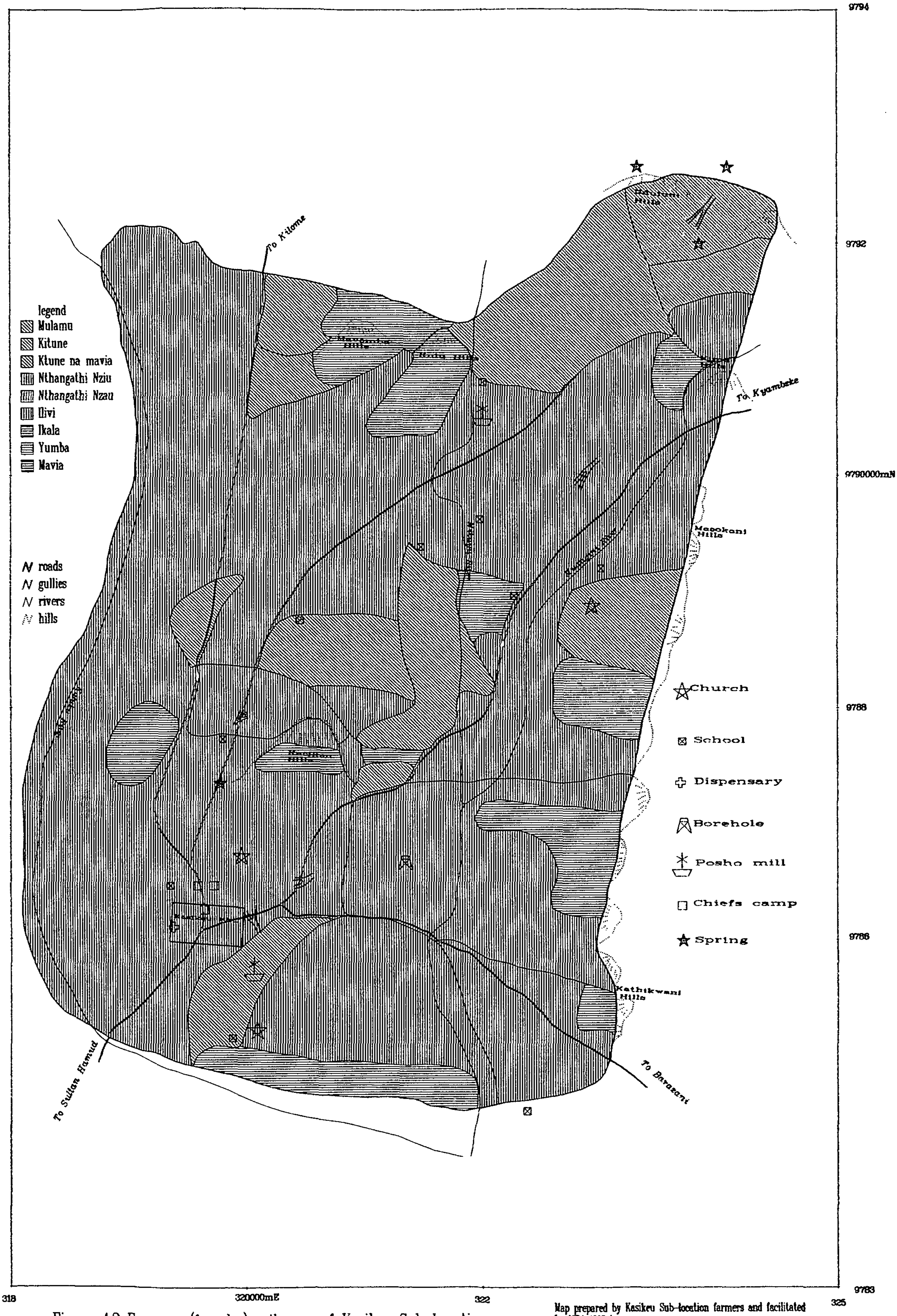


Figure 4.2 Farmers (females) soil map of Kasikeu Sub-Location

Map prepared by Kasikeu Sub-location farmers and facilitated by KRA 1998 team.
Map drawn by Kenya Soil Survey.

