PLANNING FOR RURAL ENERGY: THE WOODFUEL PROBLEM IN CENTRAL KABRAS LOCATION, KAKAMEGA DISTRICT, KENYA.

By

RAPONG'O, GERTRUDE KUBOKA

B.A. HONS (KENYATTA), 1993.

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE MASTERS OF ARTS (PLANNING), UNIVERSITY OF NAIROBI.

THE FACULTY OF ARCHITECTURE, DESIGN AND DEVELOPMENT

DEPARTMENT OF URBAN AND REGIONAL PLANNING.

AUGUST 2001

DECLARATION

This thesis is my original work and has not been submitted/presented for a degree in any University.

Rapong'o ..... 28.10.2001.

Gertrude Kuboka Rapong'o Date

This thesis has been submitted for examination with my approval as a University Supervisor

G Ngugi ..... 28.10.01.

Dr. George Ngugi Date

DEDICATION

To my children Brian, Kevin and Georgina

ACKNOWLEDGEMENT

I wish to extend my sincere gratitude to the Government of Kenya through the Ministry of Lands and Settlement (Physical Planning Department) for offering me the scholarship that enabled me to pursue this degree.

I would like to thank Dr. George Ngugi who supervised this work. I also wish to thank all the teaching staff of the Department of Urban and Regional Planning for their advice and guidance during the course and the constructive criticisms by my colleagues (the 1999-2001 M.A. Planning Class) towards this work.

I am greatly indebted to all people who in their official capacities or as individuals assisted in one way or another in the completion this project. In this regard I appreciate the assistance and co-operation of the chief and the assistant chiefs of Central Kabras Location

I further record my acknowledgement to my husband Evans for his perseverance of taking care of Brian and Kevin in my absence with Georgina. I also thank him for his moral and financial support through out the course.

I also wish to thank my parents, Mr. Chrisantus Juma Rapong'o, Josephine Wamboyi and Magdalene Nambuya, my brothers, sisters and relatives for their encouragement throughout the course. I wish to thank Irene Chemweno, my house help for taking good care of my baby, Georgina and her patience when I went to field or got held up with a lot of paper work in class.

Last but not least I am grateful to my friends Mr. Protas Muya and his wife Mathlida Shisia also Mr. and Mrs. Kiberenge for their encouragement and their generous offer to print and photocopy this work. I also thank Simon Mbugua who sacrificed his time to type and for offering his computer to enable me edit this work. To them all who contributed, I say Thanks and May God Bless You.

TABLE OF CONTENTS

List of Maps

List of Tables

List of Figures

List of Plates

ABBREVIATIONS

AFREPREN	African Energy Policy Research Network
DDP	District Development Plan
FAO	Food and Agriculture Organizations
GTZ	German Technical Co-operation Agency
KREDP	Kenya Renewable Energy Development Project
KWAP	Kenya Woodfuel Agroforestry Programme
KWDP	Kenya Woodfuel Development Project
LPG	Liquid Petroleum Gas
MENR	Ministry of Environment and Natural Resources
MoA	Ministry of Agriculture
MoE	Ministry of Energy
MYWO	Maendeleo ya Wanawake Organization
NDPs	National Development Plans
NGO	Non- government Organization
RoK	Republic of Kenya
SEP	Special Energy Project
TERI	Tata Energy Research Institute
UN	United Nations
UNCHS	United Nations Conference of Human Settlement
UNEP	United Nation Environmental Programme
USAID	United States Agency in Development

ABSTRACT

Woodfuel is a predominant source of rural domestic energy in African, Asian and South American countries, whereby the population depend heavily on wood to meet their basic energy needs. This means that the management and / or conservation of woodfuel resources should be considered a major issue in national development and planning goals particularly energy planning and its policies.

This study set out to examine the woodfuel problem in rural areas, Central Kabras Location in order to provide an understanding of the problem. The study established that the woodfuel resources in Central Kabras Location are diminishing due to increasing population and family sizes, deforestation, land use patterns, unchecked wood energy conversion methods, social, cultural values, weak institutional framework among others.

The declining trend of woodfuel resource is manifested in devotion of more time to fuelwood gathering, walking long distances in search of the resource, consumption of agricultural / crop residues as substitutes to woodfuel, decline in soil fertility, change in dietary patterns, minimization of fuel consumption and commercialization of the woodfuel resource.

As the situation stands at present, woodfuel remains a major energy source and a determining environmental and development issues therefore the study recommended short- and long-term intervention and approaches or measures to increase energy

production. The short-term approaches include woodfuel conservation or management, supply enhancement (through the practice of agroforestry and planting woodlots), institutional development and community participation, and provision of extension services. The long-term intervention approaches are intended to diversify energy sources (that is electricity, biogas and solar) that can be used by those who can afford in order to reduce over reliance on the woodfuel resources.

These interventions measures should be integrated in the national and / or regional development and environmental planning processes to improve the woodfuel production for the present and future generations. The mechanisms to achieve this include enforcing planning laws and regulations, the Chief's Act, and the National Environmental Management and Co-ordination Act among others

CHAPTER 1: INTRODUCTION

1.1 Overview

Rural development in developing countries (Kenya included) is one of the important challenges facing society this century (Tolba 1985). The provision of technologies based on renewable and environmentally sound appropriate energy sources is crucial in sustainable development of rural areas. Eckholm et al (1984:5) stated that over 90% of domestic energy needs in many developing countries comes from fuelwood in these countries virtually every rural household relies on fuelwood for all or part of its cooking and heating.

In Kenya, about 70% of the population lives in the rural areas and mainly depends on the woody biomass for their energy supply. For example, O' Keefe *et al. al.* (1984), revealed that 94% of the wood produced in Kenya is used as woodfuel both in rural and urban areas. The remainder is used for poles (2%) and industrial consumption (4%). According to the National Development Plan (1997-2001), 75% of the population depends on woodfuel, in form of fuelwood for cooking and heating purposes by the rural households while their counterparts in the urban areas use charcoal for cooking and kerosene for lighting.

Despite the fact that woodfuel is a major of source energy for most rural and low-income urban households, the potential supply is decreasing rapidly leading to severe scarcity and environmental degradation. This trend was noted by the end of the 1970's

(Barnes et al 1984), and therefore there is an urgent need to device appropriate resource management to remedy the situation.

Woodfuel resources are diminishing for various reasons. These amongst others, include

- Increased population;
- Deforestation;
- Land tenure include land ownership;
- Farm holdings sizes;
- Types of crops grown/ cultivated;
- Types of preferred tree species planted or used as fuelwood;
- Family sizes;
- Dietary patterns;
- Social and cultural values such as gender bias on the use of household farm holdings and resources;
- Weak institutional framework to implement appropriate afforestation programmes and energy policies; and
- The economic status of households and their ability to pay for alternative energy types.

The main indicators of woodfuel scarcity are many. Some of the indicators are people gather wet wood, wastage of productive labour who walk for long distances and spend more time 20-24 hours per week to collect fuelwood. People start to supplement fuelwood with other biomass like farm residues and animal dung leading to losses of

nutrients to the soil. Tree species not preferred as sources of fuelwood start being used and fuelwood becomes marketable and the prices of charcoal increase. There are also deleterious changes in diet, such as the mixture of beans and maize is excluded from the family menu because of long cooking time. The family members start feeding on fast cooking and light foodstuffs such as rice, packed foods etc., which are less nutritious. Consumers start to minimize fuel consumption by cooking one or two meals per day.

Therefore, deforestation in Kenya is rapid due to clearing forest for agricultural land and settlement (settling of squatters), fuel and uncontrolled fires. Many trees cleared for agricultural expansion are used as fuel and areas cleared for fuel production are sometimes used for agriculture and industry so the reasons for deforestation are not mutually exclusive.

In rural energy planning, there is need to realise that the availability and use of traditional fuels are tightly intertwined with the village economic and social structure (de Lucia, 1982:102). Rural energy sources should be seen as integral portion of the rural system and the rural poor (the land less small-scale landholders etc.) should be considered in rural energy planning. The woodfuel policy-makers, planners and analysts should understand the dynamics of rural energy flows and the structure before making any planning interventions. Rural energy analysis should integrate the relevant institutions and people (the poor and women) in energy planning process (woodfuel in particular).

In planning for rural energy, appropriate strategy options should be emphasized. These would provide a background and guidance for creation of concrete targets for energy policy. The strategies should include ways of efficient wood utilisation, increased wood production and introduction alternative energy sources to broaden the energy mix.

1.2 Statement of the Problem

Household fuel needs for cooking and heating are basic survival needs along with food, clean water and shelter. Woodfuel is a major source of energy for households. Woodfuel is both a commercial and non-commercial fuel, which accounts for over 70% of the total energy base in Kenya (RoK 1997a).

From various studies (by Kenya Woodfuel Development Project funded by Netherlands in Kakamega and Kisii by the Government of Kenya and Beijer Institute Fuelwood Cycle Study in various part of the country), it was established that woodfuel is a traditional source of energy. Although economic development normally encourages a change from woodfuel to conventional fuels like oil, gas, solar and electricity but they are expensive. Due to high prices of these conventional fuels, woodfuel remains a dominant source of energy in Kenya, which calls for a sustainable production and consumption. According to the National Development Plan 1997-2001, the sustainable wood supply for the year 2000 is 24,929,000 m^3 while the demand is 26,591,000 m^3. This means that there is a deficit of 1,662,000m^3 (RoK, 1997a: 81).

The present and future supply of wood resources in Kenya will depend on the interaction between wood demand, the stocks and yields of wood biomass, the competing land uses, geographic factors influencing access and transportability of woodfuel, socio-economic factors such as tools, household conditions, labour economy and land tenure (O'Keefe et al. 1984:55; Wainaina 1985). Therefore, there is need to enhance sustainable supply, if we have to industrialize and alleviate poverty by the year 2020.

Due to increased demand for woodfuel, 20 million tonnes in 1980 and was estimated at 26.6 million M^3 in 2000, the sustainable supply can meet 93.6% of woodfuel demand. This means that the forests are destroyed to meet this demand. This has led to the degradation of the forests especially in rural areas where women and girl-children walk longer distances to fetch the commodity.

The Government of Kenya set objectives to address the problem of woodfuel scarcity, which were:

- To increase supply of energy to meet the requirements of the economy;
- To rationalize the use of imported oil;
- To develop indigenous energy sources; and
- To lessen the dependence on imported fuels (RoK, 1979:442).

The Government of Kenya had to formulate strategies and policies to realize these objectives. The 1997 – 2001 National Development Plan's main aim is the provision of

adequate and reliable energy supply as a prerequisite for the development of industry, agriculture and commerce activities including the domestic sector. The plan aims to ensure sustainable wood supply at the same time avoiding environmental degradation. Through the Ministry of Energy, the following objectives should be achieved in order to ensure a sustainable supply of woodfuel:

- To promote on-farm wood production (agroforestry and woodlots) by designing and disseminating an appropriate programme for the development of fast growing trees. This would also be achieved through establishment of peri-urban plantations, rural afforestation, soil conservation and where found appropriate facilitate rural co-operatives to run forests;
- To promote the efficient use of woodfuel by encouraging widespread use of energy saving cooking stoves and use of modern charcoal production kilns;
- To promote the development and use of alternative energy sources such as biogas, solar, wind and geothermal; and
- To enhance the rural electrification programmes to areas not served.

These strategies and policies should include programmes for the conservation of the environment (NDP 1989). These policies have been followed in the subsequent plans where emphasis has been put on the efficient utilisation of resources on a sustainable basis leading to the development of a set of comprehensive guidelines and strategies for harmonizing the formally sectoral specific policies into a coherent strategy to protect and manage the environment (K'Ombudho, 1995:117).

The strategies and policies on woodfuel tend to be broad and vague since they are not clear on targets and indicators. Therefore, the study set out to examine the causes of woodfuel problem in the Central Location of Kabras Division and the environmental impacts on the Malava Forest. The study then recommended alternative sources of energy viable in the study area to ensure sustainable production and consumption of fuelwood.

1.3 Research Questions

Arising from the statement of the problem, the study set out to answer the following research questions: what are the causes of woodfuel scarcity and the effects on natural resource base? What recommendations can enhance efficient use and sustainable supply woodfuel in the study area? The research specific questions to be investigated to answer the formulated research objectives are:

- What are the sources of fuelwood? Do people practice on-farm forestry? What are other sources of biomass used for fuel? Do people practice energy conservation measures? What are the causes of fuelwood problem in Central Kabras Location (e.g. household size, income levels, social, cultural, etc)?
- What are the alternative sources of energy consumed? Which ones do people prefer most? How can they be developed further? Can people afford to invest in these alternatives?
- How effective is the institutional framework in energy planning and implementation of woodfuel programmes in the study area?

- What policy recommendations ensure sustainable production and consumption of woodfuel?

1.4 Objectives

In trying to answer the above research questions, the objectives of the study are

- To examine the energy production and consumption patterns in the Central Kabras Location.
- To investigate the energy options (or alternatives) used by the people in the study area.
- To make policy recommendations on the appropriate sources of energy used and supplied on sustainable basis.

1.5 Study Assumptions

This study was done based on the following assumptions:

- The majority of Kenyans living in rural areas will continue to use woodfuel for many years, therefore there is real need to increase and sustain the supply of wood energy.
- The introduction of alternative energy sources in the rural areas will improve rural economies.
- The institutions and individuals are important in energy planning for the rural areas.

1.6 Scope of the Study

The scope of the detailed study is limited to Central Kabras Location in Kabras Division, Kakamega District. The study focused on the analysis of household energy in the location: its production, distribution, utilisation and the role of institutions in energy production with reference to woodfuel. The study covered aspects such as the sources of woodfuel, on-farm wood production, purposes for planting trees, who plants, where trees are planted, sources of seedlings and problems associated with production, utilization of various forms of energy within the household.

The study also included institutions (such as schools) that use woodfuel. How they are affected by the shortages and what contribution they do to enhance woody biomass supply.

The information collected was appreciated against the socio-cultural, economic and ecological background of the study area. This included an appraisal of the geophysical aspects such as size, area, climatic, vegetation and soils; the economic base included agricultural or land use patterns, employment patterns; socio-cultural environment included population, structure and distribution; decision-making at the household level, beliefs and value. The above information was examined in the light of the Kenyan energy policy in terms of objectives and plans at both the district and location level.

1.7 Justification of the Study

Woodfuel is a primary source of energy in the Kenyan economy whereby it meets 70% of energy requirements of the population, electricity (1.2%), oil (21.4%) and coal (0.3%) (O'Keefe et. al. 1984). On the other hand, 73% of the Kenyan population lives in the rural areas and depend on woodfuel for their energy needs for cooking and heating. Woodfuel being a dominant source of energy will continue being used by households.

Though factors such as commercial and industrial demand for wood products, clearance for agricultural land on account of growing population, woodfuel contributes to woody biomass depletion in the rural area. Woodfuel is the most preferred source of energy in the rural areas than oil because of zero private monetary costs incurred in its collection.

As the population increases, there is more pressure on on-farm trees and the forest reserves for energy provision. As such, these resources diminish forcing people (especially women and the girl-children) to walk for long distances to forage for fuelwood. These people would engage themselves in other more productive activities to enhance their development and that of the rural areas as a whole. Due to the increased demand and decreasing supply, the woodfuel resource gets monetized creating a market increasing further pressure on of forests. Therefore, the study provided measures to enhance sustainable supply and consumption of woodfuel for future generations.

There was need for this study as the Malava Forest is found in the study area and serves the urban areas within the vicinity with charcoal. These towns include Kakamega, Malava, and Webuye while local centres include Butali. The forest is also important in the hydrological cycle and provides habitat for animals particularly monkeys.

The study enhances the existing literature on rural energy. It also provides energy strategy options that can be adopted in the rural areas with medium potential and medium population such as Central Kabras Location.

1.8 Research Methodology

This section examined the different methods or approaches used in data collection, data analysis and data presentation. This included descriptions on the different types of data sources of data, sampling procedures, methods of data analysis and presentation.

1.8.1 Types of Data Collected

In order to meet the requirements of the set objectives by the study the following types of data collected were:

- Household size;
- Economic activities (such as income levels, occupation, land sizes);
- Energy consumption such as causes of fuelwood scarcity, types of energy used for cooking, lighting and heating;
- Production patterns such as tree planting activities, types of tree species planted, sources of fuelwood, where fuelwood is stored etc;

- Types of cooking stoves;
- Dietary patterns of the people;
- Aspects of decision making at the household level;
- What people perceived woodfuel problem to be; and
- Energy policy in Kenya.

As such the following tools of data collection were used: household questions, checklists to relevant district departmental heads, focus group discussion, observation and literature review (sub section 2.1).

1.8.2 Sources of Data

The study obtained its data from various sources that included:

a.) Secondary Sources

Documentary sources were mainly used to provide background information on Central Kabras and Kakamega district within which the location is found. Literature on the role of energy in rural development, causes of wood scarcity, effects and indicators of woodfuel scarcity, coping mechanism, and Kenyan energy policies were also reviewed. The secondary information was collected from published and unpublished literature from libraries, Ministry of Energy and relevant departments such as Agriculture and Forest.

b.) Primary Sources

The primary sources provided undocumented data though interview schedules, observation and focus group discussions (sub section 1.8.3)

1.8.3 Methods of Data Collection

1.8.3.1 Interview schedule/Questionnaire

This was done through an interviewer-administered questionnaire that consisted of both open and closed-ended questions to the households. This method was used to cover the main survey of the sampled of household interviewees/respondents (70). The questions were based on the respondents' background, personal characteristics – household sizes, way of life (cultural), economic activities (land sizes, land uses, occupation, income), energy conservation measures, and woodfuel production and consumption patterns.

1.8.3.2 Focus Group Discussions

There were discussions held with the Provincial Administrators at the divisional level (i.e. the District Officer, Chiefs and Assistant Chiefs), Departmental Officers (e.g. forest) in the district on implementation of energy policies in the area.

There were also discussions with women as individuals who bore the burden of looking for fuelwood. The discussions included the causes of fuelwood shortages, who planted trees, types of trees not used for fuel, the effects of wood shortages, on types of foodstuffs prepared etc. Key informants such as village elders gave information on socio cultural characteristics of the Kabras people.

1.8.3.3 Observation

This was done alongside the interviews. This simple observation involved checking around the household property and general outlook e.g. types of trees planted, type of

houses, cooking stoves etc. Photographs present what was observed. This tool of data collection was very important since in some cases the respondents' answers were inaccurate.

1.8.3.4 Interview Sessions

On identifying the actual respondent normal greetings were exchanged and then followed by introduction. The aim of the visit was stated so as not to keep the respondent wondering. The respondents got to know that the study was on behalf of the University of Nairobi about domestic energy - fuelwood and the data collected would be used in energy planning to enhance the supply or improve consumption in Central Kabras Location. The interviewee was assured the information collected was confidential. In turn some respondents offered seats immediately on arrival of interviewers while others did so after introduction.

Some questions not applicable were skipped for some respondents. The income question was a sensitive therefore, to answers capture to this question directed to one's expenditure were asked. The filled questionnaires were checked on daily basis.

The distances between the sub locations and the time constraints necessitated the use of research assistants who made it possible for the study to carry out the interview of all sampled respondents over a span of 5 weeks.

Three research assistants were selected on the following criteria:

- Least 'O' level education but they were undergraduate students in the local universities;
- Ability to speak and understand the local dialect (Kabras);
- Ability to understand the questions within the questionnaires; and
- Be residents within the Central Kabras location.

The research assistants or interviewers were trained on how to relate with the interviewees, the objective of the research and its relation to Central Kabras. Therefore the discussion with the research assistants covered the purpose and focus of the study, approaches of interviewing, recording techniques etc. During this time the researcher went through the questionnaire with the research assistants, clarifying words in the context and that questions asked meant the same thing for all. After this exercise the actual survey started.

1.8.3.5 Sample Frame

The sample framework included household heads, chiefs and village elders, district departmental offices, individuals and groups. The number of households and size of the study area – Central Kabras Location - (in km^2) was obtained from the 1999 Population Census Report. The study area has four sub locations – Matioli, Tande, Matsakha and Chegulo – which were further subdivided into villages. The household was the unit of data collection and analysis. Village elders *(maguru)* were contacted to assist in identifying the households were who had been selected.

(a.) Sample Size

The sample size for the study was determined by the following formulas used researchers in social sciences (Mugenda et al 1999:43-44). These were:

(i.) $n = \frac{z^2pq}{d^2}$

where
n = the desired sample (if the target population is greater than 10,000)
z = the standard normal deviation at the required of confidence (1.96)
p = the proportion of the target population estimated to have the characteristic being measured (93%)
q = 1-p (7%)
d = the level of confidence set (5%)

Thus $\frac{(1.96^2)(0.93)(0.07)}{0.05^2}$
$= \mathbf{100}$

But since the study area had a population of less than 10,000 (i.e. 4508 households) the second formula was used.

(ii.) $nf = \frac{n}{1+n/N}$

where
nf = the desired sample size (when the population is less than 10,000)
n = the desired sample size (when the population is more than 10,000)
N = the estimate of the population size

Thus the sample size was $\frac{100}{1+\frac{100}{4508}}$
$= \mathbf{97}$

(b.) Selection of Respondents

The selection of the sample was through random and stratified systematic sampling by sub location and the villages were chosen according to the criteria below. All the villages in the four sub locations were selected to ensure uniformity based on:

- Location of the village in terms of access to the forest resource (Malava Forest)
- Variation in land sizes.
- Variation in woodfuel problems.

The sample settled on was 97 respondents, which was about 2.1% of the 4508 the total number of households but only 70 were interviewed due to problems outlined in the sub section. These households were then randomly selected; in Chegulo 19 households were interviewed forming 27.1% of the total sampled household, 17(24.3%) in Matsakha, 17(24.3%) in Tande and 17 (24.3%) in Matioli.

Since the households were assigned random numbers based on the land registration numbers, to be as representative as possible the interval of 45 was used in selecting the actual respondents. These random numbers were used to determine the first respondent and the next followed 45 households were skipped and then the 46^{th} household selected. From the last respondent in each covered sub location, then the 46^{th} was again selected until the whole location was covered.

Some respondents could not be found in their homesteads due to various reasons, which area discussed under, sub section 1.9, the field problems/limitations. The next household head on the list selected was whenever there was a missing one. Though the

next alternative was selected, still some were not available, as such a total of 70 questionnaires were administered to sample respondents from the four sub locations.

It was anticipated that fuel dealers (especially fuelwood in particular) would be among the respondents. However, there were only two fuel dealers (in charcoal) among the 70 administered household questionnaires. This was due to the fact that fuel dealers especially fuelwood were suspicious about the mission of the study and did not admit.

The village elders assisted in identifying the fuel dealers. Unfortunately, only two fuel dealers were identified, one was a fuelwood dealer while the other was a charcoal dealer. These fuel dealers did not readily give information as they considered their trade prohibited or illegal. The fuel dealers (especially charcoal) used bicycles and animal carts to the market either at the local markets or the towns such as Butali, Malava, Kakamega and Webuye.

The sample of 70 was adequate and reliable. By size it is beyond the minimum 30 required for application of most statistical techniques. Each sub location was covered and the villages were also represented, thus the sample was representative. The mode of selection within each stratum (that is sub locations) was random.

1.8.4 Methods of Data Analysis and Presentation

The collected data was analysed by use of both quantitative and qualitative techniques. These included descriptive statistical methods such as means, percentages and

frequencies. Cartographic method was also used which include drawing of maps and pictorial presentations.

1.9 Field Problems/limitation

Transport – some areas were inaccessible especially Chegulo sub location to the extent the 'boda bodas' (local bicycle taxis) could not penetrate these areas. This area (Chegulo) in particular is hilly and has few opened earth roads.

Household were suspicious especially those who were retrenched from government offices and were not willing to be interviewed until the researcher convinced them that the research was purely for academic purposes. The other issue was that the respondents wondered why they had been selected. Some complained that they had not been interviewed yet they were neighbours with those selected. Some men saw the fuel issue as women issue so when it came to the section of energy conservation the men allowed their wives to answer.

Energy production and consumption patterns tend to vary from one season to another of year. The study was undertaken during a festive season (i.e. circumcision and Christmas) that is a time when people use a lot of fuelwood. Therefore, to capture the seasonal variation this kind of information would require more time than available for the study. The respondents are also not good at keeping records of the amount of fuelwood used. Therefore, it was not easy to estimate how much was consumed per

meal/ month per meal or month. This makes projecting/ planning for energy woodfuel in particular difficult.

The village elders were to be paid which proved to be expensive considering that the research assistants were also paid. Some respondents also expected financial gain for having been interviewed. It was not easy at times for the researcher to convince some respondent that this was academic work. In some cases, not all questions were answered since the respondents lacked record or knowledge for example some did not know how long they cooked meals. Some intentionally/unintentionally did not answer the questions on how many meals were prepared per day which ones and why.

1.10 Operational Terms

Agroforestry: a type of land use, which involves growing of crop and/or animals and trees on the same land parcel.

Biomass: consists of woodfuel, agricultural wastes (such as maize stalks and cobs, dry pieces of sugar, bagasse), sawdust etc.

Environment: refers to the water resources, forests, soils etc. that is affected adversely with the degradation woody biomass.

Household: refers to a group of people related by blood or otherwise who live together and derive all or part of their livelihood on the farm.

Traditional fuel: refers to fuels such as fuelwood, charcoal, dung, agricultural/crop residues and other biomass material used in open fires.

Sustainable: in this case means conservation in the use of woodfuel increase supply in the woody biomass and use of alternative energy sources to avoid scarcity in future.

Woodfuel: refers to charcoal and fuelwood (firewood).

Woodlot: a piece land set aside for trees by a family (household) or community.

1.11 Structure of the study

This study was organised in five chapters:

- Chapter one focused on introduction, which includes, the statement of the problem, the research question, the objectives, the study assumptions, methodology, definition or operational of terms and the limitation of the study.
- Chapter two focused on literature review, the Kenyan energy policy review and conceptual framework.
- Chapter three focused on background information to the study area. The first section included the physical and economic profile of Kakamega District such as location and size, topography, soils, climate and vegetation. This section also included the land uses and woody biomass resources in the District. The second part of the chapter focused on the Kabras Central Location, which included location and size, climate and ecology, and the socio-cultural profile.
- Chapter four focused on data analysis and research findings.
- Chapter five focused on synthesis, recommendations and conclusions then bibliography and the appendices follow.

CHAPTER 2: LITERATURE REVIEW AND CONCEPTUALIZATION OF SUSTAINABLE ENERGY PRODUCTION AND CONSUMPTION

2.1 Overview

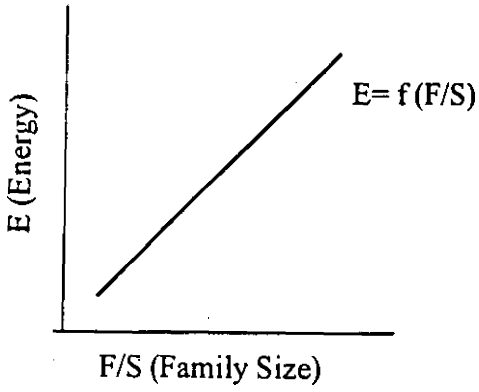
This chapter focused on literature review on the causes of woodfuel problems and what solutions can be offered to these problems. Literature on Kenyan energy policy was reviewed with emphasis on woodfuel. It included conceptual model on how sustainable production and consumption of woodfuel in the rural areas can be achieved.

2.1.1 Factors which lead to Woodfuel Scarcity

The woodfuel problem has been expressed in demographic terms whereby increasing woodfuel consumption, and pressure on land resources is blamed on rising populations with the implications that family planning (birth control measures) would solve the problem. But it is realized that the woodfuel problem is more complicated than this. The other contributory factors to this problem are rural poverty, inequality, lack of opportunities, cultural reasons and government policies. Until these problems are tackled the woodfuel problem will not be permanently cured.

