ENVIRONMENTAL IMPLICATIONS OF UTILIZATION OF RURAL DOMESTIC ENERGY: THE CASE OF SABATIA DIVISION, KAKAMEGA DISTRICT

BY

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DECLARATION

This thesis is my original work and has never been presented for a degree in any other University.

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

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ABSTRACT

Scarcity of fuelwood has led to adverse negative human and ecological impacts, which threaten to lower the quality of life especially in the rural areas. This grim situation might continue if concerted efforts and increased levels of financing directed towards woodfuel production and conservation are not forthcoming.

This study looked at four aspects of rural domestic energy, namely, production, procurement, utilization and conservation. This was done with a view of establishing the causes, impacts and possible solutions to fuelwood scarcity in Sabatia Division, Kakamega District. The division was selected as a representative area experiencing a serious domestic energy deficit.

Primary data was collected by a questionnaire and interview schedules. The questionnaire was administered to 180 households in all the four locations in the divison. Interview schedules gathered data from farmers currently using solar and biogas energy technologies; the Divisional Forest Extension Officer; the Centre

Manager, Bukura Agroforestry/Energy Centre, the Manager, Kenya Woodfuel Agroforesty Programme, and the chairlday, Kanu-Maendeleo ya Wanawake. Secondary data was extracted from relevant textbooks, newspapers, magazines, conference reports, and journals among other sources.

Both the descriptive and inferential statistical methods of data analysis were used. To get specific statistics, the Statistical Package for Social Sciences (SPSS) computer programme was used.

The study established several causes, impacts and possible solutions to the woodfuel scarcity problem in the study area. It was found that the fast population growth rate which leads to subdivision of land and clearance of bushes for agriculture and settlement is the major cause of woodfuel scarcity. Other causes established include, presence of socio-cultural factors that determine who should plant and/or cut trees on the farm, ignorance of new and appropriate methods of wood-fuel production and conservation, poor care for trees, and conflicting uses to which trees are put which consequently induce artificial shortages because firewood is

acceptance of improved wood conversion and utilizaiton technology. Other solutions include, use of alternative fuels where possible, acquisition of more land, subsidizing the cost of petroleum based fuels and training people to produce their own seedlings or supply high quality seedlings at a nominal cost.

It is hoped that the suggested solutions will be found useful in helping improve energy planning (within the framework of recommendations made in this study) in other areas with similar ecological and socio-economic characteristics as the study area.

only viewed as a by-product from trees meant for other purposes.

Impacts of woodfuel scarcity on people's lifestyles were also established, notably, the quantity of firewood stored has greatly reduced, there is increased use of agricultural residues, there's continued use of poorly dried wood and gathered materials risking exposure to pollutants due to high indoor concentrations of biomass smoke, people miss to cook essential meals because they lack firewood or because money meant for food is diverted to purchase of domestic fuel, and the rate at which woodfuel is being commercialised has increased.

The study established several solutions through which the woodfuel scarcity problem can be addressed. The most outstanding among the solutions include, stepping down the population growth rate by making family planning services easily available and accessible, implementation of agroforestry practices in the context of incorporating fuelwood production within existing agricultural systems where pressure on land is becoming critical, intensification of promotion campaigns towards

CHAPTER ONE

INTRODUCTION

Background to the Problem

Energy, especially petroleum, plays a crucial role in the socio-economic development of a country. However, the current high petroleum prices threaten standards of living worldwide, and especially in oil importing developing countries where it might prevent further development or even bring decline in development.

To many people in developing countries, the inevitable alternative to oil is woodfuel. Those who cannot afford to purchase charcoal or firewood have to content with animal dung and crop residues as their major source of domestic energy.

In developing countries, virtually every rural family relies on firewood for all or part of its cooking and spaceheating. This is because most of them cannot afford petroleum based fuels or alternative sources of energy. Heavy reliance on wood is evident even in areas where forests and bushes are rapidly disappearing. In Nepal, families depend on wood for 97 % of the household energy, while in Upper Volta, also in the grip of severe deforestation, the dependence is over 90 percent, (Hall, 1982).

In Africa South of the Sahara, dependence on wood-fuel is almost total. In Somalia, where deforestation threatens the almost sole source of energy - biomass, the world Bank (1984) estimated that biomass energy accounted for 87% of the country's total national energy consumption. In countries such as Malawi, Tanzania and Mali, wood does not merely predominate over other household fuels but it provides over 90% of the total national energy consumption, (Eckholm, 1984).

In Kenya, three quarters of its primary energy needs are met by fuelwood and agricultural residues, (O'keefe, 1985). The same source indicates that 72% of the fuelwood is consumed in the rural household sector, which also consumes 37% of the charcoal and agricultural residues. At the national level, energy to meet domestic cooking, space and water heating requires more wood

(96%) than any other purposes (Mugo, 1990).