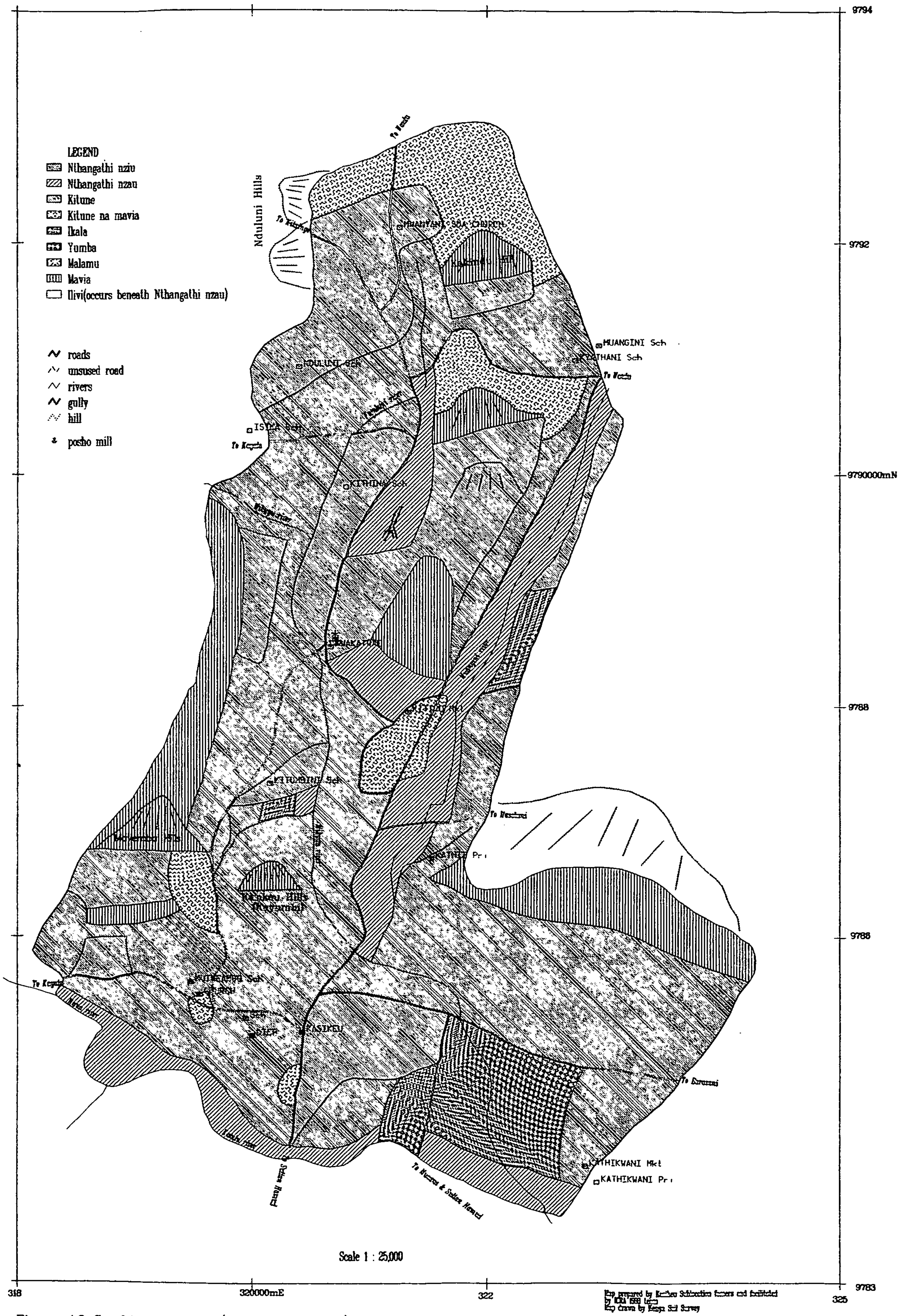
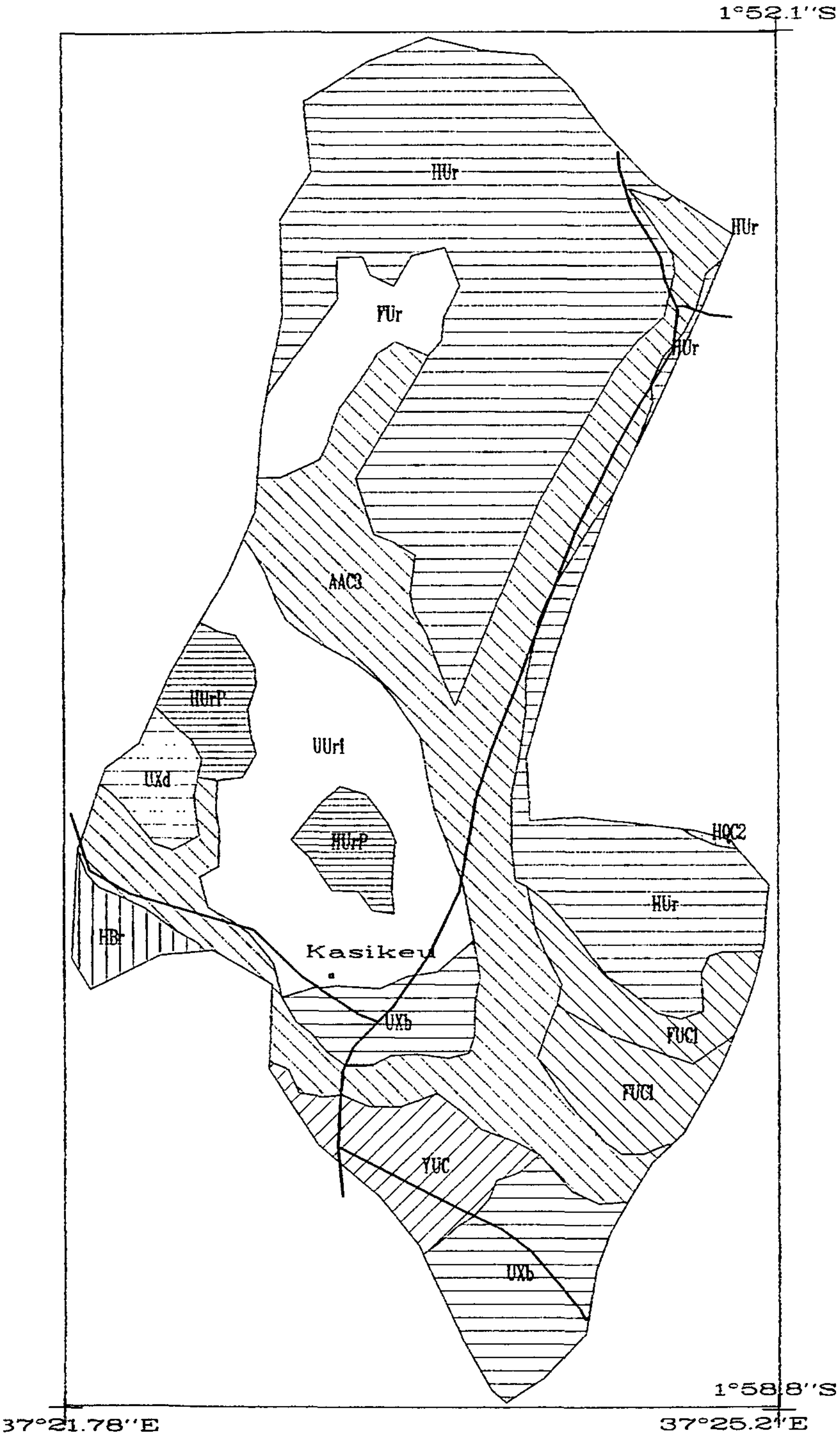