Ngugi (1990), on the same note concurs with the fact that demographic pressures have contributed to the present energy crisis in the form of woodfuel scarcity. The study revealed that the larger the family sizes the more the amount of fuelwood needed to satisfy the domestic requirements (Fig. 2.1).

Fig 2.1: Energy Consumption



(Source: Ngugi 1990:5)

In sub section 1.2, it was established that energy is one of the basic needs of the community, thus energy has to compete with other household requirements. As population continues to increase, more sub divisions of land take place diminishing the resource base for supply of fuelwood and other land based family needs. Leach (1988) says that most fuelwood supplies arise as a by-product of agriculture rather than woodfuel consumption. Conservation measures during consumption of woodfuel become more a matter of improving welfare by cutting consumer costs than attempt to save trees.

According to Wane (1986), people with secure and adequate land holdings and a reasonable level of income, woodfuel is not a major problem since they can afford to pay for alternatives. It is the poor people and the landless who suffer most from woodfuel scarcities. Poverty is also a connecting link between woodcutting and environmental degradation. The poor people earn a living by stripping the woodlands to supply the urban market with woodfuel. As it has been of late realized in Kenya, the

squatter families clear the trees on mountain slopes (such as Mau, Kenya etc) because they can find nowhere else to farm; their land is eroded and degraded about them as they cannot afford the investments needed to protect it and make it productive in the long run.

The real issues of deforestation and thus woodfuel problem are agricultural stagnation, unequal land tenure, rising level of unemployment, and rising population growth (Eckholm, 1979). While Foley (1986) extends the argument further that the rural populace cut down trees indiscriminately and is wasteful in use of woodfuel. He argues that the main contributory factor is the need for land for growing food. Due to either population growth, or migration, or war, or drought, people extend farming to lands which were formerly areas where fuelwood was collected and trees cut down to make way for crop and in due course are no longer for fuelwood supply. Furthermore, the woodfuel problem is not limited to rural area but is accelerated by the urban market for woodfuel (mainly in form of charcoal). The woodfuel would have been sufficient to meet the rural domestic needs but with its commercialisation there has emerged a competitive demand for it. The farmer who is striving to generate some income or livelihood, will rise the occasion and seize the opportunity. Although the female did fuelwood collection, the male are only involved in fuelwood collection or charcoal burning for commercial purposes. Foley concluded that woodfuel problem should not be addressed in isolation but as an integral part of the development process.

Cecelski (1985) notes that rural energy crisis manifests itself in the work of rural women, basic needs and other rural development problems. The roots of the rural fuel crisis is caused by the overuse of agricultural land and forest resources due to modernization and intensification of agricultural and animal raising, decreased access to land and impoverishment, growing industrial fuel and timber demands on rural resources, and local population imbalances. Fuel shortages are therefore a symptom rather than a cause of this widespread overload and higher prices of oil are only contributory factors. This has led to the privatisation of land and its products including trees and the commercialisation of the subsistence fuel economy with those poor households who cannot afford to pay for fuel are forced increasingly to use more human labour, reduce consumption, enter barter/labour relationships, with landlords or resort to illegal poaching subject to harassment and penalties by forest officials.

Cecelski further notes that rural energy crisis has added another dimension to rural women's work burden in meeting the family's basic needs. Women are responsible for fuelwood collection, preparation and use as part of their daily cooking tasks. Increased in time for fuelwood collection has implications on other household activities. Cash for fuel purchasing affects the family budget expenditure. In conclusion, she says policy-makers should appreciate the central role of women in the rural energy system and indeed the needs and welfare of households generally in designing interventions eases the rural fuel crisis.

Timberlake et al (1984) asserts that the emergence of the woodfuel crisis in the rural areas as concomitant to the structural changes experienced in society over time or as part of the societal growth process. Therefore, a society moves from a situation of self-sufficiency in fuelwood supply to a situation where there is a deficit/shortage. First, where the population densities of a given area are low, the household fuelwood requirements are met without any damage being done to the standing tree stocks and those who own land are able to grow their own trees. In cases where local custom permits, the local people collect fuelwood from their neighbours' farm and very little time is spend in fuelwood collection. As the population density of the local area grows there is a high demand for fuelwood which cannot be satisfied from the immediate area and as a result the fuelwood collection area is extended – a consequence of which is the increased number of hours spend in gathering fuelwood that are not available for further productive work. With time, distance to source of fuelwood becomes prohibitive and people turn to the standing tree stock, which becomes depleted. In the long run, there is a shift to use inferior alternatives such as crop residues, dung etc. Secondly, a set of structural changes, privatisation of land ownership and emergence of wood markets reinforce the emerging fuelwood crisis. Privatisation of land ownership restricts the accessibility to traditional communal resources of woodfuel that severely affects the poor, who are not able to provide for themselves from their farms. The emergence of commercial wood markets provide an incentive to the people to engage more in wood harvesting either from their own farms, on communal areas and nearby forest reserves. The landowners find it more profitable to sell excess wood for money rather than allow the poor to collect it domestic use.

Chavangi (1991) also notes that a high degree of land demarcation and privatisation lead to individual ownership. Tree raising activities was/is an individual activity within each household whereby only male farmers planted and managed trees for poles/timber for construction, split wood for sale, wood for charcoal, wood for rituals and religious ceremonies. Women involvement in tree activities was minimal thus contributing to woodfuel problems in many rural areas.

Munslow et al (1988) argued the factors that affect the woody biomass resource in a given area are grouped into three major ones: first, woody biomass resources by land use system, which include the environmental potential (climate, soils, and topography) in that area. The land use practices such as form of production, land tenure characteristic, external influences and intensity and nature of tree management. Secondly, the competing demands for wood products affect this resource. The competing demands are from the alternative uses of the wood by the local community (such as construction, folder, environmental protection, cultural etc.) and external commercial demand such as the urban woodfuel market, construction poles and others. If the rate of consumption for competing demands is high then this bring the problem of woodfuel. Thirdly access to woody biomass resource influences its demand and supply. This is affected in two ways: one physical access denoted in distance travelled, topography, population density and type of biomass. Two, social access which includes land distribution and ownership, customary practices concerning control of common land, resources, social differentiation, household decision-making, social group etc. The

factors affecting, woody biomass supply and those affecting fuel consumption are which must be identified when possible interventions are being made.

2.1.2 Coping strategies

Given the importance of woodfuel in the rural sector energy supply, it is necessary that proper and appropriate policies and implementation procedures be adopted to effect sustainable supply of woodfuel with environmental considerations hence avoid the degradation of the environment. Before planning for fuelwood was ignored by many governments in the developing world and international agencies. But due to woodfuel scarcity and its implications, it has become a topic of concern especially in the sub-Saharan Africa. Energy planners have taken an interest in woodfuel as a critical fuel since as much as 70-90% of a nation's population consume it for example, in a study done in Zambia showed that 88.2% use woodfuel (Mbewe, 1998:20) while 90% of India's rural population depend on woodfuel sources (UNEP 1995:52).

The majority of rural households will continue to rely primarily on wood and other biomass fuels for cooking and heating for the foreseeable future (Cecelski 1985:49). Also with the increasing prices of other sources of fuel (such as oil and electricity) thus there is need for a policy to strike a balance between the supply and demand of woodfuel. This policy is then a move towards self-sufficiency in energy supply. Therefore, there are three policy approaches one, on demand side; two, the supply side and three, appropriate technology. The third approach can be integrated in the first two approaches that are complementary.

2.1.2.1 Demand Management/Energy Conservation

This policy focuses on the end-use consumption emphasizing on efficiency to minimize wastage. Energy conservation measures include: use of improved stoves (e.g. Kenya ceramic *jiko*, clay woodstoves) with increased efficiency compared to the traditional metal *jiko* or three stone hearth open fire. The open fires used by the rural household have 10% efficiency while the improved stoves have increased efficiency of 30-45% thus save 65-75% of wood currently consumed and limit the deforestation problem (Tolba, 1986:78). The energy conservation measures include:

- Recovery of energy from waste materials such as bagasse from sugarcane, sorghum/maize stalks etc;
- Promotion of agroforestry - would increase the supply of woodfuel, cash/food crop production, timber production and soil fertility;
- Use of traditional methods such as putting fuelwood out, covering lit charcoal with ash etc;
- Training and skill developing- there is need on public awareness and training of group leaders (women, youths) on energy conservation methods. Information and technology can be disseminated on cooking methods that consume less fuel especially in the rural villages; and
- Integrated renewable energy developments where by the alternative sources of energy can be developed at the same time with woodfuel so as to avoid over dependence on wood. The only problem is affordability whereby the people in the rural areas cannot afford to install solar, biogas or wind pumps.

There are advantages that accrue due to emphasizing on efficiency on energy consumption. These include

- Lowers the costs of energy importation especially petroleum at the national level;
- This also has positive effects on the natural environment diminishing the social costs associated with air pollution, water and other forms of pollution (Lim 1980 as cited in Tolba 1986);
- Reduction of energy demand contributes to prolonging of life of the depletable (woody biomass) energy resources thus buying more time to develop alternatives;
- This also protects the country's economy against inflation since crude petroleum price increase in the world market causes inflation in oil importing countries such as Kenya; and
- Demand management policy protects and manages the environment against depletion by the increasing demand for the resource by the fast growing population

The government can achieve this through the energy prices (woodfuel included) and energy taxes especially on the commercial energy sources. The finances obtained can be utilized in the development of alternative energy sources.

2.1.2.2 Supply-Oriented Enhancement.

This focuses on boosting supply by ensuring a reliable and adequate affordable supply of energy in relation to the demand. This means the supply should be sustainable in the future. The supply-oriented solutions include:

- Increased supply of kerosene through modified refining and cross subsidy by taxing gasoline;
- Increase the area under community, commercial or individual woodlots;
- Increase the area under the practices of agroforestry; and
- Use alternative sources of energy such as solar, biogas, wind, mini and micro-hydroelectric power schemes to increase the types and amounts of energy disposable for each individual.

The advantage of this approach is reduction in prices of woodfuel and also relieves over dependence on the imported energy hence improving balance of payments. This approach also expands the options available to the people.

2.1.2.3 Appropriate Technology

This focuses on the maximization of local resources and ecological sustainability on specific sites (urban or rural) and the basic needs/requirements. Depending on how severe the problem of woodfuel is then priority at a local level can be considered. In this case the energy policies must be locally and socially determined by the people and not imposed from external sources. Appropriate technology approach involves community participation that can be realized when groups involve themselves in the making of the modern wood stoves in the rural areas through organisations such as Maendeleo ya

Wanawake and youth groups. This approach can also incorporate the demand management and supply enhancement for different localities. Therefore, energy policy should: -

- Integrate the energy plans and strategies with the other national development goals e.g. to achieve conservation and structural changes required in the production process in all the sectors (e.g. industry, transport, commercial etc). These plans and strategies should be incorporated in the policies of the other sector. The energy end-use for domestic purposes should also be outlined, as the domestic sector is a major consumer of energy. The social characteristics should also be incorporated as they can either enhance or diminish energy resources.
- Establish long-term energy development strategies in the promotion of efficient and environmentally sound methods in woodfuel conservation. Long-term strategies are broad and provide guidelines for major decisions in the further future. They take a period of 20-30 years and are at the national level but can be replicated down to the local levels. Medium term strategies are within a period of 10-20 years and are formulated in the light of the long-term strategies. They are more detailed. The short-term strategies (5-10 years) are designed to solve temporary and acute problems, but must also be in the light of the main or long-term strategies. These can be replicated to small (local) scale.
- Incorporate both demand management and supply enhancement strategies to form appropriate technology. This would then lead to comprehensive energy plans and strategies that once implemented by relevant institutions at national

and local levels can reduce problems faced by households either in the urban or rural areas.

2.2 Overall Fuelwood Situation in Kenya

Wood provides 70 percent of the nation's energy requirements, 57% in form of fuelwood and 13% in form of charcoal largely consumed in rural and urban areas respectively (Nyang, 1999:1). There is a growing imbalance between woodfuel demand and supply due to the increasing demand for wood products without replenishment, thus has led to woodfuel problems (crisis) in many parts of world (Kenya inclusive). Woodfuel crisis is not of energy alone but is has its roots in the dynamics of development and poverty.

There are several studies that have been undertaken to contribute to the understanding of energy situation in Kenya. The most critical of which is the study done by the Beijer Institute, which intended to contribute to the process of energy planning in Kenya. This was a national level study and it assessed the current and future commercial and non-commercial energy demand and supply situation. The study revealed the role played by woodfuel in the economy and that in the absence of appropriate intervention measures this resource would continue to be depleted leading to severe stress on the economy. It came up with recommendations as to alleviate the energy shortage problem, some of which are being implemented by the government.

O'Keefe et al (1986) saw the woodfuel crisis as it affects the urban areas argued that the over dependence of many urban residents on woodfuel is determined by the question of affordability. They also observed that the urban fuel problem is one of low incomes that is poverty, which is the trap that forces people to depend on wood resources that are being depleted faster than they are renewed. In the long run the incomes of the poor should be improved so that the poor (especially the rural poor) are not forced to strip their land of the most precious assets (trees) and be able to pay for the price of a sustainable fuel supply.

Hosier (1985) based his study on the broad agro-ecological zones in Kenya (high potential, medium potential and low semi-arid potential) categorized the rural farmers into five groups: the non-surplus farmers, the cash crop farmers and the wageworkers. The groups represented the various income-strata and were used to show how the economic status affected the use of fuelwood energy. The study revealed that the wageworkers had a lower level of reliance on and consumption of woodfuel. The surplus farmers (with land of about 1.5 ha) who had the lowest average fuelwood and paraffin consumption levels, the cash surplus / mixed farmers had the largest average farm holdings and the highest energy consumption levels. He thus concluded that the level of household income and accessibility to land has a positive relationship with the level of energy consumption. Further by calculating the income levels among the surplus group, wood consumption increased with income and thus it was viewed as a normal economic good. In wageworkers category, wood consumption decreases as

income increase and the other household categories did not show any consistent pattern of fuelwood consumption.

According to Hosier (1985), there are other factors which influenced the level of energy consumption were the cost (in terms of collection time). As fuelwood becomes scarce its consumption also decreases as household requirements are checked either through conservation or substitution. The household size also influenced the amount of domestic energy requirement as the household size increases so did the fuelwood consumption However, the larger families had efficient energy use on a per capita basis than the smaller families and finally, the dietary patterns of the household are also influenced the level of every life.

Western et al (1979) carried out a study, which examined the consumption of woodfuel in the various sectors – large and small firms, rural and urban domestic consumption. The study provided estimates of the contribution of woodfuel to the total energy consumption in Kenya, examined the consumption patterns by region and came up with projections of demand to the next two decades. Several other studies have been done which evaluate the potential supply and demand for charcoal in Kenya include Uhart (1975) and Kabagambe (1976). But these studies have tended to assess the demand in urban areas only. However other studies have been undertaken to assess the per capita consumption of wood in the rural areas in Kenya and other parts of East Africa (Openshaw (1976).

2.2.1 Micro-level Woodfuel Situation Studies

The above-mentioned studies (sub section 2.2) have tended to be at the macro-level. There are also several other studies which have focused on smaller geographical regions/areas: such as the studies of Castro (1983) on tree planting and fuel use in Kirinyaga District, this study stressed the factors affecting access to wood and other fuel supplies. Bronkensha and Riley (1983) investigated the impact of deforestation among the Mbeere and Wanjama (1985) examined the nature and extent of woodfuel crisis in Kikuyu Division in Kiambu District. This study identified the factors contributing to woodfuel shortages in the division as rapid population growth, deforestation, small land parcels and low energy conversion efficiency methods. This study sees the solutions to the woodfuel problem as being the conservation of energy, diversification of energy and supply enhancement through tree planting.

Wainaina (1985) examined the energy situation in Gaichanjiru Location in Muranga District (now in Maragua District) and found that the most critical aspects of woodfuel acquisition were accessibility, availability, quantities and quality of woodfuel and location of these resources of woodfuel. The study also established stagnation to agricultural production as residues are used as fuel and not left to rot on the farm to make farm manure. This study also identified population pressure on land as the main factor contributing to the woodfuel problem.

Musoga (1988) and Mugo (1989) investigated the rural energy problem, in Shiswa, Kakamega district and woodfuel supply and demand in a rural set up in Naitiri,

Bungoma district respectively. In these studies, it was realized that the increasing household size decreasing land sizes, low household economic base, and clearing trees for agriculture led to fuelwood scarcity. Mugo (1989) notes mismanagement as a cause of woodfuel scarcity where supply is too far below the demand. They suggested that these problems would be solved by adopting energy saving technologies e.g. wood saving stoves and increasing production of woodfuel through agroforestry and use alternative sources of energy (solar, biogas etc) can be save the trees/forests from depletion.

Mwendwa (1993) studied the socio-economic causes and effects of woodfuel – scarcity in South Imenti, Meru District which included household characteristics, over dependence on woodfuel source of energy, competition for land use and unsustainable land sub-division, proximity and accessibility to forest, lack of energy conservation measures etc. Millions of people especially rural dwellers face acute shortages of the traditional biomass fuels, which carry itself with immense cost, both in human and environmental terms although the economic costs are often indirect and hard to quantify. The problem is becoming severe due to increased demand and diminishing supplies. This is related to the increasing population and increasing oil prices (Hall et al, 1982).

Wamboyi (1997), studied how community participation would be used as a strategy in tackling the rural energy problem in Ebutanyi sub location, Vihiga District. She notes that woodfuel problem is area specific but these studies have not seriously treated the

socio-cultural factors in the supply and demand of woodfuel. This study seeks to explain how these factors affect woodfuel supply among households in Central Kabras Location energy conserving methods on the demand side and whether the people enhance supply.

2.3 Energy and the Kenyan Economy

2.3.1 Woodfuel as Energy source in Kenya

The development of rural areas in Kenya and other developing countries as noted earlier is one of the most important challenges facing the society locally, nationally and internationally. As development takes place in all the sectors of the economy, the energy requirements for these countries will grow. The energy needs are expected to grow in the future with the increasing pace of industrialization and development. As such the industrial and agricultural sectors will absorb as increasing amount of commercial energy for domestic use in the rural areas, whose needs would continue to grow. Due to anticipated increase in the consumption of non-commercial energy sources. alternative sources of energy should be encouraged in the rural areas to conserve the environment. Energy conservation methods or measures should be emphasized in order to avoid the depletion of the forests, which would have adverse effects on the rural economy.

In Kenya, woodfuel 'a fuel of the poor' (i.e. fuelwood for rural and charcoal for urban households) for is a dominant source of domestic fuels whereby about 75% of the population depends on woodfuel for their end-uses (cooking, heating, etc) in form of fuelwood or charcoal (RoK, 1997a). According to O'Keefe, et al (1984), 94% of the

wood produced was used as woodfuel and the rural households consumed 90% of this and the same situation still applies currently (Table 2.1). Although economic development normally encourages a move from woodfuel to more flexible and liquid fuels i.e. conventional energy sources such as gas, electricity and oil as they are expensive especially to the rural households. Due to the low-incomes of households (both urban and rural) woodfuel remains a dominant source of energy in Kenya, which calls for a sustainable supply.

Table 2.1: Projected Wood Supply and Demand 1995-2000 (in 000m^3)

Wood demand	**1995**	**2000**
Industrial	1,058	1,209
Poles and posts	1,219	1,435
Fuelwood	20,107	23,947
Total demand	**22,384**	**26,591**
Sustainable supply		
Indigenous forests	1,942	1,905
Woodlands and bush lands	11,240	11,157
Farmlands and settlements	7,437	9,373
Forest plantations	2,121	2,494
Subtotal sustainable supply	**22,740**	**24,929**
Non-sustainable supply	**283**	**414**
Fuel substitutes	2,011	2,395
Total woodfuel	25,034	27,738
Surplus/deficit	**2,650**	**1,147**

Source: National Development Plan (1997-2001: 81)

According to the table 2.1, the demand of fuelwood between 1995-2000 was expected to grow by 19%. This means that the sustained source of woodfuel supply should be enhanced so as to meet the increasing energy needs of Kenyans. Therefore, there is need to enhance sustainable supply by the year 2015 if poverty has to alleviated

/eradicated in the rural areas. Demand is increasing faster than supply meaning that the standing stocks will deplete faster. In Kenya, as the population increases it is accompanied with an increased demand for various energy sources. The oil crisis of 1973/74, 1978/79 and 1990/91 have contributed to the significance of the country to develop the indigenous sources of energy which includes the woodfuel, biogas, electricity etc. The wood fuel energy resources would be decreased due to competing land – such as agriculture. Due to the high population density, the practice of agroforestry assists in solving the woodfuel problems in the short run rather than woodlots.

2.3.2 Kenyan Energy Policy Framework

Kenya's energy policy framework has developed over the years since independence and is reflected in the National Development Plans (NDPs). It is also reflected in Sessional Papers e.g. Sessional Paper No. 1 of 1986. The polices are broad declarations of interest to more focused porgrammes of action. Many of these policies on woodfuel tend to be too broad and vague especially for implementers since they are vague on specifics. The reason being that there are many players who include Ministries of Energy, Agriculture, Environment and Natural Resources, non-governmental organizations, and the energy endeavors.

In the first National Development Plan 1966-1970, policy for one form of energy that is electricity was outlined and programmes to enhance its supply were spelt out. The main objective was to increase the distribution of electricity to meet the anticipated growth in

industrialization process, which was then a (national) goal. Electricity was also seen as a symbol of modernization, thus electrification programmes were encouraged both in the urban and rural areas.

The 1971-1974 National Development Plan had similar intentions as the previous one, to promote electricity but alternative sources of energy (such as sun, wind, tides, nuclear, and geothermal) were seen as possibilities. Geothermal power has been developed in Ol'karia while wind and solar sources of energy are developing at a slower rate within the country. Wind and solar energy have developed in coastal region sponsored by SEP/GTZ. During this early periods of development the main thrust of the policy goals was alleviation of poverty, ignorance, disease, and industrialization amongst others, but very little (if any) was put on the energy sector.

The first oil crisis in 1973/74 was experienced during this plan period that necessitated the need for an energy policy. The second oil crisis was in 1978/79 while the third was in 1990/91 when Iraq invaded Kuwait thus influencing the oil prices. During this period the crude oil price treble from K£16 million in 1975 to K£87 in 1996 (RoK, 1994).

In the third National Development Plan (1975-1978), the importance of electricity was still emphasized but its development was to benefit both the urban and rural areas. The plan stated that the demand for electrical energy in the urban areas would be met in full but it was also the objective of the government to extent the availability of electrical energy more widely in the rural areas. An accelerated rural electrification programme

was to be implemented during the plan period. This plan also realized the importance of woodfuel, as such the main strategy was to encourage woodlots on private farms through the rural afforestation programme. But budgeting allocation by the government reveal a bias for electrical energy resource development.

In the 1981/82 financial year, for example, 73.2% of the expenditure was directed to electric power development, while the non-conventional energy resources (woodfuel included) had a share of 11.7% and petroleum fuel has 6.3%. The situation has worsened with the recent (2000) power rationing where the parliament approved Ksh 5.1 million for electricity, the reason being increase in petroleum fuel prices, and slows pace of oil exploration in northern Kenya and the rural electrification programme.

The fifth National Development Plan (1983-1988) had detailed specific energy strategies on woodfuel. The demand management or energy conservation and supply enhancing strategies were incorporated in the energy policies and also rural electrification was encouraged though some parts of rural Kenya have no electricity. The programme in the electricity sector included:

- Acceleration of exploration of geothermal resources;
- Acceleration of the proven commercially viable wells to meet project power demand grow especially by the industrial sector;
- Stepping up the rural electrification programme (REP) to provide greater sources of lighting power to the rural population that would also promote industrial and agricultural development in these areas.

In the woodfuel sector, there was a bias for the supply enhancing strategies that included agroforestry, peri-urban plantations, and rural afforestation soil conservation. The plan noted the need for the public and private sectors (NGOs, youth and women groups) to co-operate in order to achieve the stated energy conservation measures. The government was to provide policy guidelines and incentives whereas the private sector implements the improvements in the energy production and energy use practices.

The 1983-88 Development Plan and the Sessional Paper No. 1 of 1986 indicated that the Ministries of Energy, Agriculture, Livestock and Regional Development, and Environment and Natural Resources had the responsibilities to implement the tree planting and wood conservation programmes. The Ministry of Energy was to take lead in liaising with the extension staff of these ministries to realize its objectives in the woodfuel sector.

The sixth National Development Plan (1989 -1993) acknowledged woodfuel as a main source of energy. The main policy thrust was to ensure adequate supplies, through sustained yields while at the same time protecting the environment. The government would promote the widespread use of fuel-efficient cooking stoves (charcoal-saving and wood-saving stoves) by providing support through the extension officers and demonstration to the appropriate target groups (RoK, 1989). The government also embarked on an accelerated programme electrification of rural areas to supplement the dwindling of supplies of woodfuel and improve peoples' lives through opening up opportunities for commercial, industrial, social activities and also for lighting.

The 1994-96 Development Plan's theme was 'Resources Mobilization for Sustainable Development' and some of the imperatives to achieve sustainable development in relation to the woodfuel energy were:

- To conserve and enhance the environment and natural resources base and
- To make efficient use of energy and expand the use of new and renewable energy sources.

These were to be achieved through countering rapid deforestation and the development and dissemination of technologies on energy conservation. In this regard, the development of energy efficient cooking stoves and charcoal burning kilns would be supported and the peri-urban woodlots would be established as sources of sustainable energy. Generally, the long-term goals for energy development are to achieve self-sufficiency through intensive energy generation. The policy adopted in relation to woodfuel energy was through sustained yield and demand management while protecting the environment. To meet the objectives of woodfuel policy, the following measures affecting supply and demand were to be implemented:

- Encourage more sustainable production and use of energy;
- Promote widespread adoption of fuel-efficient charcoal and wood stoves and on-farm energy production methods;
- Increase the efficiency of wood energy utilisation with particular attention to the production and distributions of improved cooking stoves by the private sector;; and
- Encourage designs of end-use device in industries and homes that can convert forest and agricultural products into fuel (RoK, 1994:91).

The eighth National Development Plan's (1997-2001) main goal is based on the industrialization of the Kenyan economy by the 2020 and alleviation of poverty by 2015. Therefore, there is need to develop an adequate and reliable energy supply as a basic prerequisite or requirement for the development of industrial, commercial and agricultural sectors. The domestic sector should not be ignored, as it is a major consumer of energy. According to the plan, the main sources of energy include petroleum fuel, electricity and woodfuel. The other sources included solar, ethanol, wind, biogas, and coal. Petroleum and electricity remain important for commercial and industrial use while woodfuel remains the main source of fuel for domestic use. Woodfuel provides 75% of the total energy consumed in the country. Since 90% of the rural population use woodfuel, there is need to ensure a sustainable wood supply. The plan states that the Ministry of Energy in collaboration with the Ministry of Environment and Natural Resources (Forest Department) will promote on-farm wood production by designing and disseminating an appropriate programme for the development fast growing trees. The Ministry of Energy will continue to promote the efficient use of woodfuel by encouraging widespread use of energy conservation, charcoal and fuelwood stoves.

The energy policy framework in Kenya also provides for the environmental conservation and management in order to utilize the resources in a sustainable manner. There are various programmes which enhance the environment in addition to increase wood supply which include Rural Afforestation Extension Schemes (RAES), practicing

agroforestry, rural reforestation, tree planting during community functions such as fund raising etc.

2.5 Institutional Framework

Government ministries, departments and non-governmental organizations in the past did not lay much emphasis on planning for woodfuel, but with the depletion of biomass, scarcity of energy and environmental degradation have led to woodfuel to be incorporated in energy planning in Kenya. The Ministry of Energy was established in 1979 due to the challenge of energy crisis to the country's socio-economic development. The main objectives were to formulate and implement energy policy; to develop hydroelectric power (HEP); to develop and exploit non-conventional energy sources (such as wind, biogas, and woodfuel geothermal and solar, to oversee oil exploitation and energy conservation (RoK, 1980).