Overdependence on biomass energy means that poor people in developing countries cook their meals only at tragic costs for themselves and the environment. According to Oelert (1987), deforestation to supply wood for fuel, to create land for cultivation and human settlement among others, is the most important environmental problem in developing countries. This rampant loss of forests is doubtlessly a serious threat to the economy and the ecological set up of any country.

The impending fuelwood scarcity as a result of overdependence on wood for energy has become too obvious to ignore. However, at the global level, this is not anything new. Such shortages were acute in mid-ninteenth Century Europe, and indirectly may have had epochal historical significance, (Eckholm, 1984). He added that,

> In Prussia during the early 1980s, five sixths of all criminal prosecutions involved theft of wood by desperate peasants who poached wood off the land holdings of the rich.

And that,

Young Karl Marx who watched debates in the Rhinelands Parliament on the subject of wood stealing penalties later said that it was his exposure to the human impacts of wood scarcity that first drew his attention to the material basis of social relations. (Eckholm, 1984:9).

In Kenya, acute wood shortages are experienced in densely populated high potential areas of Central, Nyanza and Western Provinces which import woodfuel from other provinces reports Kenya Energy and Environment Organisations, (KENGO, 1983). In these areas, it has been reported that the standing treestock has greatly reduced.

Fuelwood scarcity threatens health in many ways. It is expensive to burn wood for spaceheating and for boiling drinking water. Hence those that cannot afford extra wood are more susceptible to cold and water borne diseases. Since available wood is not allowed sufficient time to dry, burning it produces alot of smoke, which according to Smith (1985) has adverse effects on the health of household members.

Fuelwood shortage also affects health by forcing people to change their diets. Anecdotal accounts suggest that people are changing from nutritional staples which require more cooking to fast cooking but less nutritious food, (Litell, 1985). This leads to malnutrition, increased vulnerability to disease and reduction of peoples productive capacity.

As woodfuel becomes a market commodity, it becomes less accessible to the cash-poor segments of the population. For many people, paying more for fuel means less money for food, education, health and decent houses among other necessities. The poor are eventually forced to poach wood on public or private land and incur risk of prosecution.

As woodstocks around the village decline, women and children walk farther and farther for wood. In Kathmandu in Nepal, some families designate one child to spend most of his or her time scrounging for cooking fuel, (Fox, 1984). Khamati (1988) indicated that although firewood and "non-commercial" sources of energy are collected freely, the opportunity cost in terms of foregone activities is high. Thus fuel gathering has joined water collection as a source of daily drudgery, cutting into potentially productive time especially for women and children.

Once procuring wood takes too long to be worth the trouble, some households start to use agricultural residues. In Bangladesh, there are times when even crop residues are extremely scarce forcing some families to cook with fruit skins, sugar cane wastes and other burnable garbage, (Smith, 1981). The increased use of crop residues and dung for cooking can reduce food production since compost made from dung or residues improves soil fertility and structure.

From the above account, the adverse negative human and ecological impacts of the spreading fuelwood scarcity, stemming from high costs of petroleum and alternative energy sources and the consequent dependence on wood for for domestic fuel is less obscure. Like other developing countries, Kenya cannot allow the scenario outlined above in her future development. Strategic planning options of increasing supply and managing the demand of woodfuel should be identified in order to develop a comprehensive programme to reduce the problem of woodfuel scarcity. The alternative to this is deeper drudgery and dimmer prospects for millions of people.

Statement of the Problem

Scarcity of fuelwood causes widespread human suffering and ecological disruptions. This, if allowed to continue, can considerably lead to a decline in the quality of life especially in the rural areas. However, several approaches to curb this downward spiral are available.

The strain on woodfuel resources can be eased by on-farm tree planting, community forestry and agroforestry through which sustained per capita fuelwood sufficiency can be realised. Although small scale farmers plant trees, fuelwood scarcity and the associated problems evidently persist. The reasons behind this paradox were investigated.

With household energy requirements accounting for an estimated 85% of Kenya's biomass energy consumption, the introduction of improved cookstoves would ease the pressure on existing biomass energy resources. Studies reveal that use of improved cookstoves in the rural areas is yet to be popular, (Barnes, 1984; Hankins, 1987). The need to investigate why these stoves are not widely used in rural households was found inevitable.

Increased functional efficiency by improving cooking habits can conserve fuel. This is particularly true because performance of improved stoves is also highly dependent on associated user habits. These kitchen management techniques include use of lids, use of aluminium pots and use of air control devices among others. Therefore, the researcher saw the need to investigate the cooking habits currently practised.

Use of woodfuel substitutes such as maize cobs, industrial wastes (biomass in nature) and other alternatives such as biogas and solar energy could also reduce the pressure on existing woodlands. These alternatives are not widely used despite their presence in the study area. The reasons behind this were investigated.