Figure 4.3 Combined farmers(Male and Female) soil map of Kasikeu sublocation



LEGEND

HILLS, MINOR SCARPS AND LOW RIDGES (relief intensity 50 - 300 m, slopes (4-15%) top and > 16% on sides

HU soils developed on varous quartzo-feldspathic gneisses
HUr well drained, very deep, dark red to red, friable clay, in places stony (Dystric Plinthosol, sodic phase)
HUrP well drained, shallow, dark red to red, friable very gravelly clay, highly rocky and stony

HQ soils developed on granitoid gneisses and quartzo-feldspathic gneisses
HQC2 complex of somewhat excessively drained to well drained, shallow to deep, dark reddish brown to dark brown, rocky and stony, gravelly, sandy clay loam to clay (Lithosols and Humic Cambisols, lithic and rudic phase)

HB soils developed on basaltic ash and agglomerates
HBr well drained very deep, dark brown to yellowish red, slightly gravelly friable clay

FOOTSLOPES (at the foot of mountains, hills, scarps and plateaus, slopes generally 3-16%)

FU soils developed on colluvium derived from various gneisses
FUr well drained, very deep, dark red to red, friable sandy clay to clay (Rhodic Ferralsols, partly sodic phase)
FUC1 complex of well drained, moderately deep to very deep, dark reddish brown to dark brown; very friable to friable, sandy loam to clay; in places shallow, rocky and stony

UPLANDS (slopes 3-15%)

UU soils developed on undifferentiated quartzo-feldspathic gneisses
UUrl well drained, very deep, dark red to dark reddish brown, friable clay (Rhodic Ferralsols)
UX soils developed on alluvium and colluvium from various gneisses
UXb well drained, very deep, yellowish red to strong brown, friable clay (Haplic Ferralsols)
UXd imperfectly drained to poorly drained, very deep, dark brown to very dark grey, mottled firm to very firm clay (Eutric Gleysol)

PIEDMONT PLAINS (long slopes, less than 3%)

YU soils developed on colluvium and alluvium derived from vario gneisses
YUC complex of imperfectly drained to poorly drained, very deep, dark brown to dark greyish brown, mottled, firm, calcareous to non-calcareous, stratifield to non-stratified, loamy sand to sandy clay (Gleyic Luvisols and Eutric Fluvisols)

RIVER TERRACES AND FLOODPLAINS (slopes less than 2 %)

AA soils developed on recent and subrecent alluvial deposits
AAC3 Complex of
- somewhat excessively drained, very deep, loose to friable loamy sand to sand (Haplic Arenosols).
- imperfectly drained to poorly drained, very deep, black to dark reddish brown, loose to friable sand to sandy clay stratified soils (Eutric and Dystric Fluvisols)

KEY

roads
market centre

Scale 1 : 60,000

Map preparation by P.T. Kamoni

Figure 4.4 Recconnaissance soil map of Kasikeu Subl-Location Makueni District