The Ministry of Energy promotes wood energy conservation through more efficient use and wood production through agroforestry. However, it should be noted that the Forest Department in the MENR is responsible for the management and conservation of gazetted forests, as well as development of tree resources outside such areas through the provision of heavily subsidized seedlings to potential and interested individuals and institutions. The Ministry of Energy (MoE) also works in close relation with the Ministry of Agriculture when it comes to the practice of agroforestry. The MoE has agro-forestry centres in several parts of the country.

The Ministry of Energy relies mainly on external financing and technical assistance for the implementation of its woodfuel development programs through organizations such as Kenya Renewable Energy Development Project (KREDP) and Kenya Woodfuel and Agroforestry Programme (KWAP). KREDP was established in 1982 and is funded by United States Agency in Development (USAID). It has six agroforestry centres whose activities are tree seedling production; development of extension services; the production of improved cooking stoves (funded by GTZ) and training of informal sector craftsmen in stove production. KWAP is an NGO established in 1983 and operates in liaison with the Ministry of Energy. It is funded by Netherlands' Government and presently operates as Kenya Woodfuel Development Project (KWDP) formed in 1988. The activities of KWAP are related to government institutions, NGOs and farmers with the purpose of increasing the area under agroforesty in the rural areas. GTZ and Special Energy Project (SEP) are other organisations that work in association with the MoE to encourage the development of the alternative sources of energy, which in turn led to preservation and conservation of the forest thus the environment.

Although energy conservation and environmental matters should be seen as major concerns of MoE, the structural and functional analysis together with analysis of energy related policies and documents, tend to suggest that at best the key issues have been given marginal consideration. According to Bhagavan (1996), there is no separate division dealing with conservation matters in different sectors. The divisions catered are financial and administration, planning geothermal, biomass, and engineering. The

National Energy Policy and Investment Plan (1987) reviews issues and constraints in broad terms and define conservation related policy objectives as follows:

- To reduce the cost of using imported and domestic energy by eliminating wasteful consumption and maximizing the efficiency with which all forms of energy are used in all sectors of the economy.
- To promote substitution of domestic and low-cost for high-cost energy resources whenever appropriate and economically justified.

The energy conservation policy is meant to involve both the private and the public sector while the environment policy formulation is the responsibility of Natural Environment Secretariat (NES) of the MENR. This means that Ministry of Energy in its endeavour to plan for the energy resources especially woodfuel has to work hand in hand with the other ministries such as MENR, Ministry of Agriculture etc due to the impacts that increased wood consumption has on the environment.

2.5 Environmental Management Policy

In most developing countries until about half a century ago, little attention was paid to environmental impacts in the establishment and development of energy systems (Redeby et al. 1988:116). Kenya was not an exception. Environmental defects such as the deterioration of natural resources have become more apparent in recent years and energy development world wide is likely to be influenced by the progressive incorporation of environmental considerations into the planning and the decision making process. In this regard the protection of the fragile environment against man-made abuse and pollution requires the introduction of sound environmental policies and

determination by people, governments and companies to adjust and make the necessary changes.

Due to the importance of the environment, this has entered the mainstream of the government policy since independence. The government in its environmental policy aims to achieve sustainable development without the destruction of the resource base. Environmental protection has tended to be sectoral-based. The Development Plan of 1989-93 emphasized the efficient utilization of resources on a sustainable basis which led to the development of a set of comprehensive guidelines and strategies for harmonizing the formerly sectoral-specific policies into a coherent, holistic approach to protecting and managing the environment.

In that regard, afforestation programmes became nationwide campaigns so as to increase the acreage under forests plantations. The objectives of forest management were:

- To protect the forests to maintain climatic and physical conditions of the country;
- To conserve and regulate water supplies and to conserve the soil by preventing desertification and soil erosion;
- To provide woodfuel, timber and other forests products both for consumption and export;
- To provide recreational facilities for the public and preservation of wildlife; and
- Provision of employment (K'Omudho, 1995).

Woodfuel production is important to the country and as such it has been considered in the environmental policy so as to avoid the depletion of forests leading to environmental degradation.

2.6 The Conceptual Model

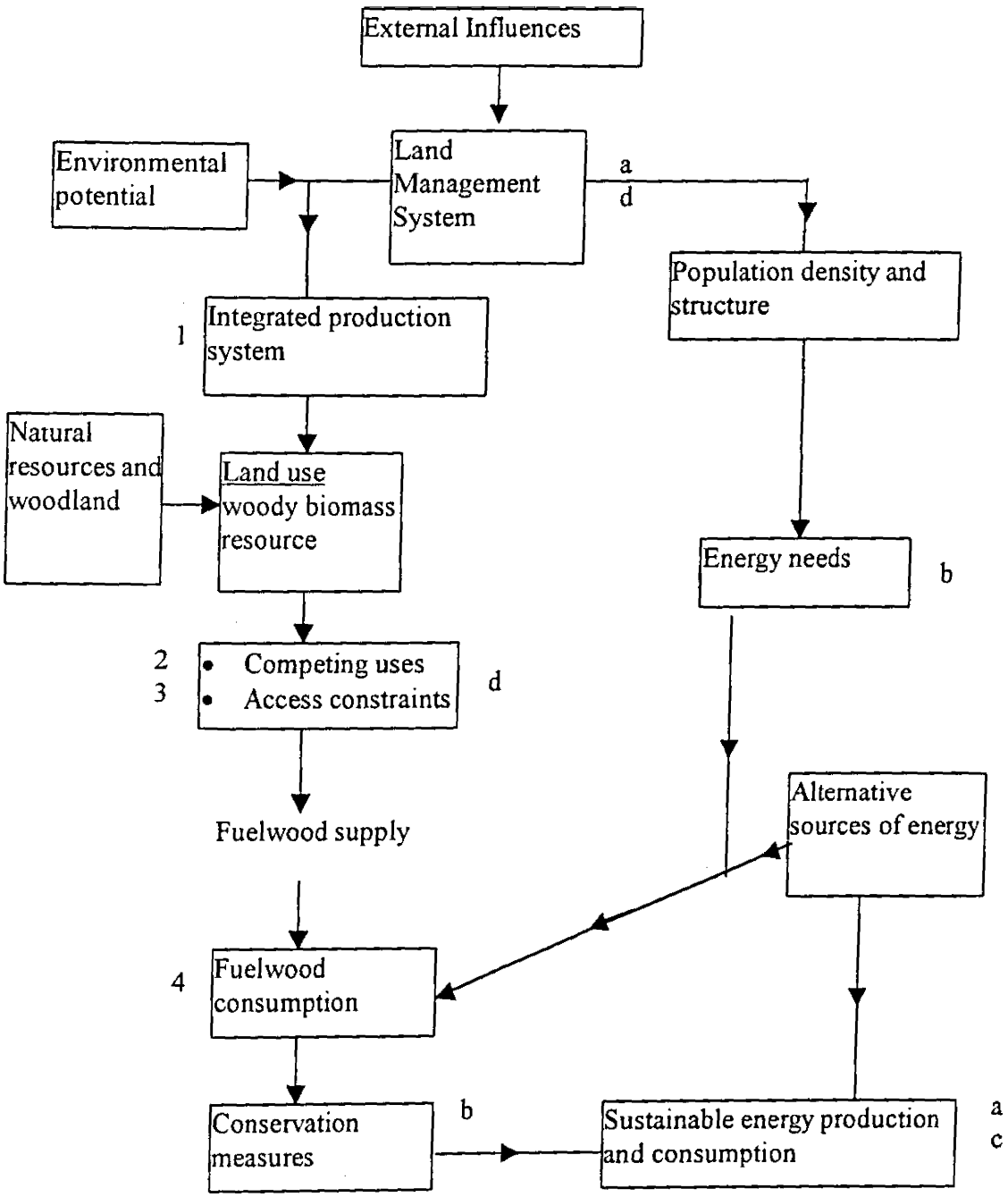
From the above discussion, the system of production and consumption is shown Fig 2.1 indicates how fuelwood supply of an area is part of the total woody biomass resource, with its availability being limited by competing uses and access constraints. The woody biomass resource reflects the rural area's land use patterns that in turn are created by the operation of the integrated production system. The integrated production system is a product of the way in which people interact with and harness the environmental potential and existing resources. This means that it reflects the fusion of the environment and land use management system and as such solutions to rural energy problems must be integrated in the local production systems.

According to Soussan (1988), the quantity of fuelwood available to each household to meet its requirements depends on the access to local resources. He came up with three factors/constraints to fuelwood in relation to Fig. 2.2: one is the distance between the resource and the points of use, this includes the time spend either on walking or gathering the wood. Two, land tenure refers to issues of who owns the land and the woody biomass. Land is subject to private property right that privatisation of land influences the quantity of fuelwood. The third factor was that the management system

of the woody biomass resource limit access. The management systems reflect the prevailing social structure, local resource management, harvesting techniques and technologies, the range of alternatives, non-fuel use of trees, customary rights, and obligations concerning the use of and access to biomass on communal and private land.

In Fig. 2.2, on the left are the crucial factors affecting supply of fuelwood. An integrated production system developed as a result of environmental potential and land management systems. It determines the existing land use and the role that woody biomass plays both in and around the farm as well as the natural forest and woodland. The best way to improve, the woody biomass, resource is by improving land use practices based upon the particular set of tree and shrub requirements defined by an integrated production system. Hence, it is possible to intervene to maintain the woody biomass or enhance the production system on the right hand side are the factors that can reduce fuelwood demand. Conservation and fuel switching can be alternative sources of fuel available.

Fig 2.2: The System of Fuel Production and Consumption and Possible Areas of Intervention



Points of dislocation which lead to problems

1. Changes in the integrated production system, which erodes the biomass.
2. Increased alternative demands upon the wood biomass resource
3. Constraints upon access to potential fuel wood supplies 4. Pressure upon fuelwood consumption.

Points and main character of fuelwood interventions

a. Supply maintenance/enhancement b. Conservation c. Fuel switching d. Resource allocation

Source: Adapted from Munslow et al (1988:21).

CHAPTER 3: BACKGROUND TO THE STUDY AREA

3.1 Overview

This chapter reviews the physical characteristics and socio-economic background of Kakamega District in general and in particular the study area, Central Kabras Location. It is divided into two parts or sections: the first section presents a detailed profile of the Kakamega district resource base with special references to woody biomass. (Note that the study makes use of the data from the entire district and Kabras Division instead of being area specific due to lack of data on smaller units of administration such as locations). This lack of area specific data is ascribed to the fact that there are no data banks for the specific units. The second section gives a brief physiographic characteristics and socio-economic profile of the study area that needed emphasis as regards consumption and production of woodfuel.

The main aim of this section is to establish alternative energy sources available and how the existing can be enhanced in the study area. Therefore, it provides a ground on which the superseding discussions that is the situation of woodfuel in Central Kabras Location and intervention approaches /measures.

3.2 Kakamega: Geographical Description

The aspects considered in this section include the position and size, topography, climate, soils and agro-ecological zones, land use, woody biomass resources and population of the district.

3.2.1 The Physical Characteristics

3.2.1.1 Position and Size

Kakamega District lies in the Western part of Kenya, within the Lake Basin. It lies between longitude $34^{0}20^{'}$ and 35^{0}E, and latitude $0^{0}15^{'}$ and 1^{0}N of the Equator (RoK, 1997 b). It is one of the eight districts that form Western Province. It is bordered by Vihiga district to the south, Butere-Mumias district to the southwest, Bungoma district to the west; Nandi and Uasin Gishu districts to the East; and Trans Nzoia and Lugari districts to the northern border it (Map 1). It is approximately 1241 Km^2 in size that is about 0.2% of the total national land mass (RoK, 1997 b).

3.2.1.2 Topography and Soils

The district has a varying topography with altitude ranging from 1250 metres above sea level (m.a.s.l.) to 2000 m.a.s.l. It can be divided into two physiographic units:

a) The southern hilly side is made up of rugged granites rising to 1950 m.a.s.l and the penplain remnants of denudation at Kakunga and Kambiri. Nandi escarpment forms a prominent feature on the eastern border of the district. Its elevation varies from 1600-2000 m.a.s.l.

(b) The extensive undulating peneplain dips westwards from about 1600 m.a.s.l. to 1500 m.a.s.l to the western boundary.

The eastern side and northwestern part have fairly deep soils. These types of soils range from the rhodic ferrel soils (which have low fertility) on the plateau and higher level plains; through the regosol with ferallic cambisols and rock outcrops on hills and minor scarps; and the valley bottom soils are water logged and are found in a few places in the

northern western and north –eastern parts of the district; to the mollic level uplands and lower middle level uplands (Jactzold, 1982).

3.2.1.3 Natural Drainage

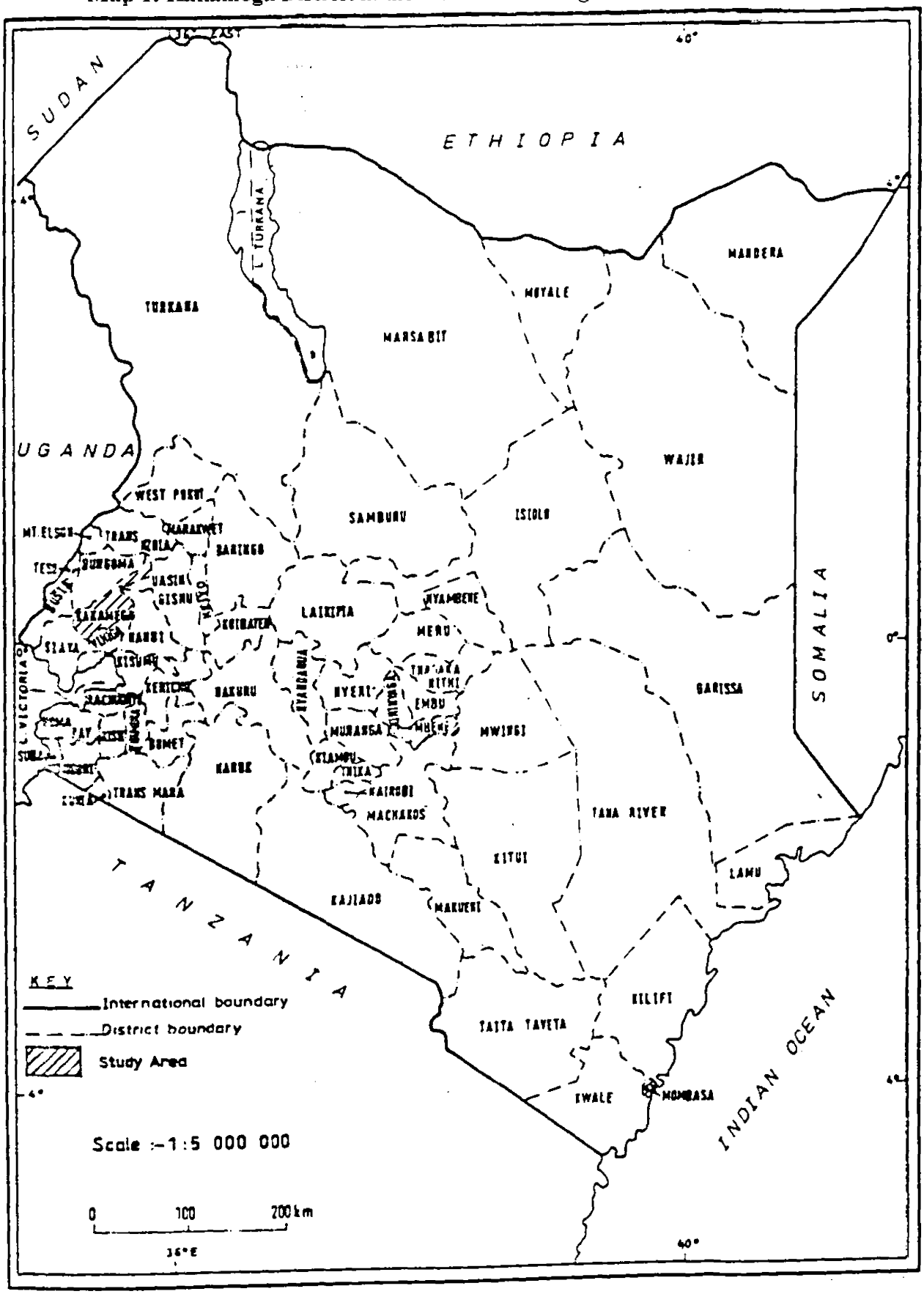
There are two major rivers, which flow within the district (Map 4). These rivers are

(i) River Nzoia from Cherengani hills forms the northern boundary with Bungoma District.

(ii) River Yala from Nandi Hills flows westwards through the district and in the southern part of the district.

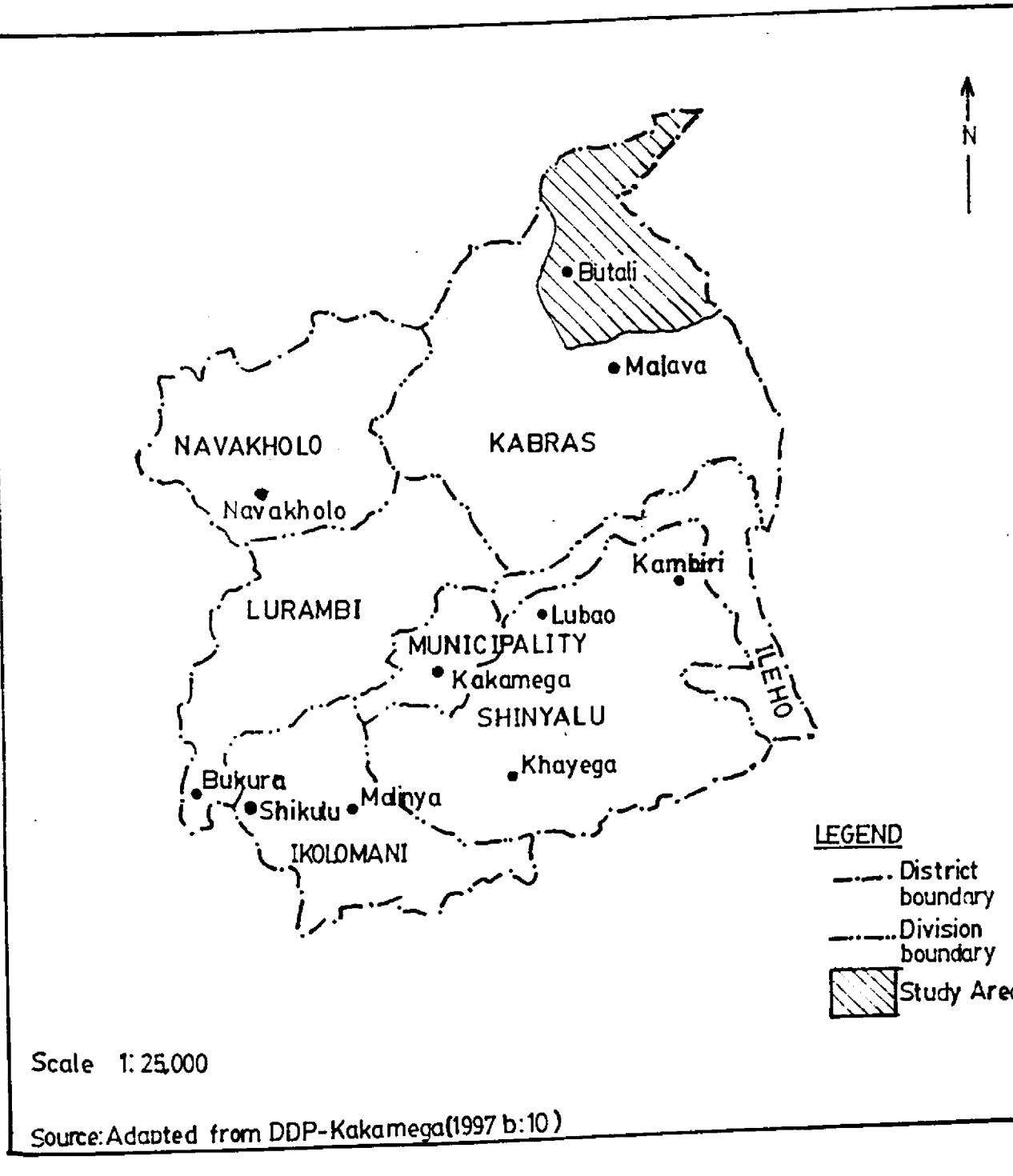
The Nandi escarpment is the catchment area for River Isiukhu that joins River Lusumu later joining River Nzoia, before draining into Lake Victoria.

Map 1: Kakamega District in the National and Regional context.



Source: Field Survey, 2000

Map 2: The Study Area



3.2.1.4 Climate

Kakamega district receives high amount of rainfall, with averages ranging between 1000 mm per annum (p.a.) in the northern parts to over 2000 mm p.a. in the southern parts. The district receives two rainfall seasons, the long rains and the short rains. The long rains are received between March and June with the peak in May, while the short rains are from July to September with the peak in August. The driest months are December, January and February.

Rainfall expected is high, 500-1100 mm during the long rains and 450-850 mm during the short rains, which varies from one agro-ecological zone to another. The rain falls in heavy showers and occurs in the afternoons with occasional thunderstorm.

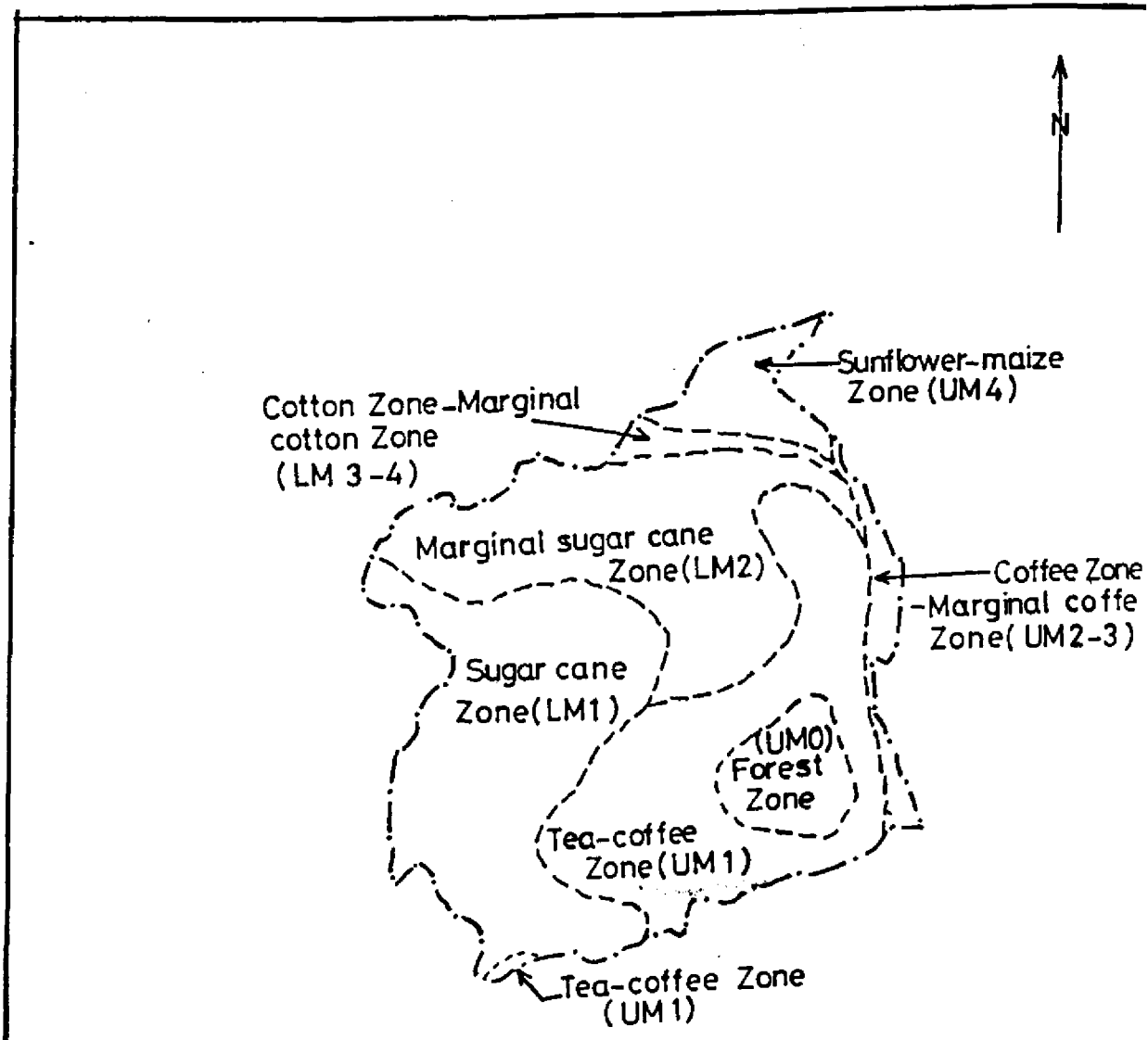
High temperatures are experienced through out the year that ranges between maximum 28^0 –32^0 C and minimum 11^0-13^0C. The lowest temperature is recorded during the night and the highest temperature during the day especially during the dry months. The evaporation level ranges between 1600 mm-1800 mm p.a. due to the high humidity and low evaporation rates.

3.2.1.5 Agro-Ecological Zones

The district is divided into nine agro-ecological zones that to a very large extent reflect the pattern of land use in the district (Map 3 and Table 3.1). The ecological zones have a direct influence on the availability and potential of the woody biomass. These zones include:

1. The upper midland zone (UMO) – It is the forest zone that constitutes Kakamega and Malava forests. This zone is too wet for good crop yields of crops and can be best used for forestry purposes.
2. The upper midland zone (UM1) or the coffee tea zone - This zone has permanent cropping possibilities and has two to three variable cropping seasons. The main crops grown are coffee, tea, maize and variety of horticultural crops. The zone has a high settlement density due to the favourable attributes of the area.
3. The upper midland (2) of coffee zone (UM2) - It is a small transitional zone in the eastern part of district similar to the tea - coffee zone but has lower yields due to less fertile soils (soils are shallow).
4. The upper midland (3) or marginal coffee zone (UM3) similar to (UM2)
5. The upper midland (4) or sunflower –maize zone (UM4) – This zone has a long cropping season that is divided into two variable growing seasons, during the long and short rains. The main crops are maize, sunflower and beans. This has high population density and affects the area under trees for the purpose of woodfuel (Table3.8).
6. The lower midland (1) or marginal sugar cane zone (LM1) - It has a permanent cropping possibilities and is the main sugar cane growing area.
7. The lower midland (2) or marginal sugar cane zone (LM2) - It has a long cropping season followed by short rains.
8. The lower midland (3) or cotton zone (LM3)

Map 3: Agro-ecological zones in Kakamega District



Scale 1:25,000

Source: Adapted from DDP-Kakamega (1997b: 23)

9. The lower midland (4) or cotton zone (LM4), (LM3) and (LM4) zones are predominantly for cotton growing (See Map 3 and Table 3.1).

Table 3.1: Agro-ecological zones of Kakamega District by Division (Km^2)

Division	UMO	UM1	UM2-3	UM4	LM1	LM2	LM3-4
Ikolomani	-	-	-	-	133	7	-
Shinyalu	135	295	44	-	24	40	-
Lurambi	-	-	-	-	345	7	-
Municipality	3	30	-	-	15	3	-
Kabras	24	-	-	113	20	217	53
Ileho	-	-	-	-	-	-	-
Navakholo	-	-	-	-	-	-	-
Total	**162**	**325**	**44**	**113**	**437**	**274**	**53**

UMO is a forest zone
UM1 is coffee-tea zone
UM 2-3 is a coffee zone
UM 4 is a sunflower zone
LM is a sugar cane zone
LM 3-4 is a cotton and marginal cotton zone
(Source: calculated from Farm Management Handbook, MoA: 1982)

3.2.3 Land Use and Woody Biomass Resources

Agriculture is the dominant land use in Kakamega district. In 1984, the agricultural land use occupied 75% of the area (65% for subsistence and grazing and 10% for cash crops). Forests, woodlots and hedges occupied 20% of the land, while 5% were under structures and others land uses (e.g. road). This has declined since then with increasing population.