About 75% of wood energy is lost in the conversion process of wood to charcoal. Therefore improved charcoal kilns can be used to counter this loss. The researcher investigated the charcoal production methods used in the study area.

Extension and public education in the areas of energy production and conservation if intensified can help to ease pressure on biomass energy resources. The study therefore investigated the adequacy of information available. Special emphasis was laid upon the role of government agencies, local leaders and non-governmental organizations in propagating ideals in seedling production, agroforestry, use of improved stoves and use of alternative sources of energy.

In order to pursue research premises outlined above, the following questions were posed to aid the study:

a. What are the major sources of primary fuels used?

b. What are the causes, effects and possible solutions to fuelwood scarcity?

c. Is there any relationship between household energy consumption with household income, education level and household size?d. Which alternative energy choices are available?

e. Which firewood energy converter technology is used?

f. Who advises the farmers and what type of advice is given concerning woodfuel production and conservation?

Study Objectives

The main purpose of the study was to investigate the existing energy problems, their causes and their implications; the substitutes and/or alternative energy technologies used; and the methods of woodfuel production and conservation in the study area. In dealing with these issues, the objectives set for the study included, to:

* determine the source, quantity and value of the primary fuels used.
* identify the causes, effects and solutions to fuelwood scarcity.
* investigate the relationship between household energy consumption with income and household size.
* make a comparative survey of alternative energy choices available.
* investigate the firewood energy converter technology used.

* find out the source and type of advice given to farmers concerning woodfuel production and conservation.

* investigate the relationship between education level and the tendency to adopt effective methods of woodfuel production and conservation.

Rationale of the Study

Despite spectacular urban growth in developing countries, the majority of the population still lives in rural areas. In Kenya, this rural population consumes more than three quarters of fuelwood used (Mugo, 1990). It is in recognition of this fact that the study was carried out in a rural setting.

The rapid population growth and rapid expansion of cultivation leading to disappearance of traditional sources of fuelwood have caused acute woodfuel shortage in the rural areas. This has led to negative human and ecological effects. For instance, deforestation, poor human health due to malnutrition and long hours of firewood gathering negatively affects agriculture.

Kenya's economy is heavily dependent on agriculture, hence every effort should be made to ensure that factors such as deforestation and conflicting land uses do not reduce its productivity. It is therefore imperative that solutions to rural domestic energy problems are found.

In the face of increased deforestation, tourism, which is a major foreign exchange earner, is bound to break down. Unless appropriate and urgent measures are taken, increasing fuelwood scarcity might compel people to cut down trees and shrubs in government gazetted forests and bushlands which are home to wild animals, the main stream for the Kenya's tourism industry. Therefore, in the absence of energy planning and policy formulation based on detailed empirical research, the ecosystem that supports Kenya's economy and ecology is destined for a likely breakdown.

Hence, there is need for a detailed analysis of energy supply and demand in rural areas to provide an adequate data base for accurately diagnosing the energy predicament affecting the rural people. Such studies should be carried out regionally to work as concrete basis for accurate comparison. It is hoped that findings from the study would be able to:

i provide information to help improve energy planning and policy formulation.

ii suggest ways through which energy requirements can be met without causing negative human and ecological impacts.

iii help to motivate household members to engage in effective woodfuel production and conservation methods.

Assumptions of the Study

In designing the study, the following assumptions were made:

a. There is currently a problem of fuelwood scarcity in the study area.

b. The community is aware of the causes and effects of fuelwood scarcity.

c. The community has possible solutions to the fuelwood scarcity but only lacks motivation and initiative to implement them.

d. The community is receptive to new ideas, such as the introduction of new fuelwood production methods, alternative energy technology and energy conservation methods.

The Study Area

The study was carried out in Sabatia Division in Kakamega District in Western Province of Kenya (Figure 1). Western Province is among the most densely populated high potential areas in Kenya. Western, Central and Nyanza Provinces are deficient in woodfuel and import it from other provinces, (KENGO, 1983). According to Litell (1985), one half of the wood consumed in these provinces is supplied from non-sustainable stocks and currently there is insufficient standing treestock available on a sustained yield basis.

Kakamega District lies within the Lake Victoria basin with the equator crossing its southern tip. A significant proportion of the district has a high agricultural potential.

The average population density according to the 1979 census is 302 persons per square kilometer, (Republic of Kenya, 1988). The average, though one of the highest in the country conceals the variation in density within the district. Divisions such as Emuhaya, Sabatia, Vihiga and Hamisi already exhibit population densities of about 1000 persons per square kilometre.