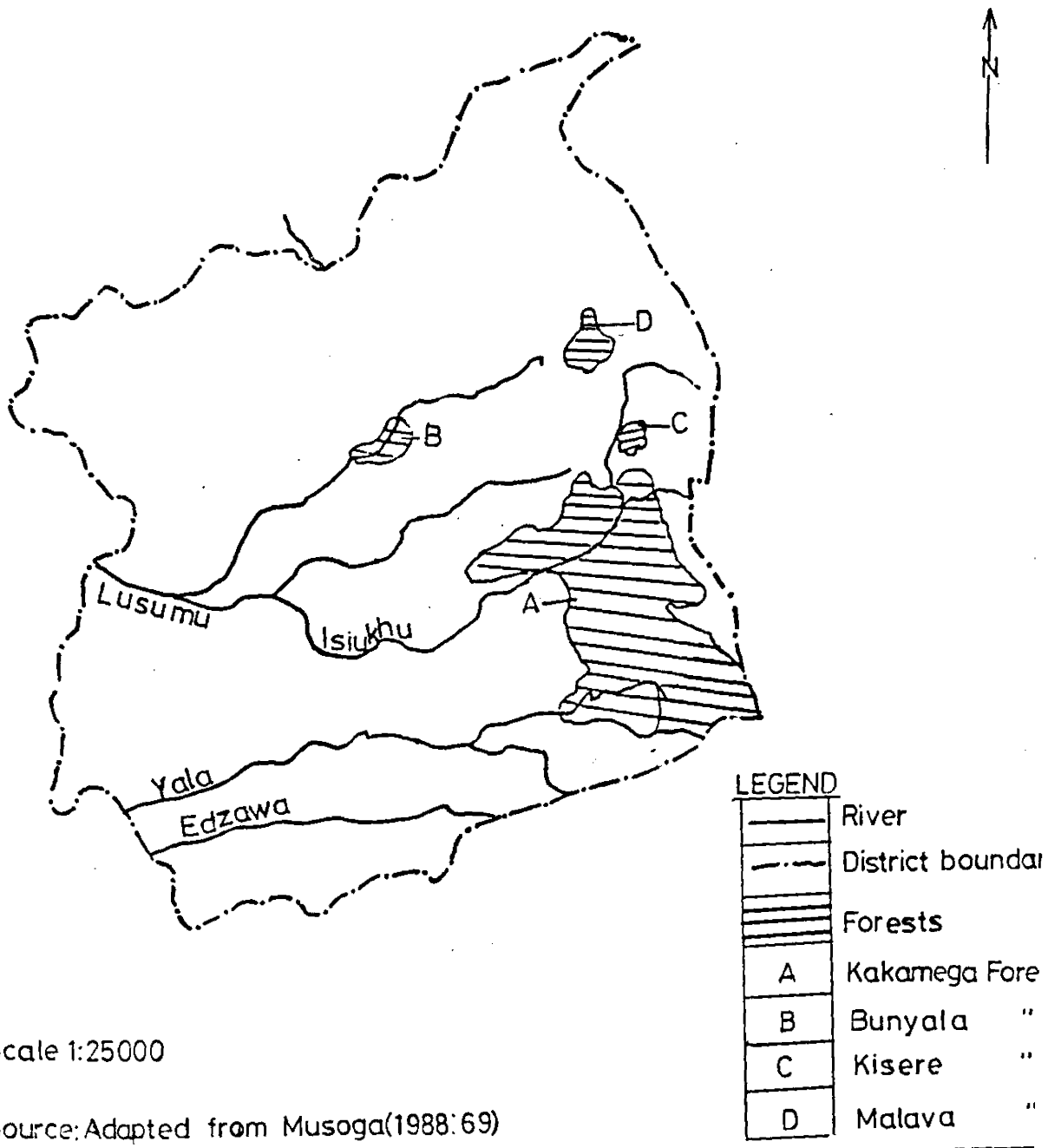
The proportion of land under agriculture increased to 82% from 75% in 1987 of which subsistence farming occupied 70% while cash crop occupied 12% respectively. The main types of cash crops are tea, coffee, and sugar cane. Coffee and tea are in the upper midland zone bordering Kakamega Forest while sugar cane is grown in the low midland zone. The main food crops include maize, beans, sweet potatoes, bananas among others.

The area under forests, woodlands and hedges decreased to 10% of the total land use while other land uses occupied 8%. The area under forestry, woodlots and hedges has continued to decline in recent times because of competing land uses with the woody biomass losing to agriculture and settlement. With the forestry practice of planting fast growing trees the indigenous forest trees have been cleared giving room to planting of exotic trees and crops. Thus, there is need for intervention in order to take care of the increasing population without adverse effects on the woodfuel supply. As the area under woody biomass decreases these implies that there will be woodfuel shortages and environmental degradation in terms of soil erosion. As such, there is need for intervention in planning for and / or provision of alternative sources of energy to ease

over reliance on fuelwood. The high population can be accommodated by intensive agricultural production techniques if proper farm management is practiced.

The area under gazetted forests in Kakamega district in comprised 7.7% of the total land area of which 62% were indigenous forests (Kakamega, Kisere and Malava) while the remainder (38%) were exotic plantation forests. The forests may be good alternative to on-farm fuel source but this is not a viable and long lasting solution to woodfuel scarcity because first, the distribution aspects are such that forests form pockets in a few isolated areas of the district (Map 4). This means that only those in the immediate neighbourhood of the forests can use them. Secondly, there are restrictions for the use of the forests as they are supposed to be preserved as national conservation areas (that is Kakamega Forest), while others such as Malava Forest are supposed to provide wood for timber and industry (such as Pan Paper industry in Webuye) therefore, fuel production is a secondary factor. In this case, there is need to incorporate the rural household consumption and supply (production) patterns in the planning of forest resources at the district level.

Map 4:Location and Drainage of Forests in Kakamega District



Scale 1:25000

Source: Adapted from Musoga(1988:69)

3.2.4 Demographic Profile

The size and demographic features of population are important variables in the equation of the development process, for they determine the pattern of resource utilisation (woodfuel included). This sub section presents the population profile of Kakamega District and among the demographic features analyzed are size, structure and distribution by division.

3.2.4.1 Population size

The population of Kakamega District in 1999 was 603,422 and is expected to increase at a growth rate of 2.14% per year; therefore it is estimated to be 629,525 in 2001, 670,812 in 2004, 745,727 in 2009, and 921,591 in 2019. Although the population growth has declined over time (3.4% in 1979, 2.98% in 1989 and 2.14% in 1999), the absolute total population in the district remains high. From Table 3.2 shows that the populations between 1999 and the year 2019 will increase by about 52.7%.

Due to the rapid population growth in the district, there is a mismatch between the supply and demand of basic facilities, services, and natural resources (woodfuel included). Energy sources mainly the woodfuel are depleted daily due to the increased demand for cooking and limited supply as population increases. The high population has created pressure on land as the average farm size per household is becoming smaller and smaller. This implies that employment opportunities and incomes from agricultural activities are gradually reducing, a situation which is contributing to the increase in the depth of poverty and over reliance of woodfuel as an energy source in the district.

Population increase also implies that there is a decrease in the area under on-farm sources of fuelwood such as woodlot and also due to continuous land fragmentation as sons have to inherit land from their parents. The increase that is land sub division in this case, may contribute to the woodfuel scarcity or shortage in the district. .

Table 3.2 The Kakamega District Population Projections by Age Cohort

Age cohort	1999	2001	2004	2009
0-4	104,173	108,676	115,807	128,740
5-9	88,378	92,201	98,248	109,220
10-14	91,098	95,039	101,272	112,582
15-19	73,830	77,023	82,075	91,242
20-24	54,084	56,424	60,124	66,839
25-29	38,126	39,775	42,384	47,117
30-34	31,126	32,473	34,603	38,468
35-39	27,682	28,879	30,773	34,210
40-44	22,786	23,772	25,331	28,160
45-49	17,776	18,545	19,761	21,968
50-54	13,841	14,440	15,387	17,105
55-59	10,953	11,427	12,176	13,536
60-64	8,835	9,217	9,822	10,919
65-69	7,208	7,520	8,013	8,908
70-74	4,985	5,201	5,542	6,161
75-79	3,690	3,850	4,102	4,560
80 +	4,051	4,226	4,503	5005
Age NS	799	834	888	987
Total	**603,422**	**629,525**	**670,812**	**745,727**

(Source: 1999 Population Census Report Vol. I, 2001)
(Note: Age NS means age not stated)

3.2.4.2 Population Structure

Age-sex structure

The population of Kakamega District portrays that the proportion of young persons aged between 0-14 stands at 47% of the entire population, showing that the population is predominantly composed of youthful population. About 59.2% of the total population is less than 20 years of age. By contrast, the most productive group of the population (20-59 years) constitutes 35.9% of the population while 4.9% of the

population is over 60 years. The district has large population of children and adolescents that is young people greatly out number their parents. The high growth of youthful population means that the rate of growth of labour is expected to also be high and this will result in demand for jobs, which are not easily available. The youthful population also means an increased demand for woodfuel for cooking and kerosene for lighting for those in school to carry out their night studies. These persons also require energy giving foodstuffs that should be provided for by their parents. The youthful population affects the dependency ratio, as these young people are mainly consumers and not producers.

On the whole the sex ratio for Kakamega District is 100 males to 108 females, reflecting out-migration of males in search of employment opportunities in order to support their households. It is however, clear from table 3.3 that sex ratios vary from one cohort to another. The male-female ratio is most disproportionate in age cohorts 24-29, 30-34, 45-49 and over 80 years, are 100:122, 100:125, 100:115 and 100:134 respectively. The trend does not change especially from ages 24 and above.

Table 3.3 The Population Projection by Sex and Age Groups (1999-2009)

Age cohort	1999		2001		2004		2009	
	Male	Female	Male	Female	Male	Female	Male	Female
0-4	52,076	52,097	54,329	54,347	57,892	57,915	64,357	64,383
5-9	44,443	43,935	46,366	45,935	49,406	48,842	54,924	54,296
10-14	45,479	45,619	47,593	47,446	50,714	56,204	56,204	56,378
15-19	36,473	37,357	38,051	38,972	40,546	41,529	45,074	46,167
20-24	24,504	26,580	25,564	30,860	27,241	32,124	30,283	36,556
25-29	17,104	21,022	17,844	18,025	19,014	23,370	21,138	25,979
30-34	13,849	17,278	14,448	18,025	15,396	19,207	17,115	21,353
35-39	12,632	15,050	13,178	15,701	14,043	16,730	15,611	18,599
40-44	10,563	12,223	11,020	12,752	11,743	13,588	13,054	15,106
45-49	8,262	9,514	8,619	9,926	9,185	10,576	10,210	11,758
50-54	6,619	7,222	6,905	7,535	7,358	8,029	8,180	8,925
55-59	4,748	6,205	4,953	6,474	5,278	6,898	5,868	7,668
60-64	4,172	4,663	4,352	4,865	4,638	5,184	5,156	5,763
65-69	3,217	3,991	3,356	4,164	3,576	4,437	3,976	5,223
70-74	2,367	2,618	2,469	2,732	2,631	2,911	2,925	3,236
75-79	1,777	1913	1,854	1,996	1,975	2,127	2,127	2,364
80+	1,726	2,325	1,801	2,425	1,919	2,584	2,584	2,873
Age NS	332	467	346	488	369	519	410	577
Total	**290343**	**313079**	**302901**	**326624**	**322768**	**348044**	**358814**	**386913**

(Source: 1999 Population Census Report Vol. I, 2000)
(Note: Age NS means Age Not Stated).

In general sex ratio depicts an increasing trend with increasing age. Sex ratio has implications in relation to the woodfuel problem in that it is the female who collect fuelwood and at the same time do other duties of weeding food crops, fetching water etc., yet they do not own land to plant trees to provide fuelwood and / or are not allowed by culture to plant trees even if they had access to land as a resource.

Table 3.4 The Population of Selected Age Groups

Age Group	1999		2001		2009	
	Male	Female	Male	Female	Male	Female
6-12 (primary	72,547	14,5061	75,685	151,336	89,656	179271
14-17 (secondary)	32,518	32.313	33,925	33,711	40,187	39,933
15-17 (female)	-	142,024	-	148,168	-	175,517
15-5 (labour force)	134,754	155,451	140,583	162,175	166,533	192,111

(Source: 1999 Population Census Report Vol. I, 2000)

According to Table 3.4 the population of all age groups is expected to increase and this rapid increasing population creating increased demand social facilities (such as health, education etc) and pressure on the natural resources (such as fuelwood for cooking, land, etc). This also means an increase in the number of mouths to feed and an increased demand for energy resources particularly fuelwood that is consumed by 88% if the population in the district (that is the rural population).

Labour Force

In 1999, there were 290,205 people (48.1%) of the total population) among whom 134,754 were male and 155,451 female. It is estimated that the labour force will be 336,514 in 2004 and 358,644 in 2009 (see table 3.4). This growth in labour force is not matched with employment creation in the district. The unemployment situation will worsen in future as the size of land holdings decrease and agricultural production declines which offers substantial share in the creation of employment opportunities. Unemployment also implies that people have no sources of income which can enable them afford alternative sources of energy other than fuelwood. The pressure on land will also aggravate the woodfuel problem unless action is taken. Unemployment can be solved through creation of opportunities in the both formal and informal sector.

There is a high literacy level among the labour force in Kakamega district, which currently stands at over 70%. The highest literacy level is at age 15-19 (91%) while the population above 45 is less literate that is less than 60% (RoK, 1997 b: 16). The illiteracy level at age 45 and above may be due to few educational institutions and less emphasis paid to education during the colonial period. The implication of high literacy

levels in this study is that people can be able to understand the importance of energy conservation measures to the environment through awareness programmes thus reducing the woodfuel shortages.

Dependency ratio

It is 100:108 for the district. This high dependency ratio has social environmental economic implications for the district. As shown in the sub sections 3.2.4.2, the population is predominantly composed of the youth. Although the children contribute to family income (by working on the farm) or as casuals, they consume more than they produce hence reducing private household savings. They are dependent on their parents and society in general for food clothing, shelter and education. Indeed, the high dependency ratio has overstretched the use of available resources in the course of providing for social and economic needs often at the expense of investments, which will generate more employment opportunities. The woody biomass is depleted for cooking purposes thus affecting food crop production as such a great percentage of family incomes is used on purchasing foodstuffs.

3.2.4.3 Population Distribution and Density

According to the population census of 1999, Kabras, Shinyalu and Ikolomani divisions had the highest population in the district. The population of these divisions was 149,510, 103,948 and 92,104 respectively (Table 3.5). Kabras and Shinyalu Divisions have high population size yet their densities are low because the area included the forests that are Malava and Kakamega forests respectively.

Table 3.5 Population Projections by Division

Division	1999	2001	2004	2009
Ikolomani	92,104	96,088	102,390	140,668
Shinyalu	103.948	108,445	115.557	128,462
Ileho	32.545	33,953	36,180	40,220
Lurambi	85,963	89.577	95,452	106,112
Navakholo	65,337	68.163	72,634	80,745
Kabras	149,510	155,97	160,207	184,769
Municipality	74,115	77.321	82,392	91,593
Total	**603,422**	**629,525**	**670,812**	**745,727**

(Source: 1999 Population Census Report Vol. I, 2000)

According to Table 3.5, the population of each division is estimated to increase by the year 2009. This requires prior planning for the resources available such as land, forests, fuelwood employment opportunities among others to cater for the population increase.

Table 3.6 Population Density by Division

Division	Area (km^2)	1999	2001	2004	2009
Ikolomani	142.9	645	672	717	1033
Shinyalu	332.6	313	326	347	386
Ileho	77.7	419	437	466	518
Lurambi	194.1	442	461	492	547
Navakholo	173.4	377	393	419	466
Kabras	424.2	352	367	392	436
Municipality	49.9	1485	1550	1651	1836
Total	**1241**	**377**	**507**	**541**	**601**

(Source: 1999 Population Census Report Vol. I, 2000)

Although Kabras division had the largest number of people in 1999 (149,510) the density is low, the division with the highest density apart from Kakamega Municipality was Ikolomani with 645 persons per Km^2 (Tables 3.5 and 3.6). The high population density in Ikolomani Division is due to small farm holdings. Although the agricultural potential of the district is high, rapid population with limited resources has generated low production and low savings trap hence increasing marginality and poverty. Due to poverty there is over dependence on natural resources thus injuring the environment for example use of fuelwood as a source of energy leads to the depletion of forests.

3.3 Central Kabras Location

Section 3.2 examined the physical and socio-economic characteristics district level where the detailed study area is found. This section briefly examined the detailed study area at the localized level. Since details have been covered in sub section 3.2, this section mainly concentrated on the socio-economic characteristics and how they affect energy demand and supply in Central Kabras location.

3.3.1 Physical Characteristics

The detailed study area, Central Kabras location is found in Kabras division of Kakamega district. The division is among the seven divisions that form Kakamega district with an area of 424.2 Km^2, which occupies 30% of the total area of the district (Table 3.6). The division is administratively divided into four locations: South, West, Central and North Kabras.

The study area, Central Kabras Location has an area of 72.8 Km^2. The amount of rainfall received on average is 2085 mm in a year. The rainfall figures show that the rainfall is reliable and adequately distributed throughout the year (Table 3.7). Rainfall is highest between March and October, having maximum in April/May and July/August with no dry season. December, January and February are characterized by low rainfall. The temperatures vary between a mean maximum of 26^0C and 32^0C and a mean minimum of 14^0C and 18^0C.

Table 3.7 Rainfall figures for Kabras Division from 1976

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	55	78	164	244	294	204	212	257	205	173	115	83

Name of the station- Malava Dispensary
Altitude -1595 m.a.s.l
Average annual rainfall –2085mm
(Source: Farm Management Handbook A: 1982)

Most of the soils are developed from granite rocks that are well drained. The soils and rainfall characteristics make the area suitable for agriculture and also trees can grow fast while the rate of forest regeneration is high.

Ecologically, the location lies within the star grass zone. This zone is found at an altitude of 1350 m to 1800 m.a.s.l. It is a zone of high agricultural potential and very suitable for cash and food crops, livestock keeping, agroforestry and forestry practices. According to Table 3.1 and Map 3, it can be observed that much of Kabras Division lies in the lower midland (LM2) zone, which is 217 Km^2 (48%) of the division. The lower midland (1) zone (LM1) covers 20 Km^2. The detailed study area is found in the UM4, UM2-3, and LM1-2 where trees can do well if planted. These zones are important in relation to the amount of woody biomass that is available and how fast it is being depleted for fuel.

3.3.2 Land use Patterns

The total land available for agriculture is 367 square kilometers meaning that 81% of the whole division has good agricultural potential. The current utilisation of the agricultural land indicates that 13.9% of land is under sugar cane, 31.8% under maize,

13.9% under crops like bananas, cassava, millet, and horticultural crops while 40.4% under grazing and forest. The average land per household is 2.19 hectares and average land per person is 0.36 hectares as such many farmers have not set aside land for woodfuel (Musoga 1988). The average land per individual affects the growth of trees for fuel and other uses. The crops grown are maize, sugar cane, millet etc. whose residues are used to substitute the trees for fuel.

Central Kabras Location is mainly composed of small-scale farmers growing crops for household consumption and for the local market. Livestock such as cattle, poultry, sheep, pigs, and donkeys are also kept. The donkeys and cattle are used as draught animals for ploughing the land and transporting of goods to and from markets. Many people practice agriculture as the main economic activity meaning that the area under trees is affected.

3.3.3 Demographic Profile

According to 1999 Population Census, the division's population was 149,510 persons while the detailed study area (Central Kabras Location) had a population of 23,496. Table 3.8 shows area, the population, and the number of households of sub locations in Central Kabras Location in 1999.

Table 3.8 Population of Central Kabras Location

Sub location	Area	Population	Density	Number of Households
Matioli	12.2	3,823	313	746
Tande	15.7	5,403	344	1,021
Matsakha	20.6	7301	354	1,442
Chegulo	24.3	6969	287	1,299
Total	**72.8**	**23,496**	**323**	**4,508**

(Source: 1999 Population Census Report Vol. I, 2000)

According to the specific age group, over half of the population is below 20 years of age. This youthful population together with these over 60 years forms the 65% of dependent in the study area while 35% take care of them. High dependency ratio poses a problem on the provision of basic facilities and resources especially food, health, education and fuelwood. This leads to decline in the area under forests and woodlots, as more land is required for production of food leading thus in the long run to scarcity in woodfuel.

The population estimates (at the growth rate of 2.14%) of the location by the year 2009 will be 29,037 meaning that there will be an increased demand for woodfuel and other resources. In this case, there needs to be an increase in the supply of the fuelwood and this requires planning interventions to have a sustainable supply and efficient use by that time.

3.2.4 Socio-Cultural Profile

In Central Kabras Location, the family is the basic unit of social interaction among the Kabras people. It is within the family that one is socialized through norms, values and beliefs of the society which are passed on from the older members to the younger members. During the process of socialization, duties for the various genders and age groups are defined e.g. boys deal with herding animals, slashing and ploughing while girls deal with domestic chores such as fetching water and fuelwood. Accessibility to fuelwood resources in the study area is determined by the socio-cultural considerations.

The Kabras people are a partrilineal society whereby the individual traces his/her lineage from the paternal side. This means that the society is partrilocal in that on marriage, the female spouse resides in the home of the male spouse. This kind of arrangement influences the patterns of resource ownership and / or accessibility, role definition and decision-making within the household. Therefore, the man is the crucial decision maker especially in regard to decision affecting the use of land, which is generally seen as a critical resource in society and other resources that denotes permanence like trees.

In Central Kabras Location, women do not own land but many hold it in trust for the male children in cases where their husbands passed away. Division of labour is along gender lines. The man takes up the challenging and field-oriented tasks while the kitchen was/is the territory of the wife and all that happen in kitchen basically cooking is left to the discretion of the women and consequently the task of fuelwood collection is left to the wife and the female children. This was and is still the attitude of the male even in this era of fuelwood scarcity. According to Chavangi (1991) there are plenty of trees on the farm yet there is scarcity of fuelwood in the kitchen because the trees belong to the man.

In regard to division of labour, planting of trees is and / or was a male issue. The men plant and manage the trees on the farm (Chavangi, 1991). The purpose for planting trees was for economic and sacrificial purposes (activities monopolized by men) and as a landmark for boundaries between different farms. Since planting a tree indicates

ownership of that land and women did not own land they had no business with planting trees. Due to this reason, women did neither plant nor manage trees and this has contributed to the increased problems of fuelwood shortages in the rural areas including the study area.

The Kabras community practices farming that is crop growing and animal husbandry. The cattle are kept for social and economic purposes. Economically, they are seen as a store of wealth while socially they are used for paying dowry, slaughtered in funeral occasions, circumcision ceremonies, etc. Land is valued as a means of subsistence to the household and provides one with a base for a sense identity and association with their kin, a massive of wealth and provides continuity between generations as it is inherited. Land and farming practices influences the supply of woodfuel for domestic purposes.

In summary, the study area (Central Kabras Location) and the district have favourable geographical environment for the woody biomass development, increased demand for other human needs as food crops, cash crops, settlement etc, the exploitation of this potential is becoming a constraint. The forest exist in the area cannot be accessed by a significant proportion of the population and also the socio-cultural characteristics is constraint to adequate provision of woodfuel to the household.

CHAPTER 4: FUELWOOD AS ENERGY IN CENTRAL KABRAS LOCATION

4.1 Overview

This chapter presents the field findings divided into sub sections. The first sub section presents the socio-economic characteristics of the respondents. Second, the land use patterns in Central Kabras Location. Third, marketing of produce from the farm. Fourth, energy supply and consumption patterns in the study area and lastly, how the respondents perceived woodfuel problem and what they did to solve the problem.

4.2 Socio-economic characteristics

The social and economic characteristics discussed under this section are: household size, age structure, employment, and cultural attributes and how they influence the type of fuel used, amount consumed and their sources.

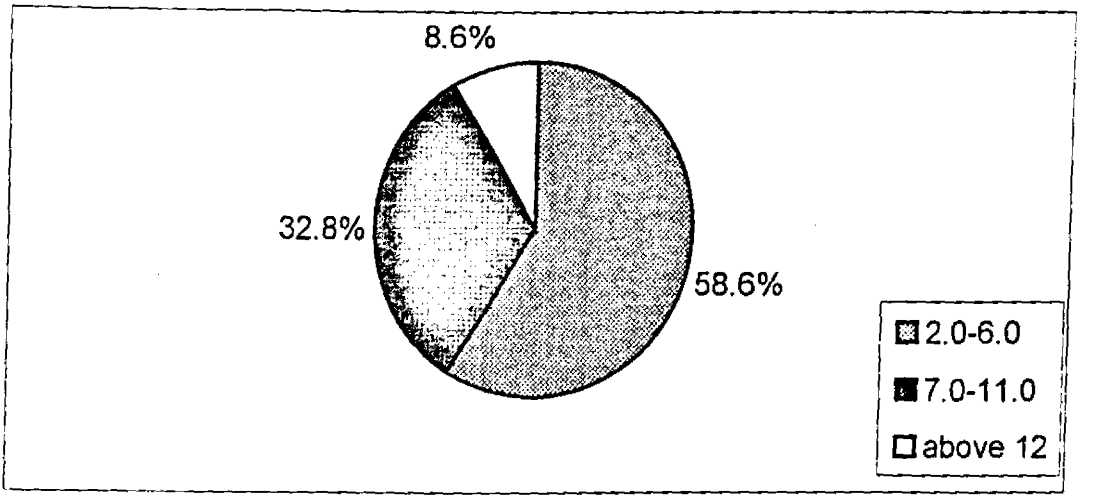
4.2.1 Household Size

Most of the households (58.6%) had between 2 to 6 persons (Fig. 4.1) and the average household size was 6.7 persons, with the smallest household size of 2 and the largest 17 persons. There were 7% polygamous head of households whose size ranged between 12-16 (average 13.8 persons) this implied more fuelwood used to prepare food for these large families.

The household size has various implications in respect to domestic supply and consumption of energy. This means, first the larger the household size, the more the amount of fuelwood required to meet the domestic energy needs. A single person's

fuelwood consumption of 941 kg per annum (Hosier 1985), the households with between 2-6 persons will require about 1882 to 5646 kg per annum.

Fig. 4.1: Household size



(Source: Field Survey, 2000)

In terms of land, this means that 0.2 acres of the farmland has to be committed to fuelwood production yet 1.4% of the households have a total land size of 0.25 acres. If they commit 0.2 acres to fuelwood production they would have only 0.05 acres left for crop growing which is not adequate to feed the family.

The household size will also influence food requirements, if they have to produce from the farm. For example if each household member consumes 120 kg of maize per year then in the case of the first category 2-6 persons will need 240 kg to 720 kg per annum. This means that to be able to meet the food requirement per person approximately 0.2 acres have to be set aside to meet the annual maize requirements of each individual. Thus, a household member requires 0.4 acres to sustain themselves with annual fuelwood and maize requirements, with the minimum land size of 0.25 acres, a

household size of 4 requires 1.6 acres, then this particular household faces a deficit of 1.35 acres or a household size of 14 requires 5.6 acres of land for both requirements but has a only of 1 acre thus has a deficit of 4.6 acres.

The household size will influence the amount of income spent on energy, since there are other competing income consuming items in the family (e.g. education, medical etc), which may be seen as priority. This means that fuelwood is assumed to be free whereby commodity none or little money may be allocated to fuelwood purchasing.

4.2.2 Age structure

The ages of the people interviewed are presented in Table 4.1

Table 4.1: Age structure

Age	Number	Percentage
0-9	71	15.7
10-19	112	22.9
20-29	120	25.3
30-39	66	14.1
40-49	46	9.7
50-59	32	6.8
60-69	18	4.0
70 and above	7	1.5
Total	**472**	**100.0**

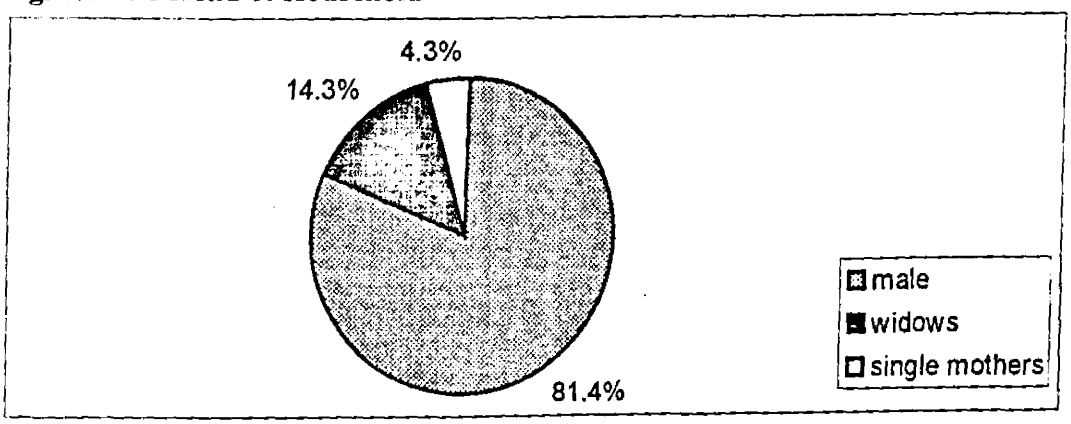
(Source: Field Survey, 2000)

There is 15.7 % of the sample population (0-9), who need health care in terms of medication, hygiene (such as boiling drinking water) and balanced or nutritious meals prepared for them. This implies that fuelwood would be used in preparation their meals. The school going group (38.6%) is an income consuming in terms of expenditures on fees, uniforms and books. This means priority given to education (78.3%) among households compared to other family budgets like fuelwood (1.7%).

The household expenditure on fuelwood also depends on the dependency ratio that the ratio of the unproductive population (0-15 and 65 and above) to that of the productive population. According to the study, the dependency ratio of the area under study is 100:126, meaning that for every 100 productive people there are 126 dependents. This will influence the fuel used depending on whether the productive population is economically active in terms of employment and also if they have other resources (such as land) to support their dependents.

According to Table 4.1, there were a total of 472 people of whom 234 (49.8%) were male and 238 (50.2%) female, with a sex ratio of 1:1. Despite the sex ratio being 1:1, 81.4% households were headed by the male and 18.6% headed by female. The female-headed households were further subdivided into two: single mothers (4.3%) and widows (14.3%) (Fig. 4.2).

Fig. 4.2 The Head of Household



(Source: computed from Field Survey, 2000)

The head of household had an influence on decision-making on issues of household expenditure and also the amount of fuelwood consumed. For instance, the male-headed households used more fuelwood compared to female-headed households. A sample of

6 households, of average household size of 3, the first 3 households headed by female used 9 bundles per month while the other three male-headed households used 17 bundles per month. The explanation for this variation was income levels and land sizes. (Note that in this case one bundle of fuelwood is approximately 10 kg).

4.2.3 Household Income Levels

The head of households interviewed were engaged in various activities to earn a living. They were employed in public and private sector, business, farming and others (table 4.2).

Table 4.2: Occupation of Household Heads

Type of occupation	Number	Percentage
Farmer	39	55.7
Business	7	10.0
Employee	16	22.9
Retiree	4	5.7
Others	4	5.7
Total	70	100.0

(Source: Field Survey, 2000)

The occupation of household heads determined the type of fuel used and the amount of income spent on fuel. For instance, in the cases of the 22.9% employed either in the public or private sectors used kerosene stoves, while 18.8% of the same group used gas for cooking other than fuelwood. Thus the occupation of a household head had an influence on the type of fuel used for cooking purposes.

The Table 4.3 shows the income levels of the household heads of the people study area. The levels of income range between Kshs. 300 and Kshs. 20,000 and have been divided into 6 income brackets.

Table 4.3: Levels of Incomes of Household Heads

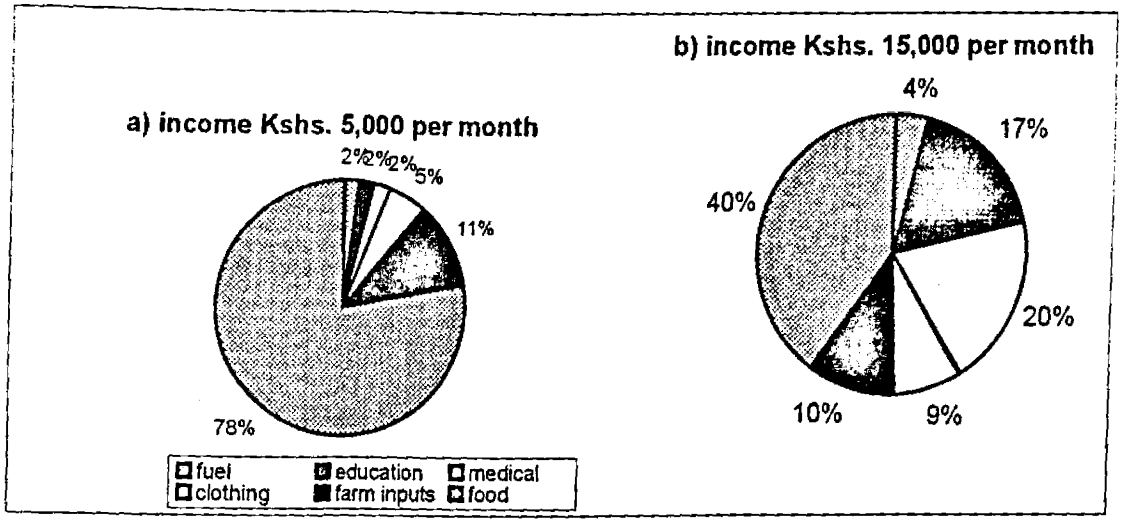
Income in Kshs	Percentage
< 1000	33.3
1001-2000	13.3
2001-3000	10.0
3001-4000	8.3
4001-5000	8.3
> 5000	26.8
Total	**100.0**

(Source: Field Survey, 2000)

The income bracket of less than Kshs. 1,000 (33.3%)is earned by farmers with small land parcels out of whom (3.3%) are casual workers on people's farms to supplement what they get. From table 4.2, 55.7% of head of households are farmers, of these farmers only 11.7% realized an income of over Kshs.5,000 per month while the rest (88.3%) got less than Kshs.5,000.

The income levels had implication on household expenditure on the amount of money spent on household needs such as 78.4% on education, 8.2% on clothing, 1.6% on fuel (particularly paraffin), 7.8% on food and 4.0% for medication. In relation to Fig. 4.3, shows two samples of typical household expenditure from the study area. This means that more preference on expenditure among households interviewed is given to food, whether the family is in the first income-bracket (Kshs.1,000) or the sixth income bracket (Kshs.15, 000).

Fig. 4.3 Typical Household Monthly Expenditure



(Source: Field Survey, 2000)

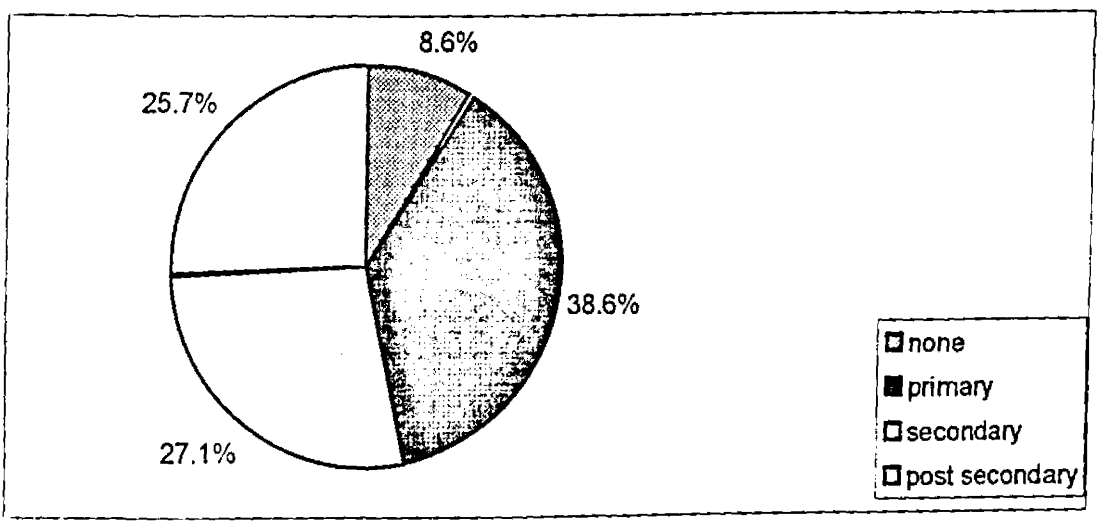
This expenditure trends on different items did not vary among the households, but the only difference was the amount of money spends on these items. Despite having 10 acres of land for Fig 4.3 (a) and 30 acres or Fig. 4.3 (b), food takes a larger percentage of household incomes, compared to fuelwood 2% and 4% both for Fig. 4.3 (a) and (b) respectively. This means that in household budgets vary thus little money is spend on fuel, particularly fuelwood as it was perceived to be a free commodity from on-farm, neighbours' farm or the forest.

The income levels also have an implication in that the household heads have no money to save so as to buy seedlings or prepare the nurseries for planting to increase the on-farm number of trees, thus aggravating the fuelwood problem on the farms. The income levels are also important especially when proposals made to be implemented by

household head, whether they can afford alternative sources of energy (such as solar or biogas) with their incomes.

According to Fig. 4.4, there were 38.6% respondents who had obtained primary education, 27.1% secondary, 25.7% post secondary while 8.6% had no formal education. Thus, the level of education also influenced the technology used for cooking. Education levels are also crucial when creating awareness on energy-saving techniques or alternative sources of energy such as biogas or solar. It was realized that those who attained secondary education and primary education (42.4%) used energy saving stoves for cooking though not regularly.

Fig. 4.4: Education Levels of Household Heads



(Source: Field Survey, 2000)

4.3 Land use Patterns

Land is important, as it is the source of food. In addition, land produce was sold and the money was spent on other household requirements. Furthermore, land gives the individual sense of belonging.

4.3.1 Land Sizes

The land sizes in the study area range between 0.25 acres to 30 acres (Table 4.4) with the average size of 6.6 acres per household, 1.9 acres per male-members and 0.95 acres per person.

Generally, in the study area, family landholdings tend to be in several pieces. For example, 40% of the household had their land parcels in consolidated form. But others had their aggregate holdings in scattered pieces. In addition, land sizes tend to reduce with increase in household size (particularly number of male). This is due to fact that the male children have to inherit a piece of land from their fathers, regardless the aggregate size of land parcel the family has. The decreasing land sizes have an effect on the supply of fuelwood, since 12.9% of the respondents attributed the shortage of on-farm fuelwood to this factor.

Table 4.4 Lands Size in Central Kabras Location

Size	Number	Percentage
<1.00	7	10.14
1.01-2.00	8	11.59
2.01-3.00	11	15.94
3.01-4.00	9	13.04
4.01-5.00	7	10.14
5.01-6.00	5	7.25
6.01-7.00	5	7.25
7.01-8.00	1	1.45
8.01-9.00	2	2.89
9.01-10.00	4	5.79
>10	10	14.49
Total	**69**	**100.00**

(Source: Field Survey, 2000)

Land sizes determine the amount of land set aside for growing crops, grazing or woodlot. For instance, 60.85% of the respondents had land sizes of less than 5 acres of which only 21.2% had established woodlots (averagely 0.5 acres).

According to Table 4.4, the mode class is 2.01 to 3.00 acres of land, which is below 3.5 acres per household as recommended by the Food and Agricultural Organization of the United Nations. Despite the fact that 50.71% have less than 4 acres, the landholdings are still viable to support at least one livestock (cattle) that can lead to the development of biogas as an alternative source of energy for the households.

According to the field survey, 75.7% inherited the land they owned, while 21.4 % had brought it and 2.9% was a combination of the two. The households who had title deeds were 47.8% (bought land-24.3% and inherited 23.5%) while 52.2% did not have titles for their land inherited from their forefathers. The land ownership and tenure is important in that it can be a constraint or an opportunity to fuelwood production. The security of inherited land was determined by having a title deed, which implies absolute ownership and the freedom of use. But where a son was only allocated for use (i.e. planting of crops) the father could still allocate them a different piece in the next planting period or during the permanent transfer. Therefore, the son had difficulty in making long-term decisions on the use of land until he had a permanent allocation.

4.3.2 Land Use Activities

As seen chapter 3, the study area is suitable for growing crops, keeping animals and planting various trees species. The activities on land were allocated different land sizes. Table 4.5 summarized the total amount of land allocated to various land uses out of the total 452 acres utilized by the respondents whereby 440.76 acres (97.5%) are used for various land activities while 11.24 acres (2.5%) are under-utilised or left fallow with thickets and bushes.

Table 4.5 Land Use Activities

Land Use Type	Area	Percentage
Crops	275.05	60.8
Grazing/pasture	103.35	22.8
Woodlot	18.68	4.1
Agroforestry	11.63	2.6
Homestead	32.80	7.2
Under-utilised	11.24	2.5
Total	**440.76**	**100.0**

(Source: Field Survey, 2000)

According to Table 4.5, three-fifths (60.8%) of the land is under crop production. The crops grown are both cash and food crops, which include, sugar cane, maize, beans, sweet potatoes, cassava, bananas etc. Sugar cane is grown by 60% of the respondents for the purpose of earning incomes to pay for fees and other household items.

Mixed cropping is practiced by 90% of the respondents, particularly maize and beans during the planting season. After beans have been harvested in June or July, sweet potatoes and cassava are planted in between the maize lines to be consumed during the dry season (December- February). Agroforestry that is planting of trees and food crops on the same land parcel was practiced by 8.6% respondents. The kinds of trees planted

were both exotic and indigenous like *mukhule* and *mibobo* (Plate 1). The people practiced mixed cropping to improve on the soil fertility and structure and increase the amount of food produced per area.

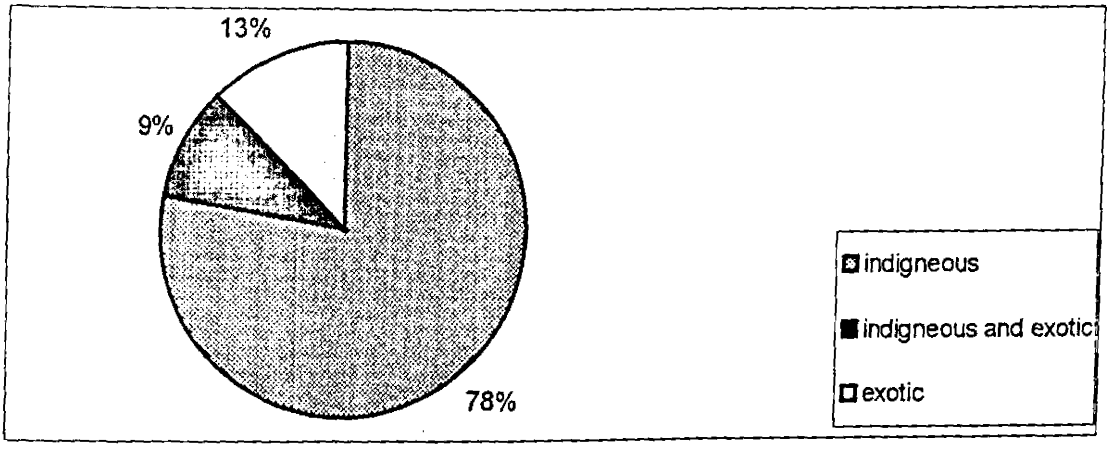
Plate 1 Types of the trees planted on the same parcel of land with food crops

It is worth noting that from the study area that both family labour (94.3%) and casual labour was used to work on the farm. Among the family labour, women (88.6%) played a major role in agriculture, men (61.4%) and children (62.9%) were also involved. The men were involved either in ploughing using draught animals and deciding on what was to be planted such as sugar cane and paying casual workers.

The use of family labour implied that the time of women to collect fuelwood was limited thus causing shortages in the kitchen since they were the collectors and users of fuelwood. Due to women's involvement in food production the children's playtime was reduced as they assisted their mothers to gather fuelwood.

Livestock are kept by 91.4% of the respondents. The types of livestock kept were cattle both indigenous and exotic animals (Fig. 4.5). The respondents who did not keep cattle were 8.6% because they could not afford and they had no grazing ground due to the small land parcels. The indigenous cattle are preferred due to the fact that they demanded little on the farm in terms of land required for planting fodder like nappier as in the case with the exotic animals.

Fig. 4.5: Types of cattle kept



(Source: Field Survey, 2000)

The other types of livestock kept are goats and sheep. Every household in the study area keeps poultry. The respondents (90.6%) had set aside part of their land for grazing their animals, which accounts for 22.8% (Table 4.5). The grazing land included the area under nappier grass. Out of the 91.4% who kept cattle, 9.4% practiced zero grazing. The exotic cattle (e.g. Guernsey) were fed in zero-grazing units on solely on-farm products and grass such as unwholesome maize, hay and nappier grass and supplemented by animal feeds that are bought once in a while.

The respondents grazed their animals in various places particularly both the indigenous and exotic. There were 71.9% of the respondents grazed their animals on their farms, while 12.2% on their neighbours' farm, 4% in the forest and 11.6% grazed their animals along the road (Plate 2) and communal land along the river valleys. Animals were grazed on their farms due to no existence of communal land, ownership of sufficient pasture, and increased population and privatisation of land thus land sizes had declined restricting people to use the available limited resources. Livestock keeping should be integrated in farming activities for production of manure and of milk sold (sub section 4.4) earning the household income.

Plate 2: Indigenous cattle grazing along the Kakamega – Webuye road reserve.

The other land uses as shown in table 4.5 included the woodlots and homesteads that occupied 4.1% and 7.2% respectively. The area under woodlot is very small and there is need to expand it by having every household to spare about 0.1 acres (an eighth of an acre) for planting woodlot. Most woodlots observed had very young trees (Plate 3) and

also the main purpose of the woodlots was commercialised for timber, building and roofing posts etc and not fuelwood. The branches and twigs were consumed as fuel but never burned for long.

Plate 3:A woodlot of young eucalyptus trees

Homesteads occupied 7.2% of the land, ranging between 0.25 acres to 2 acres. Homesteads in the study area did not consist of only housing structures but also included trees planted in the homestead, and where it was large it was also used for grazing. The trees planted provided shade, shelter and fuelwood after pruning the branches (Plate 4).

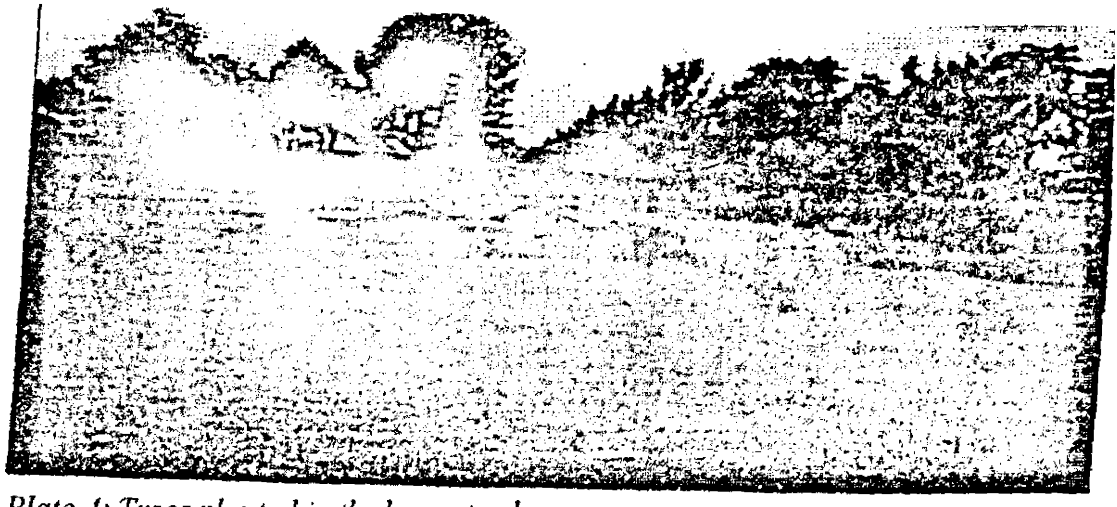


Plate 4: Trees planted in the homestead.

The land uses, land sizes and household sizes influence the area under woodlot or even the number of trees grown. For instance, 22.8% of the land was under pasture / grazing had one or two trees scattered in the grazing land not for fuelwood, but to provide shelter and shade for the animals for all weather (that is rainy and sunny). The other example is the larger the land the more the acreage left for fuelwood production. Out of the 27.1% of the respondents who planted woodlots only 36.8% (land sizes of over 5 acres) set aside over 1 acre of their land to this land use while others 63.2% had less than an acre of their land under woodlot.

4.3.3 'Shamba' System

The 'shamba' system applies to when the Forest Department converts an indigenous forest into exotic species forest or replanting a harvested forest. A part of Malava indigenous forest has been cleared and is being used for both planting of exotic trees (cypress and pines) and growing crops by farmers who border the forest. The affected sub locations are Tande (Shitirira and Muhoni villages) and Matioli (Makhwabi and

Cereal Board villages). The portions allocated to farmers ranged between 0.5 acres to 1 acre. The households neighbouring the forest are to assist the forest department to tend the trees, in turn they plant their food crops (particularly maize and beans) on the same parcel of land for a period of 3 - 5 years.

This system began in 1997, during which there was woodfuel (that is fuelwood and charcoal) boom from the forest without restrictions from the forest department as the trees were being cleared to create room for planting of the tree seedlings. At the same time there was an increase in maize production by households who planted in the area, for example one of the respondents through an informal discussion said that in the previous years (before 1997) he used to harvest 2 bags (90 kg each) from his 0.25 acre of land per annum. But with an extra half an acre got through the 'shamba' system, he got 12 bags in total (without use of fertilizers) as the forest land was very fertile. He hoped the trees would grow slowly so that he could use the portion for a longer period than the three years allocated for their use.

The problem with this system is that three quarters (75%) of these portions were allocated government employees including the provincial administration officers, while the remainder (25%) to individual who bordered the forest and used it frequently as a source of fuelwood and pasture for the livestock got small portions (ranging between 0.1 to 1 acre).

The implication of the 'shamba' system was that the forest area declined in size. (Note that the research could not be able to establish the exact area of the Malava forest before and after implementation of 'shamba' system). This meant that those who depended on the forest as a source of fuel wood experienced shortages (Plate 5). Secondly, the cleaning of the rain forest or the indigenous forest increased the surface run off because the areas cleared were hilly. The clearing of indigenous trees such as *mitoto, mibanga, minyelenyende* (Plate 6) will have a long-term adverse climatic effect in the future, which could not be realized at the time of study. Thirdly, from a focused group discussion with the village elders from the affected villages and the forest officer (Kakamega) it was realized that the tree seedlings were withering every crop planting season as the farmers intentionally cut their roots so that they could use the portion for a longer period. The other issue is that how sustainable is the 'shamba' system? Will it offer a solution to the fuelwood problem or worsen the situation? The 'shamba' system was beneficial in the short run due to the fact that it led to increased food production but in the long run the soils would be depleted and fuelwood remained a problem due forest restrictions. As the study established there was no an immediate answer to these questions, and there was need for the government to review its policies in relation to the 'shamba' system and its benefits to both parties that is the government and local community.

Plate 5: An old woman (on the left) splitting a tree stump in the area where 'shamba' system is practiced to obtain enough fuelwood for supper.

Plate 6: Indigenous trees that play an important role in the climatic conditions are cleared and replaced with exotic trees.

4.3.4 Problems on the farm

The study area is mainly an agricultural area, which included the crops grown, animals kept and other activities related to farming. The field survey realized that there were several problems that hindered the development of agriculture and thus increase or improvement in the income levels of respondents. These problems were experienced either singly or multiple at the farm level, but the analysis dealt with each problem in isolation to show the their importance. These included:

(i) Infertile soils (41.4%) that were caused by over cultivation and soil erosion. The situation was worse where the land sizes were small and land not left fallow or crop rotation was not practiced.

(ii) Decline land sizes (12.9%) caused by increased family sizes, with an average of 6.7 persons and subdivision of these small land parcels among sons.

(iii) Poor harvests (28.6%) caused by small land sizes, infertile soils, pests and diseases and changes in the weather conditions. Lack of extension services is a contributory factor as extension officers visited only 5.7% from Ministry of Agriculture, Livestock and Rural Development.

(iv) Fuelwood shortage was experienced by 12.9% of the respondents and was caused by non-replacement of cut trees, increased family sizes which meant increased demand of fuelwood, declining land sizes meant land left for fuelwood production was also declining and also non-existence of communal land which supplied families with fuelwood. The woodfuel problem was manifested by the fact that women (9.8% of the selected sample) were forced to 'steal' fuelwood from their neighbours' farmers.

(v) Lack of financial resource (18.6%) to buy the necessities (e.g. food, farm inputs, and fuel). Through focused group discussions, it was realized the people (particularly men or the head of households) were poor in priotising when they had any money. For example, after earning sugar cane money they used their incomes irresponsibly by drinking, extra-marital escapades in some cases getting temporary extra wives who deserted when the money supply got exhausted. There are also no co-operative for credit facilities and services, especially in the agricultural sector.

(vi) Poor road (2.9%) also contributed to the low incomes, as the surplus farm produce could not be the market easily. The respondents also felt that the prices for each bag (90 kg) of maize sold to National Cereal and Produce Board (at Kshs.800) was low compared to the market prices (at Kshs.1,200) during harvest time, thus resorted to selling their produce directly to the businessmen.

These problems had an implication on the area under on-farm forestry, as land sizes declined and level of income and expenditure on various households' items. These problems in one-way or another aggravate the on-farm fuelwood scarcity for example, poverty may lead to deterioration of the woody biomass.

The respondents had various ways of trying to encounter their problems, to increase crops yields agrochemicals (fertilizers, pesticides etc) and farm manure were used or applied by (51.6%) of the respondents; improved farming methods such as planting nappier and sweet potatoes and terracing on steep slopes, practicing crop rotation was

done by 15.7% to ensure soil fertility was not lost through erosion and over cultivation. The fuelwood problem was solved by planting trees in a woodlot or on the cropland (1.6%) and the collecting dead wood from the forest (10.9%).

4.3.5 Case Studies

The study revealed that trees are an integral part of rural production systems. Fig. 4.6 shows the area occupied by trees and the farm layout of two selected households headed by a female and a male respectively. The two households have different fuelwood requirements. Despite the fact that the two households plant trees, the male-headed household experienced fuelwood shortages and was forced to buy. The female-headed household (Fig. 4.6(a)) has no woodlot and does not experience shortages because the male-headed household sales the tree products furthermore leaving none for fuelwood domestic consumption. The problem of fuelwood depends on who makes decision as far as the trees are concerned (who plants and where) and their purposes.

The trees planted perform many functions such as provide cash income from sale of poles, source of energy and building materials, shade, shelter etc. The cash income is given priority over energy so that when trees are cut down, the woman gets the branches while the trunk is sold. The money obtained from the sale of tree products meant to benefit the whole family, but most of time it is spend on luxuries (e.g. drinking beer), men also decide to plant sugar cane, (cash crop) leaving small parts or none for fuelwood depending on the size. Thus the sugar cane economy has contributed to the fuelwood problem as the bushes and thickets have been cleared to create for the purpose

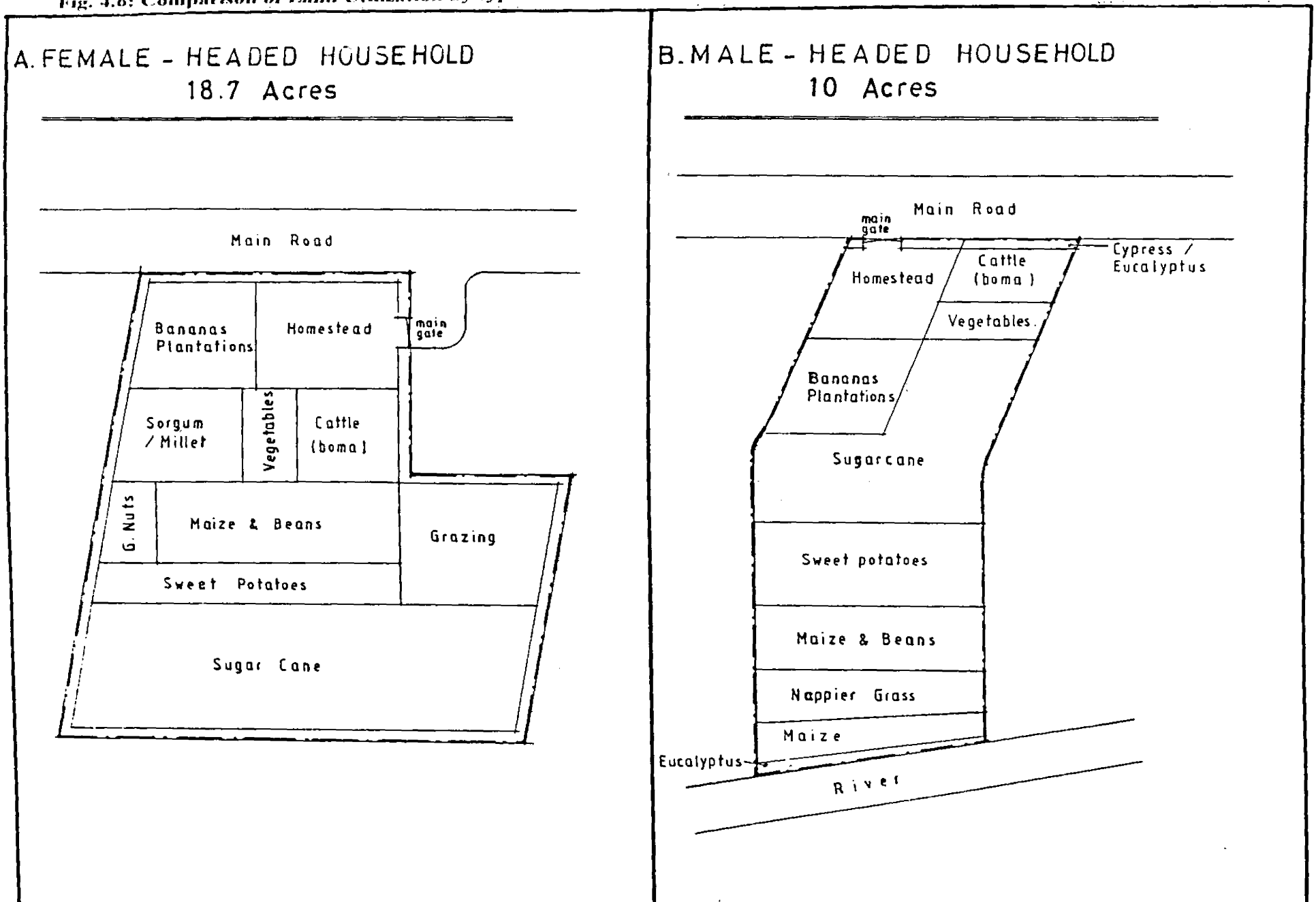
of growing sugar cane. In Fig. 4.6(a), the household head is a female, the decision-maker on what to plant where on the farm. There was no woodlot, nevertheless the trees are planted along the hedges and any available vacant space (land) including the grazing ground.

In both cases, the types of trees planted are eucalyptus and cypress. The eucalyptus has a negative effect on the soils rendering them less moist and fertile for example in Fig. 4.6(b), the area under woodlot is fragile (marshy) thus these trees will lower the water table.

4.4 Marketing of Farm Produce

According to the field survey, 87% of households in the study area sold farm produce whether they had a surplus or not to get cash to meet the other basic budgetary needs. These households included farmers, not formally employed (78.8%) and the formally employed (8.2%) sold products from the farm to meet their needs such as medical care, clothing, educating other family members, farm inputs and buy paraffin for lighting purposes.

Fig. 4.6: Comparison of Land Utilization by type of Household Head



The products sold included milk by 49% of the respondents on daily basis, maize (42.6%) and potatoes (41%) annually. The other products sold on annual basis were beans (98%), fruits (33%), cattle (12.2%) and groundnuts (5.6%). These products were sold when need arose. The respondents (60%) who planted sugarcane delivered it to West Kenya Sugar Company found in the same division, as there was no sugar jaggery (factory) in the study area. It was noted that the expenditure on food was high (Fig. 4.3) yet the selling of food products was carried out by the households in the community under study in order to raise funds to purchase other household needs / items. But all the same, the expenditure on food was higher than on fuelwood since the community perceived fuelwood as a free community.

All the respondents (87%) who sold their farm produce did not use middlemen or co-operatives but sold their products directly to the business people (for example sweet potatoes dealers from Eldoret and maize dealers from Kisumu) or the consumers. These respondents had no delays in payment for their deliveries but the only problem is that they sold their produce immediately after harvest when the prices were generally low.

The modes of transport to take the farm produce to the market are motorized (3.3%) and non-motorized (96.7%) which can be further subdivided into various means as shown in Table 4.6.

Table 4.6: Means of Transporting Farm Produce to the Market

Means	Percentage
Walk	45.9
Walk and Draught animals	6.5
Bicycle and walk	8.2
Bicycle	32.8
Bicycle and Draught animals	3.3
Vehicle	3.3
Total	**100.0**

(Source: Field Survey, 2000)

The most popular means is walking (45.9%) and bicycle (32.8%) because of the hilly nature of the landscape. Vehicles are the least used (3.3%) because of poor conditions of access roads especially in Chegulo sub location, which is hilly in nature and is far from the main roads Kakamega and Webuye and the existing roads were not maintained as such affected marketing farm produce especially sweet potatoes and maize. The argument was that if the roads were maintained and more access opened, this would improve their incomes and they would be able to afford fuelwood and also switch to other alternative sources of energy.

4.5 Energy Supply and Consumption Patterns

The study area has no electricity supply from the national grid. Therefore, the alternative sources of energy available are fuelwood, biogas and solar energy.

It has been realized that the economic base of households is weak with 33.3% (that is 60 of the households interviewed) earning less than Kshs. 1,000. The remaining 10 (14.3%) did not respond to how much they earned per month as it was less than Kshs. 1,000 and never kept records. Due to this weak economic base 97.1% depend on fuelwood for cooking and not on alternative energy sources such as biogas, solar. (It

should be noted that the study area Central Kabras Location - is some of the rural areas without electricity).

The diminishing of land resources due to increasing sub-division as household size are large and also due to competing land uses to fuelwood such as crop growing, livestock, housing etc results in to shortages of own farm fuel. The resulting effect is that there is imbalance between supply and demand of fuelwood. This section also discussed tree planting and agroforestry in trying to solve the fuelwood problems by the respondents. All households have planted trees yet, 90% are not aware of tree species such as *sesbania sesban* and *gravelea robusta* can be intercropped with the food crops.

This section also discussed the cultural factors that influence the supply and demand of fuelwood in the context of who plants trees, who owns the tree and that some tree species were not used for fuelwood.

4.5.1 Supply Patterns

4.5.1.1 Sources of Fuelwood

The respondents obtained the fuelwood from various sources such as on-farm, neighbours' farm etc (Table 4.7)

Table 4.7: Sources of Fuelwood for Household

Source	Percentage
On-farm	54.2
Forest	2.9
On-farm and buy from market	17.1
On-farm and forest	5.7
On-farm and neighbours' farm	11.4
On-farm, forest and neighbours' farm	2.9
On-farm, forest and buy from market	2.9
Neighbours' farm and forest	2.9
Total	**100.0**

(Source: Field Survey 2000)

(a) On-Farm as a Source of Fuelwood

The study established that over 54.2% of the households depend entirely on their farms to satisfy their fuelwood needs. However, in combination with other sources, over 94% of households depended on fuelwood for their needs (Table 4.7) from their farms. The types of fuel from the farm were woody biomass included cutting down of trees or splitting tree stumps (Plate 7) and crop residues (e.g. maize cobs).

On-farm is the most important source of fuelwood in the study area but faced with competition from other land uses mainly crops and livestock. The problem of declining land sizes as the number of people per household increased meaning that the land parcels were becoming uneconomically viable for farm forestry particularly woodlots for woodfuel, it was for this reason that the respondents preferred to use land for crop production. The trees cut also had competing purposes / uses for example they provided fuel, poles and posts for building and fencing etc.

ure 7: On-farm tree stumps (in the foreground right) split for fuelwood. Notice the generating eucalyptus trees.

cio-cultural beliefs among the people in the study area to a certain extend also fluenced fuelwood supply. The study established that women were not allowed to ant trees for various reasons which included first it was believed that, young married women would become barren if she planted trees. Given that children were ery important in any marriage women feared to risk losing their fertility by planting ees. Second, land ownership, land belonged to the man, therefore, it was the husband r his sons to plant the trees and they belonged to him. Third, married women were not llowed to plant trees, as this would lead to the death of their husbands. Since being a idow was not a good alternative and taking care of the children single-handed was difficult, therefore women did not plant trees. The study established that only [illegible] of the women were allowed to plant trees if their husbands were dead.

Nevertheless the study also established due to changing times (what respondents called modernization) with christianity, 35.5% of women were allowed to plant trees while others 1.5% could plant trees if their husbands worked away from home. The others 56% to plant trees made use of their male children (20.6%), husband (34.4%) and male casual workers. It was realized that the involvement of the household in the energy market presents a chance to break the socio-culturally determined division of labour where procurement of fuelwood was a monopoly of the female folk and men had no business with it. Men were breadwinners' so the purchase of fuelwood had to be incorporated in their budgets. With time this requires discussion between the husband and wife on how they can have sustainable supply and it is with the intention that 35.5% of the male head of household had no trouble with their wives planting trees for fuel and other purposes in the home

The supply of fuelwood on the farm was also influenced by the fact that certain tree species such as *mutoto* used (2.9%) as shrines, *eshiuna* (protect and the homestead against any evils especially by witches) and *combretum (murembe* that is only used by widows) were not used for fuelwood. Trees such as those struck by lightening, *mutua* (cactus), *lunani* etc were not used as the smoke produced while cooking was believed to cause health problems in form of boils *(mabure)*, though they had good fuel. The study also established that these trees were being used by 75.8% of the respondents for cooking either in form of fuelwood or charcoal owing to scarcity or ignorance. However, these trees did not exist as they had been cleared to create space for agriculture.

(b) The Forest as a source of Fuelwood

In the past, when the land sizes were uneconomically small for on-farm forestry (i.e. woodlot and agroforestry) then households with such parcels got their fuelwood requirements from the forest. The households within a radius of 5 km (50.0%) also collected fuelwood from the forest (Table 4.8).

Table 4.8 Distance from the Forest

Distance in Km	Percentage
<1	50.2
1.01-5	11.4
>5	38.4
Total	**100.0**

(Source: Field Survey, 2000)

The respondents who lived 5 km away from the forest relied on other sources of fuelwood particularly on-farm and buying from either the market or neighbours. It was only woodfuel businessmen (1.4%) who used bicycles to transport the product from the source (forest) to the market.

The Poverty Alleviation Programme indicates the maximum distance travelled in acquiring services for households should be 5 km therefore the 61.6% who walk to the forest are still within the limit of the strategy to alleviate poverty.

According to the peoples' perception, the forest is supposed to be a free source of fuelwood but the respondents (17.1%) had problems in accessing this resource. The forest restrictions protect the area thus access to the resource is limited. The households had to pay Kshs. 37 per month for a permit to be allowed to collect only the broken and fallen branches in the forest area. Despite the fact that the amount paid for the permit

was low some respondents could not afford it. These respondents were not allowed to cut down any log whether wet or dry. This permit is to be renewed on monthly basis and those found collecting fuelwood without a permit were taken to court and / or charged with trespass. The 'shamba' system has affected the supply decreasing the area under forest.

The forest and own farm fuel wood sources were inadequate thus people resulted to searching on neighbour's farm (21.4%) and buying from the market (21.4%). Households bought fuelwood from neighbour's farm or those who collected from the forest. The households bought trees, which were then cut and split by use the axe into pieces of about 100 cm long and 8 cm wide. For instance, eucalyptus tree of about 18 metres wide and 30 metres long costed Ksh. 500 that could fulfill an average household fuelwood needs for month.

A bundle weighing 10 kg costed Kshs.20 (average price) but the price range was between Kshs.10 to 50 depending on the season. The higher value (Kshs.50) was charged during the wet season and Kshs.10 during the dry season as fuelwood was relatively abundant and also crop residues were utilized for cooking. Considering that 33.3% of the respondents earn less than Kshs.1,000, they cannot afford to buy fuelwood per month or alternatively if they use 1 bundle per day, the average expenditure on fuelwood would vary between Kshs.300 to 1,500 per month. According to the field study 71.4% of respondents used agricultural crop residues / wastes (e.g. maize cobs and stalks) owing to the inadequacy of the various sources of fuelwood.

(c) Storage of Fuelwood

After collection of fuelwood from whichever source, the pieces were left outside (Plate 8) in the sun to dry before being stored. There were two ways of storing fuelwood depending on the season of the year. The green / wet wood was placed on *inungo* that is above the fireplace where the wood was to be dried by the smoke from the fireplace. This type of storage was done during the dry season so that the fuel wood would be used during the rainy season (Plate 9). This mode of storage is important so that the 44.4% of respondents who did not have *inungo* had problems during the rainy season since the soaked wood used produced a lot of smoke. Alternatively the collected wood was stored outside to be used during the dry season. Both dry and wet / green wood was stored here. This kind of storage was constructed on the eastern (sunrise) side against the kitchen wall (Plate 10). During the wet season the damp and dry wood was mixed during cooking.

Plate 8: Pieces of wood left outside to dry in the sun before storage.

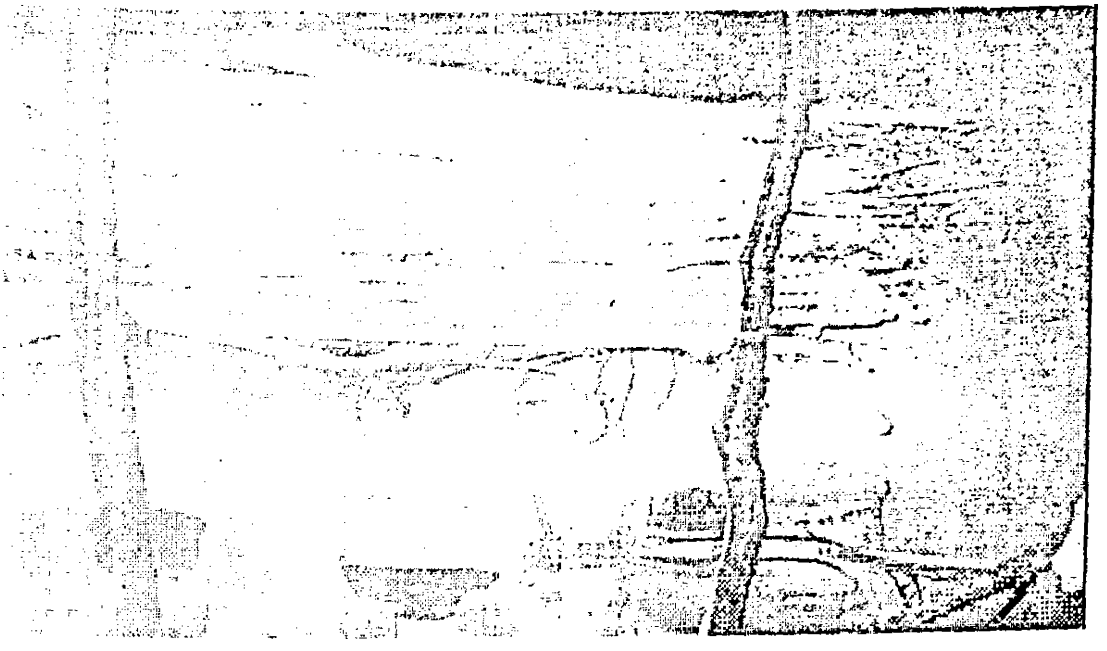


Plate 9: A traditional method of storing fuelwood.

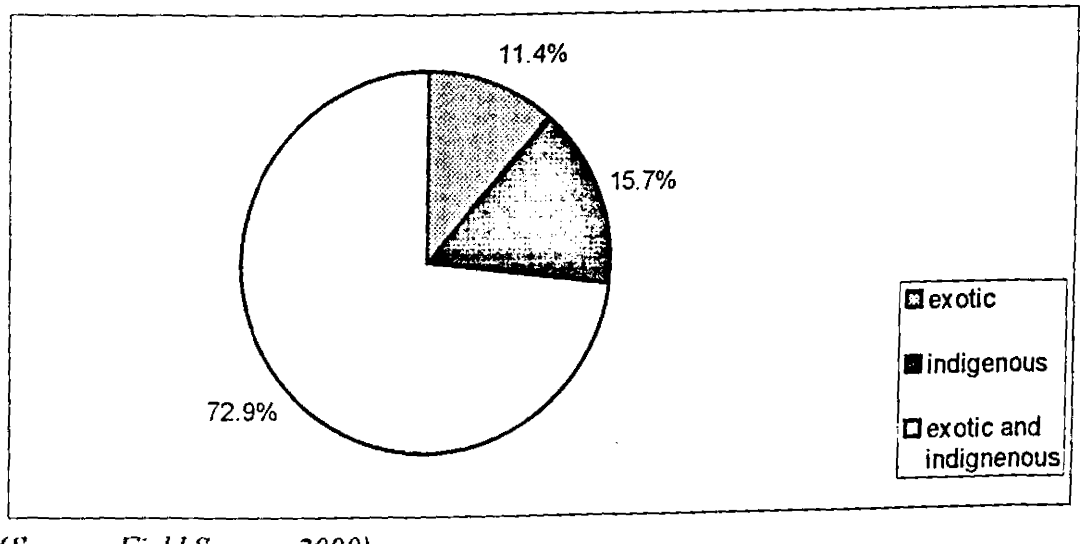
Plate 10: Fuelwood stored outside against the kitchen wall.

4.5.1.2 Farm Forestry

In relation to on-farm source of fuelwood, trees were planted in particular places depending on who made the decisions. The married women (81.4%) revealed the decision on where trees were planted was by the men unless one was a widow or single-mother. The trees were viewed by women as a male issue and also because the tree was seen a source of building materials (associated with men) and income generating. The men are the ones who also controlled the household finances of the households (earnings and expenditure).

The households practiced farm forestry whether on a very minimal scale (means planting one tree in a year) or large scale (planting more than five trees or over a quarter of an acre. There are various tree types / species that were preferred by the different households (Fig 4.7).

Fig. 4.7 Tree Type / Species planted by Households

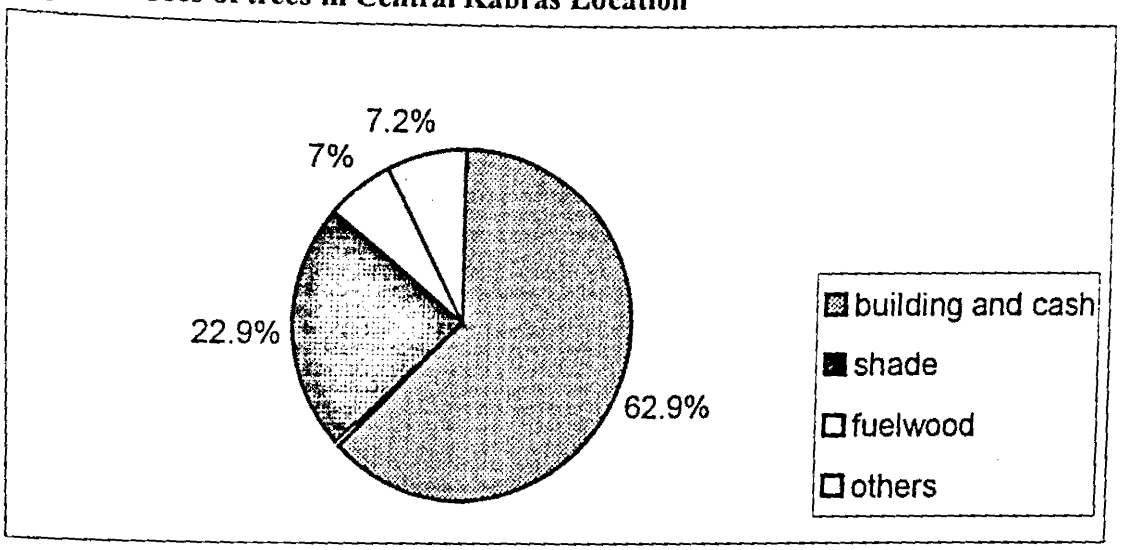


(Source: Field Survey, 2000)

According to Fig. 4.7, the exotic tree species planted are mainly eucalyptus and cypress / pine whereas the indigenous trees included *musiola, mukomari, mukhonje, mbanga* etc. The preferred trees species in the study area are planted by 84.3% for exotic and 88.6% for indigenous of the respondents.

The eucalyptus and cypress were preferred because matured faster than the indigenous species and provided very good building materials in terms of straight poles and timber, which could be sold. The eucalyptus was preferred by 53.6% of the respondents because it had market in terms of timber, hardwood and the fact that it regenerates after cutting and the branches would be used as fuelwood (Plate 7). The indigenous species were preferred since they were hardwoods, whose timber was valuable and durable for furniture making thus fetched more money. In terms of fuel, the indigenous species burned longer than the exotic species. It was established that all households planted trees for purpose such as for sale and building (62.9%), shade (22.9%), fuelwood (7.0%) and others (7.2%) (Fig. 4.8). In this case, the importance of fuelwood was secondary, thus contributed to problems of scarcity on the farms still exists and is bound to increase.

Fig. 4.8: Uses of trees in Central Kabras Location



(Source: Field Survey, 2000)

As noted earlier in sub-section 4.5.1.1, the households who depended on on-farm fuelwood supply were faced with the problem of competing land uses. Due to also small land parcels the households have chosen specific areas where they planted their trees as (table 4.9). In total cases of farmers who plant trees around the house are 62.5%, hedges 92.2 %, woodlot 17.2% and cropland 9.4%.

The respondents did not prefer trees such as eucalyptus and cypress to be planted on farm land or crop land (in particular) as they reduced the soil fertility while the shade caused stunted growth of the food crops leading to low harvests (productivity). The respondents 62.5% preferred planting trees (especially indigenous) around the house to provide shade (Plate 4). The respondents preferred planting trees along the hedge and around the house because the land parcels are small and the owners wanted to maximize agricultural production. Moreover the small parcels could not permit the household to spare part of it for woodlot.

Table 4.9 Where Trees are grown on Farms

Where	Percentage
Hedge	26.6
Around the House	6.3
Crop land	3.1
Hedge and woodlot	7.8
Hedge and around the house	37.5
Hedge, cropland and around the house	6.3
Hedge, woodlot and around the house	9.4
Total	**100.0**

(Source: Field Survey, 2000)

During the study, it was established that 85.7% planted trees on their farms out of whom 75% planted less than 100 seedlings and 25% of the households planted over 100 seedlings per year on selected parts of their farms (Table 4.9). The trees planted were for various uses mainly building, fuelwood, shade etc.

There were 87.1% of the respondents who owned tree nurseries. The ownership of tree nurseries establishes that households planted trees to increase the supply of fuelwood checking on the problem of scarcity. It was also established from the study that 57.3% of the respondents who had tree nurseries sold these seedlings to people within Central Kabras Location and Kabras Division. The average cost of each seedling was Kshs.5 with variations in price depending on the type of tree species. Cypress was at Kshs. 2 per seedling, eucalyptus was Kshs. 5 per seedling and a pine seedling at Kshs. 3 each. The eucalyptus seedling was more expensive because of the wood valuable timber and its nature of regeneration. The source seeds planted in nurseries were obtained from mature trees (94.2%), market (3.9%) and the Forest Department (3.9%).

The respondents (12.9%) who did not own tree nurseries bought the seedlings from the forest department (Malava forest) and Butali market. This shows that despite the fact that people were near the forest department where they could obtain seeds and/or seedlings, cheaply or free, they did not make use of it.

It was established that the District Extension Forest Officer's office could not offer extension services to farmers to improve on own farm forestry due to inadequate staffing and lack of field vehicles. This explains why only 10% of the respondents practice agroforestry and which can also explain why 84.3% of the exotic species grown are eucalyptus and cypress/pines, which cannot be planted on the same parcel with crops. Only 5.7% of the respondents were visited by extension officers and given advice on farm forestry.

4.5.2 Energy Consumption Patterns

The study revealed that there was over dependence on limited forms of energy for cooking (Table 4.10).

Table 4.10 Energy for Cooking

Type	Percentage
Fuelwood	90.0
Charcoal and Fuelwood	5.7
Kerosene and charcoal	2.9
Fuelwood and others	1.4
Total	**100.0**

(Source: Field Survey, 2000)

Fuelwood accounts for 90% of energy used for cooking. When combined with charcoal and kerosene then the proportion rises to 97.1%. There are various reasons to account for this phenomenon. Fuelwood was perceived as a free commodity that could be

obtained at very minimal if any, costs in terms of money and time spend in its procurement. But in reality it was not free as respondents bought fuelwood or paid Kshs. 37 per month to collect fuelwood from the forest (sub section 4.5.1.1). According to the study a number of hours were spent to collect fuelwood either from on-farm, neighbour's farm or the forest.

Table 4.11 Time taken to collect Fuelwood

Time in hours	Percentage
<1	55.6
1.01-3.00	24.0
3.01-5.00	18.5
>5	1.9
Total	**100.0**

(Source: Field Survey, 2000)

According to Table 4.11, the majority of the respondents (55.6%) who depended on-farm source of fuelwood took less than one hour since it was easily available. There 20.4% of the respondents took more than three hours to collect fuelwood from the forest. The time taken procure fuelwood had increased compared to 20 years ago when woodfuel was relatively abundant. On the other hand 24% of the respondents took one to three hours to collect fuelwood depending on the source whether it from the farm, the market or the neighbours' farm.

The dependence on fuelwood was as a consequence of income levels for example, the lowest income is Kshs. 300 that cannot enable the household to afford alternative source of energy such as kerosene or biogas. In this regard the cheapest kerosene stove costs Kshs. 400 and the kerosene to be used to cook the meals has yet to be bought. This becomes expensive for such households thus relied heavily on fuelwood. Consequently

the use of any form of fuel, type, its quality, and quantity for cooking dependent on income of the consumers.

(a) Cooking Systems

According to the field study, there are various modes of cooking stoves that are used by people in Central Kabras Location ranging from the traditional three stone hearth to modern gas cookers (Table 4.12).

Table 4.12 Type of Cooking Stoves

Type	Number	Percentage
Three stone hearth	44	62.9
Three stone hearth and Ordinary (metal) *jiko*	19	27.1
Energy saving *jiko* and kerosene stove	2	2.9
Three stone hearth and other combinations	5	7.1
Total	**70**	**100.0**

(Source: Field Survey, 2000)

Table 4.12, shows the type of cooking stoves used by respondents in the study area. There were 62.9% of the respondents used only the three stone hearth, however in total 97.1% used the three stone hearth stove for cooking their meals (Plate 11). Furthermore, the wood saving stoves were used by 7.1% of the respondents (Plate 12).

Plate 11: The traditional three stone hearth cooking stove that uses more fuelwood. Notice the type of cooking utensils and ploughing instrument (on the right).

Plate 12: A traditional charcoal kiln constructed in the homestead for household needs.

The three stone hearth cooking stove is preferred because first it is cultural to own one. Second, its flexibility to accommodate *sufurias* and pots of all sizes when need arose depended on the number of to be cooked for. Third, they are cheap to construct because it is made from soil and does not cost money, but what is needed is time, soil and

labour. Any body (male and female alike) knew how to construct them. Fourth, the respondents it argued that the three stone hearth served various uses at the same time such that cooking can go on at the same time there is space heating, the heat and smoke that is omitted from the fire place help dry fuelwood on the *inungo* and preserve the building materials of grass thatched houses. Despite the advantages of three stone hearth stoves cooking, it is a wasteful stove having a conversion ratio of only 10% while the remaining 90% is lost or wasted.

Due to the fact that 71.4% who used fuelwood used crop residues such as maize cobs, maize stalks, dry cassava sticks and dry pieces of sugar cane as well. This showed a symptom of fuelwood shortage as well as a decline in soil fertility (these crop residues like maize cobs and stalks were supposed to rot on the farm to produce farm manure that enriched the soils. This also implied that meals more not properly cooked, as the flame was not strong enough.

There is need to promote energy efficiency methods so that the households can save more fuel wood for tomorrow. The ordinary metal charcoal *jiko* is used by 34.3% of the households have low energy efficiency, with a conversion level of 4.8%. There is need to improve on these by using energy saving charcoal *jiko* (Kenya ceramic *jiko*) used by only 10% of the respondents.

The study realized that 95.7% of the respondents depended on kerosene, 1.4% use solar, and 2.9% on kerosene and fuelwood (especially maize stalks and wood sticks) for

lighting. But in total 98.7% used depended on kerosene for lighting purposes. Space heating was another energy end-use whereby 38.6% of the respondents used fuelwood whereas 20% used charcoal. As noted before, cooking and space heating took place concurrently.

(b) Dietary Systems and Cooking Utensils

The energy consumption patterns of the people of Central Kabras Location should be looked at besides their dietary patterns (table 4.13). The types of meals cooked for breakfast lunch and supper had implications on fuelwood requirements.

During breakfast tea was cooked by 84.9% of the respondents. Tea was preferred as it cooked faster than sweet potatoes or maize and beans. The respondents had a high preference for tea with either sweet potatoes (41.7%) or maize and beans (2.9%) so that lunch was forgone, in other words to them breakfast served two purposes of breakfast and lunch. This meant that they saved on fuelwood to be used for cooking lunch. Porridge *(wimbi)* was prepared for breakfast by 10% of the respondents. Porridge was nutritious and was prepared for both the adults and the children, and because it took about 30 minutes thus saving on time and fuelwood compared to a families who prepared tea and sweet potatoes.

4.13 Types of Meals Prepared

f Day	Type of meal	Percentage
ast	Tea/cocoa/coffee	
	Porridge	
	Tea and sweet potatoes	
	Tea and maize plus beans	
	Others	
	Total	
	Sweet potatoes	
	Ugali and vegetables	
	Maize and beans	
	Others	
er	**Total**	
	Ugali and vegetables/meat	
	Sweet potatoes	
	Others	
	Total	

rce: Field Survey, 2000)

e were a variety of meals cooked for lunch by 87.1% of the

et potatoes (52.3%) a stable food in the area (sweet potat

sehold). They took a shorter time (one hour) to cook compar

%) that took at least four hours. *Ugali* and vegetables (

hours to cook for lunch was not prepared by 12.9% of the

nbined breakfast and lunch to save on fuel. During supper

% compared to 39.3% at lunchtime because it took less time

avy meal since people went to the farm before breakfast day

tatoes (appeared at every lunch and supper time) among

ne and consumed less fuelwood to cook.

he research established that maize and beans *(mayenchela)* was

a month because of its demand on time and fuelwood. It

uelwood so that they cooked until they were soft, but the

crop residues could not cook this meal and if they did this would require a whole night or day attending to fire.

The time taken and amount of fuelwood consumed in preparing meals also depended on the types of utensils used. It was noted that 11.4% households used only *sufurias* while 88.6% used both *sufurias* and pots (Plate 11). Meals such as sweet potatoes, maize and beans, vegetables were cooked in pots as cooked fast when heat concentrated in the pot, the food cooked faster than on *sufurias*. The people in the study area see pots as a way of conserving fuelwood while cooking. It should be noted that in preparing energy policies on woodfuel there is need to indicate the utensils to be used, so as to conserve on the available woodfuel resources.

(c) Shortcoming of the Cooking System

According to the field study (table 4.14) there were problems faced by the women in the kitchen that included, the use of fuelwood in the inefficient three hearth cooking stove (97.1%)and the energy saving woodstove (2.9%) without a chimney (Plates 10 and 11). This led to high levels of indoor pollution in the kitchens. Smoke was a major pollutant that caused eye irritation and respiratory afflictions.

Table 4.14 Problems Experienced in the Kitchen

Problem	Percentage
Smoke	50.0
Heat and smoke	7.1
Smoke, heat, attending to fire	8.6
Smoke, heat attending to fire and safety	11.4
Smoke, heat and attending to fire	18.6
Safety	1.4
Others	2.9
Total	**100.0**

(Source: Field Survey, 2000)

The table 4.14, indicates that smoke accounts for 50% on its own as a problem, but in total it ranks first with 95.7% of the respondents complaining. Smoke was caused by use of wet or green fuelwood especially during the rainy season and the wood stoves were open without chimneys.

According to the study, 90% of the kitchens had small round windows whereas 10% had no windows thus smoke could only get away through the door. Still the 2.9% of the respondents who used charcoal stoves also experienced the smoke problem due to the use of traditional kiln in conversion of wood to charcoal. The second important problem was heat experienced by 45.7% of the respondents due to the open nature of the fireplace. Lack of safety (12.8%) in the kitchen especially to young children who could easily sustain burns. Attending to fire was a problem experienced by 38.6% of the respondents because of use of small twigs and crop residues that burn faster like paper, therefore one has to sit by the fireplace to attend to fire until the food is cooked. Other kitchen problems (2.9%) included lack of adequate fuelwood etc.

These problems imply that there is need to use fuelwood efficiently to reduce scarcity and the use of appropriate technology (stoves with chimneys and modern kilns) to avoid smoke problem. The kitchens should be properly ventilated with two or more large windows.

4.6 Peoples' Perception of the Woodfuel Problem

This sub section discuss what viewed people as the woodfuel problem on their farms and the solutions to this problem. People's perception on this problem would not be quantified but knowing what the problem was supportive or important in preparing woodfuel policies that affected the rural areas.

The woodfuel problems experienced by 88% of the respondents in the study area were manifested in a number of ways (Table 4.15) when compared to 20 years ago.

Table 4.15 Community's Opinion of the Fuelwood Problem

Problem	Percentage
Time taken to collect fuelwood	11.3
Fuelwood is expensive	22.8
Forest restrictions (Malava)	17.1
Fuelwood is scarce	26.8
No problem	12.0
Others	1.4
Non-replacement of trees cut down	8.6
Total	**100.0**

(Source: Field Survey, 2000)

The first group of respondents (11.3%) viewed fuelwood problem in terms of time taken to collect this resource whether farm or forest or neighbour's farm. In this case, they used more than five hours to get enough for a day time which the collectors would use a doing other duties in the home.

The second group of respondents (22.8%) bought fuelwood and found it expensive yet the purchased fuelwood did not last longer. The third group 17.1% of the respondents collected fuelwood from the Malava Forest found that the Government restrictions a problem in procuring fuelwood since one had to pay for that service. The fourth group

(26.8%) saw the problem of woodfuel in terms of scarcity. This resource was scarce and not sufficient for cooking purposes. Due to scarcity of fuelwood and time spend in collection led to commodification of this resource thus making it expensive. The fifth group of respondents viewed fuelwood problem in terms of non-replacement of trees cut down for fuel, timber or building materials etc. This group felt that if every individual replaced the cut down trees without gender discrimination then there would be no problem. The last group accounted for 12% of the respondents did not have fuelwood problem as such did not practice energy conservation measures as they had enough.

In terms of supply enhancement and demand management the solutions / suggestions to the above fuel problems were given by the respondents as follows. As regards supply enhancement this meant the increase of the amount of energy resources (i.e. fuelwood, kerosene, electricity etc) to the household.

On demand management, 85.7% of the respondents were aware about energy conservation but only 23% suggested that this would supplemented by supply enhancement to solve the woodfuel problem. Fuelwood was viewed as a fuel that would continue being used by future generations whether in form of charcoal or fuelwood thus 31.1% advocated for planting more trees either on cropland (agroforestry) or woodlot.

The study area is among the rural areas not supplied with electricity through the rural electrification programme therefore, 32.9% of the respondents suggested that if the area was served with electricity from the national the forest and on-farm sources of fuelwood would be saved from depletion. Others saw the development of solar energy (4.3%) and biogas (2.9%) as a solution to this problem, while 7.1% suggested that liquid petroleum gas (LPG) should be an alternative to solve these problems. Another group, 13% of the respondents suggested that the government was to create employment opportunities for the unemployed that would enable them to buy fuelwood or adopt the alternatives energy sources other than fuelwood. With supply electricity *jua kali* activities such as welding would absorb the unemployed youths. Looking at the alternative energy sources such as electricity not supplied at all in Central Kabras Location, biogas is not developed, solar used by 1.4% of the respondents and liquid petroleum gas used by 2.9%. As far as this issue is concerned it creates ground for creating awareness for the community to venture into alternative energy sources and also conserve the available wood resources by practicing energy conservation measures.

In summary, in reference to sub-section 4.3.4, the problems experienced on households farms, in trying to solve the woodfuel scarcity, there is need to consider the problems of low productivity from agriculture, poor roads, marketing and financial poverty in order to empower them and conserve the environment because poverty is one of the causes of environmental degradation.

CHAPTER 5: RECOMMENDATIONS AND CONCLUSIONS

5.1 Overview

The recommendations and conclusions in this chapter are based on the synthesis of findings in the preceding chapters that were concerned with study problem; literature review on causes of woodfuel scarcity and Kenyan energy policy; the physical and human characteristics of the study area and the fuelwood situation in Central Kabras Location that revealed the physical, socio-cultural and economic aspects of energy indicators.

5.2 Synthesis

The study set out to examine the energy production (supply) and consumption (demand) patterns in Central Kabras location (that is to investigate the woodfuel problem), to investigate the energy options or alternatives used, and to make policy recommendations on appropriate energy options in the study area.

In an attempt to meet these objectives, the socio-economic data on age, incomes, household size, land uses, land sizes and cultural attributes was investigated and analysed. People's perception of woodfuel problem was collected. The data analysed to cater for the second objectives was on supply enhancement such as where trees are planted and their purpose, sources of seedlings, the amount of energy consumed for meal preparation, types of meals prepared, and aspects of fuelwood conservation. The third objective was answered by the data on types of energy sources consumed and what

the local people felt would be the best option for them within their physical environment.

It was established that the economic base of the study area is weak as manifested in employment patterns (22.9% were formally employed), low household incomes, the agricultural practices, small land/farm sizes and large household sizes (average 6.7 persons).

The people in study area depend mainly on fuelwood for all their domestic energy requirements especially for cooking. Kerosene was dominantly used for lighting. In addition, charcoal was used for cooking and heating. The over dependence on fuelwood for cooking in comparison to other sources is due to its abundant existence and accessibility relative to those energy sources especially on financial / cost considerations.

Community's perception of woodfuel problem was gauged in terms of scarcity, expense and time taken to collect fuelwood. One of the major causes of inadequacy (scarcity) was due to rapid population increase that led to increased sub-division of household landholdings hence reduction of acreage under on farm forestry leading to decline to the area under woody biomass. Sub-division of land in combination with privatisation of land (non existence of communal land) had exacerbated the problem. People also cut down trees without replacement. Another major cause of scarcity is over dependence

on woodfuel as the major source of energy for cooking and use of a simple but very wasteful technology – three-stone hearth (open fire).

As regards policy formulation and implementation, the study established that there were no extension services from the government departments for example, 94.3% of the households had not visited to be advised on agroforestry and / or appropriate tree species to be planted by extension officers from Ministries of Agriculture, Forestry and Energy for the last one year. Thus caused a problem in the implementation of energy policies in general and woodfuel in particular.

The study also established that despite the proximity to a resource base (Malava Forest) scarcity still prevailed at household level. Accessibility was hindered by the forest restrictions and a monthly fee that was to be paid which some households could not afford as the problem is pronounced due low income.

It was also established that provisions for tree planting and social/farm forestry to support sustainable fuelwood supply at a communal and household level were extremely low. The people did not make use of the forest department services in the area to plant more trees in general or even get involved in agroforestry practices in particular. This because people perceived that fuelwood was a free commodity from the environment and did not require the services of the Forest Department

Fuelwood as a use of trees was secondary to building materials and cash. The number of trees planted depended on the household farm size. Income levels to a certain degree had major influence in this respect. Those who had large land sizes and high-income levels were able to acquire seedlings for planting and commit more land to tree planting. It was also found out that the tree species (eucalyptus and cypress) were the more popular exotic species planted on the farms which actually adversely affected the soil structure and fertility. Many households planted the trees on hedges, which was not sustainable system of supply of fuelwood.

The study also established that the head of households made vital decisions on fuelwood especially in tree planting on the farm. Men were the main decision makers since women were not allowed to plant trees, as they did not own the land that was a drawback for the supply of adequate woodfuel. This means that women should be empowered by being issued with title deeds and employment in the formal sector to enable them make decisions on the of land and also be able to purchase their requirements. Secondly from the household survey and focused group discussions women had no access to land and its resources especially trees as they belong to the man. With cash crop economy - sugar cane - land was committed to sugar cane growing to earn income spend on education, clothing, food and other family needs. But at the same time, it was found out that in many cases men had other personal priorities, which did not contribute to the enhancement of woodfuel supplies.

5.3 Emerging Issues

It was established that the road network and condition was poor which constrain efficient marketing of agricultural produce and reduced the chances of diversification of energy sources (alternative sources). To solve the marketing problems farmers thought they should form a co-operative which would market the farm products and also offer credit facilities to improve farm productivity which were lacking for the farmers except those who were in formal employment.

Another issue was lack of awareness of energy-saving techniques whereby 84.3% were not aware while the 15.7% who were aware only 14.3% had the energy saving charcoal stoves. There is a high percentage (84.3%) of people not aware of energy saving techniques because the location does not have any Maendeleo ya Wanawake, youth groups or similar public education groups for it is from such groups that awareness can be created. Supply enhancement on-farm forestry is seen as the only way to solving woodfuel problems. Wood fuel can be planted on the available space on the cropland (agroforestry), woodlot and also along hedges.

The supply of electricity through the rural electrification programme (REP) in the study area would relieve over dependence on fuelwood, promote the development of industries to process sweet potatoes as they are planted by every household in the location as there is a ready market within and out side the study area. This would lead to availability of employment opportunities thus raising the living levels of the people. As regards the provision of electricity the people will have to coordinate with the

Ministry of Energy (policy-makers) and the Kenya Power and Lighting Company (the distributors)

In regards of the above findings we realize that the availability and use of traditional fuels (fuelwood) are tightly intertwined with the village economy and social structure. Thus rural energy sources should be seen as an integral portion of the rural system. In that it was established the bottom line for the whole scenario is that woodfuel is major source of domestic energy and is bound to remain the same in the future in the rural areas. Therefore appropriate intervention approaches are required towards supply enhancement and demand management for fuelwood as a source of energy.

5.4 Recommendations

5.4.1 Overview

The study established that over time, there has been through major shifts as concerns the energy situation in the study area. First there has been a steady transition from over abundance to severe shortage of fuelwood. This situation is now approaching a crisis level. This calls for policy approaches with solutions that may be tailor made for study area for effective implementation. Secondly, there has been a shift from complete reliance on traditional fuels (i.e. fuelwood) to other modern fuels (kerosene). The implications are that any policy approach must incorporate a strong element of rural development opportunities and increased income in general and kerosene in particular.

In short, there is a real need to evolve rural energy strategies that not only focus on fuelwood but also looks at other viable alternatives such as biogas and solar energy. The rural energy policies should be local areas specific as wood fuel problems vary from one local area to another, depending on the physical environment, socio economic and cultural characteristics. In that respect, the formulated energy policy should aim to achieve optimum energy use by influencing production (supply) and consumption (demand) patterns using demand management and supply enhancement strategies. Emphasis on participation and institutional development (family and government levels) can improve the wood fuel problem and the recognition of the central role of good enabling conditions for development. The recommended solutions to the over-reliance on woodfuel can be divided into short term and long term intervention approaches (measures).

5.4.2 Short term Energy intervention approaches

5.4.2.1 Woodfuel Management

Woodfuel management approaches should be the first steps to be undertaken by any community faced with shortages. Thus energy conservation can be encouraged through the promotion of efficient use of woodfuel. This can be attained in the following ways:

1. Improvement on the cooking stoves.

The three stone hearth mode of cooking should be replaced by an improved stove (such as *kuni mbili*) design that 'fit the cook'. These improved cooking stoves should be

designed to fit in the local building structures, portable and stable. These improved jikos should have the following characteristics:

- Offer a good match with the present cooking patterns such as cooking functions; size and space or portability, range of fuels and cooking utensils;
- Save time on fuel collection, cleaning pots and kitchen due to smoke etc;
- Be more fuel efficient that is use less fuelwood;
- Reduce smoke and accidental burns;
- Reduce maintenance and have a long time i.e. use the available local materials for repair and construction; and
- Act, in development - oriented programmes, as a vehicle for giving women greater confidence in their ability to improve life for themselves and children.

In this regard, energy planners should remember that the improved stoves are to be used by people with low incomes (the poor) therefore there is a paramount need for the designing of efficient, environmentally sound, socially and economically acceptable by the local people. The improved wood stoves for that matter should be simple to operate, cheap, be fast in cooking and also fulfil all or some of the roles of the three stone hearth stove that is be able to heat and light the house concurrently.

This is also calls for promotional / educational programmes on energy conserving cooking styles which will involve research, training and dissemination of information of energy-saving wood and charcoal stoves. This function can be carried by energy

conversion technology centres. These centres should be at all levels of administration particularly at village and sub locational levels.

2. Efficient Energy use in cooking

Cooking methods/practices that are less fuel consuming should be adopted such as:

- Soaking foods that take longer to cook such as maize and beans to reduce the required cooking time;
- Using appropriate devices, that is the utensils used foodstuffs such as maize and beans that take longer to cook should be cooked in earth pots while fast cooking meals such as tea, rice, etc should be cooked in *sufurias* (aluminium pots)
- Covering pots with well fitting lids to contain heat and water making cooking take shorter time or faster.
- Using dry wood while cooking to avoid energy waste.
- Putting out embers and banking fire and reclaiming charcoal after use to conserve on energy consumption.

5.4.2.2 Woodfuel Supply Enhancement

This is the most unavoidable approach to increasing supply of woodfuel through the process of tree planting. Tree planting will have to be incorporated in the existing land uses in order to alleviate the wood fuel problem now and in future. This can be done through the practice of farm forestry in form agroforestry and woodlots.

1. Agroforestry

It entails planting trees shrubs and grasses (nappier) on farmlands or croplands in alternating patterns with crops, which has been identified as an appropriate way to increase fuelwood supplies without taking up scarce land or seriously disrupting existing patterns of production. It is also essential that the range of products created reflects people's needs and that the demands of the crops and the trees reflect both the local environmental potential and availability of family labour. The practice of agroforestry should be encouraged through research and public education. People, through the help of the extension officers attached to the area should be educated on the subject (agroforestry) inclusive of the tree species that can do well and take a shorter time to mature such as *sesbania, leucaena, calliandra* and *mimosa* species. The importance of inter-cropping trees and crops are: -

- Maintaining soil fertility e.g. leguminous species *leucaena* are nitrogen fixers and take a short time to mature and also sprout after cutting;
- Assisting in alleviation of woodfuel shortages on the farm;
- Provision of poles for construction, fruits and environmental protection; and
- Trees also provide leaves for animal fodder and mulch to protect the soils.

In essence, the trees to be planted should be fast growing and be multi-purpose providing fodder, mulch fuelwood, improve soil structure and fertility, and building and construction materials.

2. Woodlots

We should note that agroforestry is very important and suitable where land sizes are less than one acre, but all households in the study area should practice it. Woodlot creation is another form of farm forestry for those with large land parcels. Both tree species used in agroforestry and others such as eucalyptus can be planted in a part or section of the land. They can serve the purposes of fuelwood, building materials and timber.

5.4.2.3 Institutional Development and Community Participation

This should be emphasized for success of rural energy policies. The government has good policies but they have not been fully implemented. The study realized that the Ministry of Energy was not represented (like the other ministries) at the provincial and district levels. This meant that the woodfuel policies were to be implemented by the other departments (like forest) who laid emphasis on their own policy programmes and projects. Therefore it is being proposed that the Ministry of Energy should devolve responsibilities to the lower administrative levels. Furthermore, the roles of the Ministry of Agriculture and Rural Development and the Forest Department as regards rural energy should be properly defined and well co-ordinated with the role of Ministry of Energy in the respect.

Participation of individuals in communities is crucial for the success of rural energy policies. The people should first understand their problem of fuel wood and then what they can do to solve this problem participation should involve the government organisations, non-government organisations and local community organisations which

are highly effective vehicles in supporting energy service delivery. Participation in the development of wood stoves programmes by women is another success as they are the collectors and users of fuelwood.

5.4.2.4 Extension Services

It should be seen in both short and long terms in solving the woodfuel problem. It was realised that there were virtually no extension services, training and education programmes for people in Central Kabras location. To make extension service effective there should be:

- Decentralization of regional energy centres from the national level to the district / division levels to promote the training and research in appropriate tree species and to spread agroforestry practices in the rural areas.
- Integration of energy related organizations that are ready to work with local community in the rural areas such as non-governmental organizations.

5.5 Long term Energy Intervention Approaches

In planning for rural energy needs, alternative sources as electricity, biogas and solar should be incorporated in the plans so that the wood resources are not over stretched. Since the policies are made at high (national) level they should be well defined, including how they can be achieved at lower administrative levels such as the district and divisional levels.

The long-term intervention measures to be undertaken should be geared towards the diversification of the energy sources. The government and the local community should encourage the transition away from woodfuel, with such a shift being in the general development of rural areas.

The study established that only 22.9% households utilised alternative energy sources (kerosene, 12.9% and LPG, 10%) for cooking purposes. These were used mainly for lighting and cooking urgent meals such as tea. The other alternative sources such as electricity and biogas were non-existent in the study area while solar (1.4%) was used for lighting. The government should subsidize the prices of these sources so that they are affordable by the rural population. People in the study area were aware of these alternative sources but were constrained by economic reasons (70%) with incomes less than Kshs. 5000. The socio economic constraints were seen as major hindrance to fuel switching. The alternative energy sources recommended would be consumed by those who could afford them so as to relieve strain on the woodfuel resources. These alternative sources of energy are: -

1. Solar

Apart from installation costs, solar energy is abundant and the potential to utilize it in the study area is plausible. It should be enhanced for lighting, heating and cooking. Solar cookers are boxes fitted with a reflector and the cooking pot is placed inside the box. For this to be used there is need for research to be done on how this technology can be used indoors and how the panels can be fitted on the grass-thatched roofs with

precautions to avoid fire hazards (we should also note that 31.4% of the households interviewed had grass thatched roofs).

Sunlight on the other hand can be converted directly in to electricity by use of photovoltaic cells. The electricity is produced during the day and stored in batteries to produce light at night.

Through harnessing solar energy for cooking and lighting, it will go a long way in reducing the wood fuel demand/consumption deficit. With increased awareness of depletion of the other sources of renewable energy sources (fossil fuel reserves) and the price increases, solar energy being free remains the most viable long term solution to rural energy needs.

The advantages of solar electric systems over alternative electricity sources include: -

- The initial cost of solar electric system (SES) is less than a generator or grid electricity connection.
- Solar cells use no fuel. Because they are no recurring fuel expenses, solar electric systems are often cheaper than the paraffin (Table 5.1), dry cells, generators and centrally recharged lead-acid battery alternative when valued in terms money over time.
- Solar electric systems are modular and relatively simple. This means that they can be built up a piece at a time if necessary. For example, schools without enough money to install power throughout the compound can be done in phases

first install in the classroom block and expand to other blocks such as the laboratories, work shops etc when funds are available.

Table 5.1: Costs of Lighting a room: Paraffin versus Solar Electricity

Energy source	Paraffin	Solar Electricity
Equipment required	Pressure Lamp, mantles and fuel.	'Neste Magic Lantern' ▪ 6Wp module ▪ lead acid battery ▪ 7 watt lamp ▪ mount
First cost	US $30 (Kshs.2400)	US $160 all equipment
Annual recurrent	US $60-100 per year	US $20 per year Battery/tube replacements
Total outlay after 3 years	US $210-330	US $240

(Source: Marchaim, 1992)

However, according to Table 5.1 the solar electric system has attractive benefits. First, it has a longer life span than the pressure lamp. Secondly, in the event of prices rising or shortages, the solar electric systems will not be affected. Thirdly, the fluorescent tube lamp does not produce soot, smoke, or glare, as does the pressure lamp. The electric lamp can be turned on with the flick of a switch, instead of the more tedious process of lighting a pressure lamp. Since the advantages of the solar electric systems outweigh those of installation of electricity for domestic use the solar energy should be encouraged and / or developed to reduce over reliance on both paraffin / kerosene.

2. Biogas

The potential for biogas production is based on the ownership of livestock (cattle, goats, sheep, donkeys etc). The study established that 91.4% owned livestock and thus the dung produced and other farm wastes such as grass, household food left overs and wet agricultural residues could be used to generate gas (biogas) that could be utilized for cooking and lighting. Each household that can afford to generate their own gas should

be encouraged thus reducing over dependence on fuel wood. In this case, the extension services are required to assist households develop this technology. Demonstration farms at the village level for training purpose would enhance and encourage the use of biogas.

Biogas technology in the long run is potential to bring an economically viable solution to the following problems: -

- Dependence on imported sources of energy.
- Deforestation which leads to soil erosion and therefore to a drop in agricultural productivity.
- Providing inexpensive fertilisers to increase food production. The biogas production from organic not only produces energy but also preserves nutrients, which can be recycled back on the form of slurry. It is a conditioner and also provides humus to the soil.
- The disposal of sanitary wastes, which cause severe public health problems and disposal of industrial wastes that cause pollution. The digestion of wastes can reduce the parasitic and pathogenic bacterial counts by 90% breaking the vicious cycle re-infections via water (drinking) that is not treated in rural areas.

Just like solar energy, biogas technology has not realised its full potential for energy production in less developed countries (Kenya included) as the biogas programme are hindered by (i) operational difficulties, (ii) the need for better economic initiatives (iii)

organised supervision and initial financial costs, and (iv) readily available and inexpensive non-commercial fuels such as fuelwood.

3. Electricity

Rural electrification programmes running country wide should be enhanced in the study area so that those who can afford to pay for the service (electricity) can use it thus lessen the over reliance on woodfuel.

In addition to the above specific energy diversification approaches, other general policies can be included in the package as a part of long term strategies. These include farm management systems, cultural/gender rural development.

4. Farm Management System

Although agroforestry and woodlots were included under short-term intervention measures, tree planting, as a part of cash crop farming should be promoted in rural areas. This should include fast growing tree species in order to complete with food crops and cash crops.

5. Cultural and Gender Concerns

There should be concerted effort in public education and awareness as applies to cultural values on the use of cultural values on the use of family land to promote fuelwood production. In relation to the family institution decision-making, uses and accessibility to land resources should be harmonized among husbands and wives. This

will reduce conflicts on who plants, uses and owns the trees on land. The harmonization on decision making can lead to increased on-farm fuelwood production as the females will have access to land resources and at the same time can influence decisions particularly on the need to plant trees particularly for fuelwood.

6. Community Access to Malava Forest

At present, the community has access to products of Malava Forest through monthly payments for wood harvesting or through the "shamba" system. In order for the community to identify with this natural resource more, it is proposed that the Forest Department leases the community a part of the forest land for tree planting after creating awareness among people. The community should form a co-operative which will manage a part of their leased products on scientific basis and its products could be sold at market rates or value to members of the community or to outsiders. As such the Forest Department Officers become advisers to the community on technical issues, planning and management rather than enforcers of protective rules and at the same time the community will use the natural resource to generate employment and increase incomes.

7. Rural Development

From the study, it was found out that one of the main problems in the study area is unemployment, low levels of incomes and general underdevelopment. In fact, it is due to these factors in combination with others that have led to energy shortage in general and fuelwood scarcity in particular leading to environmental degradation. Therefore,

there is need to promote rural development through co-operatives to market agricultural products, rural industrialization by, for example, agro-based and small scale industries *("Jua-kali")* and through improvement of rural communication (rural access roads). Rural electrification should be a component of this strategy especially as it applies to industrialization. In this regard, planning for rural energy needs, including fuelwood should be seen as part of planning for rural development.

5.6 Conclusion

The study set out to investigate the woodfuel problem in Central Kabras Location and it established that the fuelwood problem was perceived in terms of the time taken to procure the resource; non-replacement of cut down trees; the restrictions by the Forest Department; the scarcity of fuelwood; and the cost of purchasing fuelwood. The fuelwood problem was caused by increasing population, that led to land sub division, socio-cultural factors, poor methods of fuelwood conversion and increased need of land for agriculture and settlement.

In regard to the physical and human characteristics prevailing in the study area, the recommendations are area specific to address the energy problems as well as rural development issues. The recommendations include woodfuel management to ensure efficient use of fuelwood, increase in production and energy mix. The Ministry of Energy and the relevant departments should ensure the implementation of energy policies to ease the woodfuel problems in the rural areas. This can be achieved through participation of the rural community in managing the resource base of Malava Forest.

However, it was also established that the socio cultural factors determined decision-making structure within the household where the women had limited accessibility to the tree resources. The study recommends that both parties (men and women) should discuss so as to ensure that men participate in woodfuel production and solve the conflict over tree ownership and use on the farm. All in all the intervention approaches or measures should supplement one another so that the different groups in the study area can adopt either or a combination of these approaches depending on the household resource endowments so as relieve over dependence on woodfuel.

5.7 Areas for further research

It was established that further research should be carried out in the following listed topical areas in an effort to fully tackle the problem of energy in the rural areas. These are:

1. The role gender (women) in woodfuel production. How does the traditional institutional arrangement influence this role?
2. The need to find out impacts of installation of electricity in the study area on incomes and development of alternative sources of energy.

BIBLIOGRAPHY

Barness C. et al (1984) **Wood, Energy and Households: Perspective on Rural Kenya.** Beijer Institute of African Studies, Uppsala.

Bhagavan, M.R. (ed.) (1996): **Energy Utilities and Institutions in Africa.** Zed Books Limited, London.

Chavangi, N. (1991): *So Firewood can Wreck a Home? Working with Sensitive Issues at a Community Level* in **Forests, Trees and People**, Newsletter No. 14, Oct. 1991. Swedish University of Agricultural Science, Uppsala. (Page 16-23).

de Lucia, R. J. and Jacobs, H. D. (1982): **Energy Planning for Developing Countries: A Study of Bangladesh.** John Hopkins University Press, Baltimore.

Eckholm, E. et al (1984): **Fuelwood, the Crisis that Won't Go Away.** IIED. Washington D. C

GTZ – SEP (1985): **Background, Current Activities Outlook the Future.** GTZ-SEP, Nairobi.

Hall, D. O et al (1982) **Biomass for Energy in the Developing Countries: Current Role, Potential, Problems and Prospects.** Pergamon Press, London.

Haugeraud, A. (1980): **Economy Ecology and Fuelwood Scarcity in Embu.** Unpublished Paper.

Hosier, R. (1985): **Energy in Rural Kenya: Household Demand and Rural Transformation.** Beijer Institute of African Studies, Uppsala.

Jaetzold, R. and Schmidt, H. (1982): **Farm Management Handbook of Kenya: National Conditions and Farm Management Information, Vol.II/A.** Ministry of Agriculture, Nairobi.

Kagambe, D. (1976): **Aspects of Resource Conservation: The Role of Charcoal Industry in the Kenyan Economy.** I.D.S. University of Nairobi, Nairobi.

K'omudho, B. O (1995): *Kenya's Policy on Environment and Development: Focusing on Afforestation* in Atchia, M. and Tropp, S. **Environmental Management: Issues and Solutions.** John Wiley and Sons Limited, London. (Page 117-120).

Karekezi, S. and Mackenzie G. A, (1993): **Energy options for Africa: Environmental Sustainable Alternatives.** Zed Books Limited, London.

Kenya, Republic of (1974): **National Development Plan (1974-1978).** Government Printers, Nairobi.

Kenya, Republic of (1979): **National Development Plan 1979-1983.** Government Printers, Nairobi.

Kenya, Republic of (1983): **National Development Plan (1988-89)** Government Printers, Nairobi.

Kenya, Republic of (1986): **Sessional Paper No. 1: Economic Management for Renewed Growth.** Government Printers, Nairobi.

Kenya, Republic of (1987): **National Energy Policy and Investment Plan.** Government Printers, Nairobi.

Kenya, Republic of (1997a): **National Development Plan, 1997-2001.** Government Printers, Nairobi.

Kenya, Republic of (1997b): **Kakamega District Development Plan (1997-2001).** Government Printers, Nairobi.

Kenya, Republic of (2000): **National Population Census, 1999 Vol. 1.** Government Printers, Nairobi.

Khamanti, B. (1995) *The Environmental consequences of Energy Production, Energy Transmission and Energy use* in Atchia, M and Tropp, S: **Environmental Management: Issues and Solutions.** John Willey and Sons Limited, London. (Page 91-96).

Leach, G. and Mearns, R. (1988): **Beyond the Woodfuel Crisis: People, Land and Trees in Africa.** Earthscan Publications Limited, London.

Marchaim, U. (1992): **Biogas Processes for Sustainable Development.** Food and Agriculture Organisation of United Nations, Rome.

Mildeberger, E (1986): **Women and Household Energy in Murang'a District.** MYWO/GTZ unpublished Report.

Mugo, F. W (1989): **Woodfuel Demand and supply in a Rural sets up: A case of Naitiri Location in Bungoma District.** Unpublished MA Thesis, University of Nairobi, Nairobi.

Munslow, B et al (1988): **The Fuelwood Trap: A study of the SADC Region.** Earthscan Publications Limited, London

Musoga, H. (1988): **The Rural Energy Problem: A Case Study of Woodfuel in Shiswa Sub Location, Kakamega District.** Unpublished MA Thesis, University of Nairobi, Nairobi.

Mwenda, G.K. (1992): **Energy Problems in Rural Kenya: An Examination of Causes and Effects of Woodfuel Scarcity in South Imenti,** Meru District. Unpublished MA Thesis, University of Nairobi, Nairobi.

Ngugi, G. (1990): **The Effects of Population on the Environment: The Fuelwood Crisis in Mai-ai-ihaii Village, Kiambu District.** A Paper presented to KENGO's Environment 2000 Conference, Nairobi. 23rd – 26th October 1990.

Nyang, F. O. (1999): **Household Energy Demand and Environmental Management in Kenya.** University of Amsterdam, Netherlands.

Nyoike, P. M. and Okech, B.A. (1980): *Rationality of Kenyan Energy Demand Management* in **African Energy: Issues in Planning and Practice** by AFREPREN. Zed Books Limited, London.

Ochanda, N. (1987): **Land Use in Kakamega District.** Ministry of Planning and National Development. Technical Report No. 92, Kenya.

O'Keefe, P. (1984): **Energy and Development in Kenya: Opportunities and Constraints.** The Scandinavian Institute of African Studies, Uppsala.

O'Keefe, P., Juma, C., and Aitken, J.M. (1986): *Wood in Towns: No Money to Burn.* **The Courier.** No.95 Jan-Feb.

Omosa, M. (1987): **The Fuel Crisis in Rural Kenya: A Socio-Economic Analysis of the Fuelwood Scarcity in Bura Irrigation Scheme Tana River.** Unpublished Ph.D. Thesis, University of Nairobi, Nairobi.

Redeby, L. K. (1998): **Planning and Management in the African Power Sector.** Zed Books Limited, London.

Reddy et. al. (1981):**Southern Percepetives on Rural Energy Crisis.** Nautilus Bolinas, California.

Rivero, S. I. And Flood, R. (1999): **The Role Wood Energy in Africa.** Food and Agriculture Organization of the United Nations, Rome.

Soussan, J. (1988): **Primary Resources and Energy in the Third World.** Routledge, London.

Tolba M. K (1985): **Energy Supply/Demand in Rural Areas in Developing Countries**. UNEP, Nairobi.

Tolba, M. R. (1986): **Energy Conservation in Developing Countries.** UNEP, Nairobi.
UNCHS (1993): **Application of Biomass Energy Technologies.** UNCHS (Habitat).

UNEP (1995): **Environmental Considerations and Energy Options in Managing India's Long Term Energy Strategy.** UNEP and TERI, India.

Wainana, M. (1985): **Planning for Rural Development with Special Reference to the Provision of Energy in Gaichanjiru Location, Muranga District.** Unpublished MA Thesis, University of Nairobi, Nairobi.

Wanjama, L. N. (1985): **Planning for Rural Energy with Special Reference to Kikuyu Division.** Unpublished MA Thesis, University of Nairobi, Nairobi.

Wane, C. (1986): *The Woodfuel Challenge: Looking to the Future.* **The Courier.** No. January – February 1986-88.

World Bank (2000): *Fuel for Thought: Environmental Strategy for the Energy Sector* in **Partnerships for Development.** Creative Communication Group, West Sussex (Pages 205-207).

World Bank (1996): **Rural Energy Development: Improving Energy Supplies for Two Billion People.** World Bank, Washington D.C.

APPENDIX 1

UNIVERSITY NAIROBI

DEPARTMENT OF URBAN AND REGIONAL PLANNING

HOUSEHOLD QUESTIONNAIRE

Questionnaire No.:……

Name of interviewer:……

Name of village:……

Name of sub-location:……

A. PERSONAL INFORMATION

1. Name of respondent:……
2. Sex (Male/Female):……
3. Age:……
4. Marital status:……
5. Household size:……
6. Occupation:……
7. Household head income:……
8. What are the other sources of income in the family?……
9. What is household expenditure on
   - Fuel: ……
   - Education: ……
   - Food: ……
   - Medical care:……
   - Clothing: ……
   - Others (Specify): ……
10. What is the preference in household expenditure? (Which one is given first priority?)……
    ……
    …

10. Record the household characteristics in the table using the codes given after the table:

HAO1	HAO2	HAO3	HAO4	HAO5	HAO6	HAO7	HAO8
Name	**Sex M/F**	**Hold status**	**Age**	**Marital status**	**Educational level**	**Where born**	**Occupation**
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

HAO3 - Household status

01 Household Head

02 Spouse of household head

03 Child of household head/spouse

04 Others

HAO5 - Marital Status

05 Married

06 Unmarried

07 Separated

08 Divorced

09 Widowed

10 Polygamous

HAO6 - Educational Level

11 None

12 Primary

13 Secondary

14 Higher

HAO7 - Where born?

15 Within the Division

16 Within the District

17 Outside the District

HAO8 - Occupation

18 Farmer

19 Businessmen

20 Employee

21 Informal

22 Unemployed

23 Student/Pupil

24 Others (Specify)

12 (i) What is the type of house?(observe)

a) Permanent (Stone/brick/corrugated iron sheets)

b) Semi permanent (Mud walls and Corrugated iron sheets)

c) Temporary (Mud walls and Grass thatch)

(ii) If (c), where do you get the building materials from?

B. LAND AND LAND-USE

13. Is your land a) Bought c) Inherited

b) Rented d) Squatted

14. Do you have a title deed? Yes/No

15. What is the total land acreage?.....acres

16. What acreage is under

a) Crops.....acres

b) Grazing/pasture.....acres

c) Woodlot.....acres

d) Agro-forestry.....acres

e) Others (Specify).....acres

17 a) What are the crops grown on the farm?

Cash crops:	Food/Subsistence:
1.....	1.....
2.....	2.....
3.....	3.....
4.....	4.....
5.....	5.....

b) (i) Who work on the farm?

- Father
- Mother
- Children
- Others (Specify)

(ii) What is the work of the following members of the family on the farm

- Father.....
- Mother.....
- Female children.....
- Male children .....

18. What are the annual yields (output/harvest) of the crops mention in No. 16?

Crop:	**Yield:**
……	……
……	……
……	……
……	……

19. a) Do you practice inter-cropping? Yes/No

b) If yes which crop?……

c) If no why?……

20. Do you keep animals? Yes/No

if yes,

Type	**Number of animals**
1	
2	
3	
4	
5	

21. a) Do you practice zero grazing? Yes/No

b) If yes, what are the sources of fodder?……

……

c) (i) If no, where do you graze your animals?

- Own farm
- Neighbours farm
- Communal field
- Forest
- Others (specify)

(ii) Why do you graze your animals there? (choice in c i)

22. a) Do you sell crop or animal products? Yes/No

b) If yes.

Kind of product	**Quantity/Amount**	**How often**	**Price per unit**
1.			
2			
3			

23. How do you market your farm produce?

a) Individual

b) Co-operative

24. What means of transport do you use to market?.....

- Ox –cart
- Donkey
- Bicycle
- Others (specify)

25. a) What are the main problems on the land?.....

.....

b) What do you think are the causes of the problems on the land?

.....

26. What are possible solutions (Suggestions)?.....

.....

C. ENERGY PRODUCTION SUPPLY AND CONSUMPTION

27. What form of energy do you use for,

Form of energy	Cooking	Heating	Lighting
Charcoal			
Fuelwood			
Kerosene			
Petroleum gas			
Others (Specify)			

28. How much of the above sources of energy in No. 27 do you use daily/ monthly/ annually?

(a) Fuelwood (Kg, bundles).....cost.....Ksh. per unit

(b) Charcoal (Debes/Bags etc.).....cost.....Ksh. per unit

(c) Kerosene (Treetop bottles, litres).....cost.....Ksh. per unit

(d) Gas (Cylinders).....cost.....Ksh. per unit

(e) Agricultural wastes (Bags of maize cobs, stalks etc.).....Ksh. per unit

(f) Others (Specify).....Ksh. per unit

29. (i) Where do you get your fuelwood or charcoal from?

a) Our farm (Woodlots/Agroforestry)

b) From neighbours farm

c) Forests

d) Buy from market

e) Others (Specify)

(ii) If (c) How far is it from home?.....Km

How long do you take to and from the forest? .....Minutes/Hours.

(iii) How long does it take to collect fuelwood?.....Minutes/Hours

(iv) Who collects fuelwood?.....

(v) If (iii) what methods do use to gather fuelwood?

- Cutting using *panga* or axe
- Collecting broken branches

30. Do you get energy that you need for cooking, lighting, heating, when you need it and enough for the purpose? Yes/No

31 a) Do you experience any shortage problems of the various sources of energy? Yes/No

b) What time of the year do you experience shortages (approx.)?.....

c) Which source of energy is in abundance?.....

32. What do you think can be done to increase the supply of fuelwood?.....

.....

33. (a) How do you compare the availability of woodfuel before (20 years ago) and today?.....

(b) Which tree species were used for fuel and which ones were not?

.....

.....

(c) (i) Are the tree species not used for fuelwood consumed today? Yes/No

(ii) If yes what is the explanation for this?.....

.....

D TREE SEEDLINGS DEMAND & SUPPLY

34. How many trees do you plant annually? (Approx.).....

.....

35. (a) (i) Who plants trees on the farm? .....

(ii) What the reasons for this? .....

(b) Where are trees grown?

- Crop land (Agroforestry)
- Hedge
- Woodlot
- Around the house
- Others (specify)

36. Which tree species do you plant?

1.....

2.....

37. a) Which species do you prefer?.....

.....

(b) Why?.....

.....

38. (a) What are the uses of these trees? (In order of importance)

1.....

2.....

3.....

4.....

5.....

b) Where do you get the seedlings from?.....

c) Are they easily available?.....

39. a) Are you visited by extension officers, who give advice on tree planting? Yes/No

b) What kind of advice do they give on tree planting?.....

.....

40. (i) Do you have a tree nursery? Yes/No

(ii) If no, why?.....

(iii) If yes, how many seedlings do you raise per year?.....

(iv) Where do you get the tree seeds from?.....

41. Which is the nearest tree nursery?.....

How far is it from your family?.....

42. (i) Do you sell the seedlings? Yes/No

(ii) If yes, how much per seeding?.....Ksh.

43. a) What problems do you experience in raising the seedlings?.....

.....

.....

b) What do you do to solve the problem?.....

.....

d) How does the government through the relevant ministries assist you?

E. ENERGY CONSERVATION

44. Which kind of cooking do you use?

(a) Three stone early open fire

(b) Ordinary *Jiko* (metal only)

(c) Energy saving *Jiko* (clay + metal/KCJ)

(d) Kerosene stove

(e) Wood-saving stove

(f) All the above

(g) Others (Specify).

45. Which one of the above uses more energy inputs?.....

46. a) (i) How many meals do you make in a day?

- Breakfast, Lunch + Supper
- Breakfast + Supper
- Breakfast + Lunch
- Lunch + Supper

(ii) How many meals do you prepare or cook per meal? .....

b) Give reasons for your choice?.....

.....

47. a) Do you take any measures in preparation of meals in relation to availability of woodfuel? (maize and beans, *tsisaka, lisutsa*)? Yes/No

If yes, why?.....

.....

(b) (i) What cooking utensils do you use? (Pots, sufurias etc.) .....

(ii) Do you cover your food while cooking? .....

48. What do you with leftover charcoal and firewood still glowing after cooking is finished?

a) Pull the firewood out.

b) Put the firewood/charcoal off with water.

c) Cover with ash.

d) Leave it burn down

49. Do you have any problems with your three stone earth open fire ? Yes/No

If yes, what problems?.....

.....

50. What is the main problem in the kitchen while cooking?

- Smoke
- Heat
- Attending to fire
- No safety
- Others (Specify)

51. a) Have you heard about/seen one of the new improved wood stoves and or improved charcoal *jikos*? Yes/No

b) Do you have one? Yes/No

c) Why haven't you bought one?.....

.....

52. What are the advantages and disadvantages of theses improved cooking stoves

Advantages:

……

……

Disadvantages:

……

……

53. Who told you the information about the improved cooking stoves?……

54. What are the alternative sources of energy you would prefer to use other than woodfuel?……

55. What are the reasons for your choice?……

……

56. Where do you get water from:

a) Tap water d) others (specify)

b) Well water

c) River water

57 a) Who fetches water from the river?……

b) How clean is the water?……

c) (i) .Do you boil the water for drinking?……

(ii) If yes how much fuel do you use per 20 litre jerican?……

(iii) If no, why don't you boil your drinking water? ……

(iv) What is the distance of the river from home? ……Km.

How long (time) do you take? ……Hours

APPENDIX 2

UNIVERSITY OF NAIROBI

DEPARTMENT OF URBAN AND REGIONAL PLANNING

CHARCOAL BURNERS AND SELLERS CHECKLISTS

A. CHARCOAL BURNERS

Questionnaire No.:……

Name of Interviewee:……

Date of interview:……

Time of interview:……

Name of Village:……

Name of Sub-location:……

1. Name of respondent:……
2. Age:……
3. Sex:……
4. Marital Status:……
5. Occupation:……
6. Household size:……
7. Household income:……

a) A part from charcoal burning, what are your other sources of income?……

……

b) (i) What is your monthly expenditure in order of preference?

1……

2……

3……

4……

5……

(ii) Is your income enough to meet your demands?……

……

8. How much do you earn from charcoal

per day?……Ksh.

per week?……Ksh.

per month?……Ksh.

9. What is the unit of measurement?

a) *Debes* b) 100 Kg gunny sacks c) Kilograms d) Others (specify)

10. What is the cost per unit?……Ksh.

11. What is the source of the trees converted to charcoal:

a) Farm b) Forest c) Bought from neighbour d) Others (Specify)

12. Do you experience any problems in getting trees to burn charcoal? Yes/No.

If yes, what problems?.....

.....

13. How do you solve these problems?.....

.....

14. a) Do you always have customers? Yes/No

b) Where do they come from?.....

15. Which type of tree do you prefer for charcoal.....

Why?.....

16. (a) What method do you use to burn charcoal ?

- Traditional earth kiln
- Modern kilns (Metal)

(b) How do you store your charcoal?.....

17. Do you plant any trees to replace those cut? Yes/No

If No, Why?.....

.....

18. How do you transport your product to the market?.....

19. (i) What do you use for cooking? Fuelwood/charcoal

(ii) What do you use for lighting?.....

B. CHARCOAL SELLERS

20. What is the name of the market?.....

What source of energy do you use for

a) Cooking:.....

b) Lighting:.....

21. How do you get the charcoal?

a) Brought to me on order by the charcoal burner.

b) Buy from the market stores

c) Burn

d) Others (Specify)

22. (i) What are the units of measurement?

a) *Korokoro* (2 Kg Kimbo)

b) Basin/*Debe*

c) 100 Kg gunny bags

d) Others (Specify)

(ii) What is the price per unit?.....Ksh.

23. How many bags do you sell per day?.....

24. How much do you earn

per day .....Ksh.

per week.....Ksh.

per month.....Ksh

25. a) What time of the year do you have more sales?.....

Why?.....

.....

b) When are charcoal sales low?.....

Why?.....

.....

26. What are your other sources of income?.....

27. a) Do you experience any problems in acquiring charcoal for sales? Yes/No.

b) If yes, when?.....

c) If no, why?.....

28. What are the advantages and disadvantages of using charcoal for cooking?

Advantages.....

.....

Disadvantages.....

29. a) What alternative sources of energy would suggest for use?.....

.....

b) What are the reasons for your choice?.....

.....

30. How best do you think charcoal can be used (Conservatively).....

.....

31 Why did you decide to engage in this kind of business?.....

.....

APPENDIX 3

UNIVERSITY OF NAIROBI

DEPARTMENT OF URBAN & REGIONAL PLANNING

INSTITUTIONAL CHECKLIST

1. Name of the institution:
2. Name of respondent and Position
3. Sub-location where the institution is found?
4. What is the area of the compound? What is the area occupied by buildings, playing fields, farm etc.? Do you have any woodlots on the compound? How many acres?
5. How many people does the institution cater for?
   a) Students b) Teachers c) Sub-staff
6. a) Do students feed on the compound? Yes/No
   b) How many meals per day?
   c) What kind of meals? E.g. maize and beans, rice etc.
7. What sources of energy does the institution use for cooking?
   a) Fuelwood
   b) Charcoal
   c) Others (specify)
8. What is the source of energy used for cooking?
9. How much does it cost per month? (Tonnes/Lorry/Tractor/Cylinder etc.)
10. How many tones/lorries of fuelwood does the institutions use per month
11. How many kilograms is each lorry load?
12. What type of cooking stove do you use
    a) Three stone hearth
    b) Wood saving stove
    c) Metal *Jikos*
    d) Charcoal Saving *Jiko* (KCJ)
    e) Others (Specify)
13. Do you experience any shortage of the source of energy you use? Yes/No
14. Other than shortages what other problems are experienced in use of fuelwood?
15. What energy conservation measures do the school taken under table to save on? the amount of fuel consumed?
16 What do you use for lighting?
17 What amount of fuel do you use for lighting and how much does it cost?

APPENDIX 4

UNIVERSITY OF NAIROBI

DEPARTMENT OF URBAN AND REGIONAL PLANNING

BUSINESS CHECKLIST

Questionnaire No.:……

Name of Interviewer:……

Name of Sub-Location:……

Name of Market:……

Type of Business:……

1. When did you start your business?……
2. Where do you get your stock from?……
3. a) What items are sold more?……
   b) Why?……
4. Where did you get initial capital from?……
5. What sources of energy do you use for,
   a) Cooking
   b) Lighting
6. What amount of fuel in Q5 do use for cooking
   Per week……(*Debes*, Sacks, Kg, Tractors)
   Per month……(*Debes*, Sacks, Kg, Tractors)
7. What amount do you for lighting
   Per week ……(Litres, Fanta/Bottles, Kilowatts etc.)
   Per month ……(Litres, Fanta/Bottles, Kilowatts etc.)
8. a) Where do you get your fuel for cooking from?……
   b) Do you collect it personally?……Yes/No
   c) (i) If yes, how far is it from this market?……Km
   (ii) How much money do you spend on transport?……Km
   (iii) How much time do you spend weekly in seeking to find fuel……
   d) (i) *If no, who brings the fuel?*……
   (ii) How much do you pay for the service?……Ksh.
9. How much money do you spend of fuel?
   For cooking ……Ksh
   For lighting ……Ksh.
10. What are your other sources of income?……
11. How much do you spend on?
    a) Fuel……Ksh.

b) Food ..... Ksh.

c) Education (Fees)..... Ksh.

d) Medical ..... Ksh.

e) Clothing:..... Ksh.

f) Others (Specify)..... Ksh.

12 a) Do you experience any problems with energy supply?..... Yes/No

b) If yes, what are the problems?.....

.....

b) What accounts for these problems?.....

.....

c) What possible solutions (suggestions) do you offer?.....

13. a) Where do you store your woodfuel?.....

b) Where do you dispose your charcoal dust?.....

14. Who are your common customers? (in case of Hoteliers)

a) Male b) Female c) Children

15. What types of foodstuffs do you prepare?.....

.....

16. What quantity (amount) of food do you cook?.....

17. What amount of fuel does each food type consume? (Quantity and unit of measurement).....

18. Which foodstuffs do you prefer cooking?.....

Why?.....

19. What do you do in cases of shortage in supply of fuel?.....

.....

20. What type of cooking stove do you use?

a) Metal *Jiko*

b) Charcoal saving *Jiko* (Ceramic)

c) Wood-saving stoves

d) Kerosene stove

e) Others (Specify)

21. Other than wood and kerosene, what other sources of energy would prefer to use?

.....

22. How can we increase the supply of woodfuel?.....

.....

23. How efficient can the available woodfuel energy be consumed?.....

.....

APPENDIX 5

UNIVERSITY OF NAIROBI

DEPARTMENT OF URBAN REGIONAL PLANNING

CHECKLIST QUESTIONS FOR DEPARTMENTAL OFFICERS

STATISTICAL/DEVELOPMENT OFFICER

1. What is the population of the Kakamega Districts and central Kabras location? (Include sub-location population?)
2. What is the household size? Household number?
3. What is the sex ratio?
4. What are the literacy levels?
5. How many people live in the urban centres in Kakamega District?

II LANDS SURVEY, PHYSICAL PLANNING OFFICER

1. What is the average land size?
2. Map showing the administrative boundaries of Kakamega District and the areas (in Km^2) for each.

III MINISTRY OF ENERGY/AGRICULTURE/ENVIRONMENT AND NATURAL RESOURCES

What are the energy objectives with reference to wood fuel by the year 2000?

Which policies and strategies are put in place to achieve the objectives?

Measures undertaken in energy conservation. How activities are your Department/Ministry?

Which projects have been identified and implemented in the area under study?

How successful are they?

what policies and strategies are put in place to protect and mange the environment in order to enhance supply of woodfuel in Kakamega District?

a) What problems do you face as government agencies in performing your duties in this sector (energy)?

b) In your opinion, what are the possible solutions? What is the government doing about them?

How are the public and the private sector (NGOs) involved in the supply fuel and/or conservation energy? Which NGOs are in the area of study?

7. What alternative sources of energy are economically viable in this region? (i.e. can the people afford ? Are they environmentally friendly?)

How many people use biogas and electricity in the area under study? What policy issues does the government have on this alternative sources of energy at the local level?