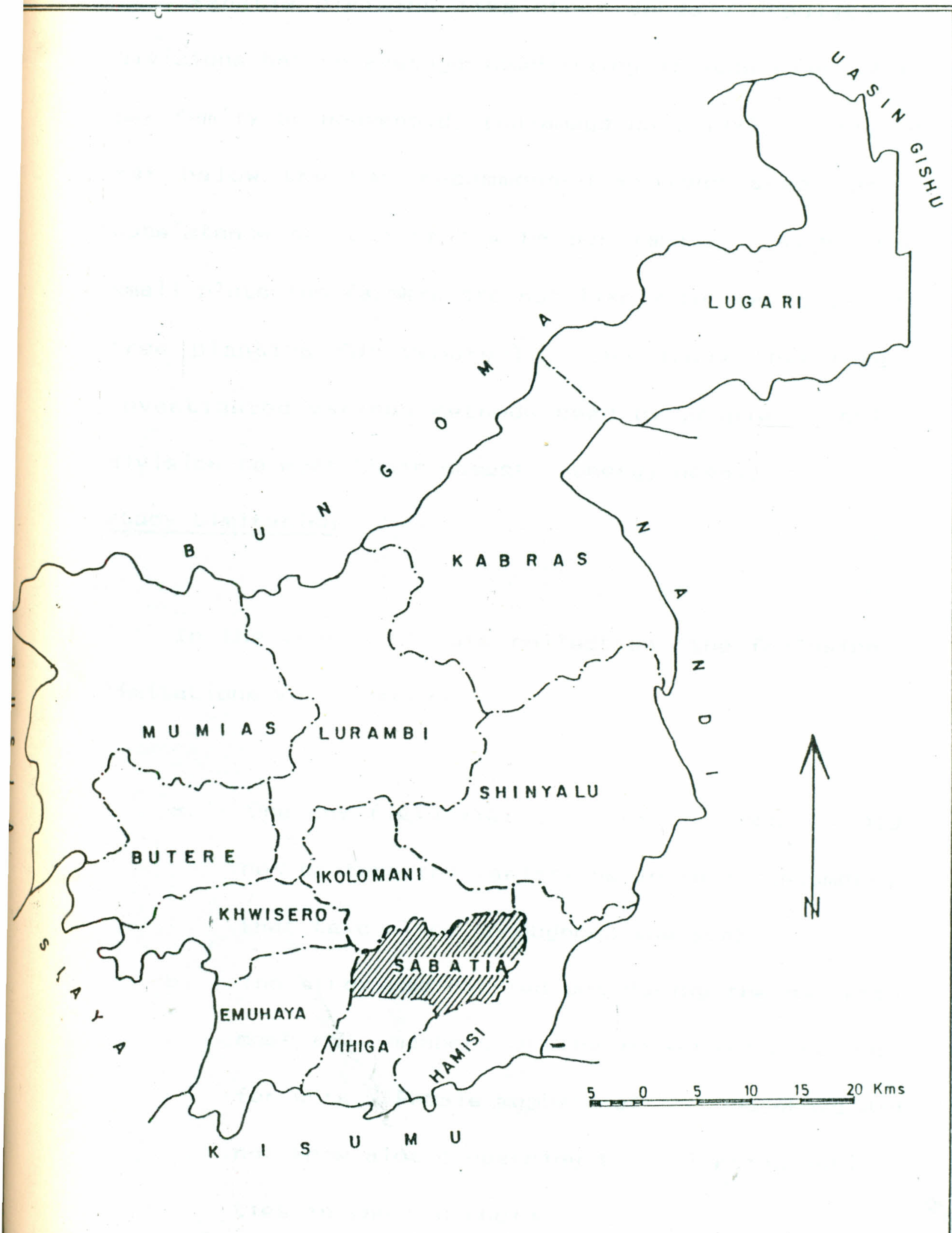

Fig. I. Location map of the study area in Kakamega District.

Sabatia Division like other densely populated divisions has an average landholding of less than 0.5 ha per family or household, (Kakamega DDP, 1988). This is far below the FAO recommended minimum area for subsistence purpose of 1.4 ha per family. With such small plots the farmers are not likely to commit them to tree planting for woodfuel. The study therefore investigated various methods used by people in this division to meet their domestic energy needs.

Study Limitation

In the course of data collection, the following limitations were observed:

a. One day field visit to every household could not capture the variations in fuel consumption that take place throughout the year.

b. The study was carried out during the day when most male members of the household were out for work. Female members of the household did not know alot concerning tree planting activities in the household.

c. One hundred and eighty households were sampled. This might not be a typical representation of the situation in the division, district, province or country. Individual households differed markedly in their geographical, socio-economic and environmental set-up. Therefore broad generalizations can only be made with caution.

Definition of Terms

The following terms as adopted from various sources were used in the study:

AGROFORESTRY: Is a term used to describe all land use systems and practices in which woody perennials are deliberately grown on the same unit of land as crops and/or animals. There must also be a significant economic and ecological interactions between the woody and non-woody components for a system or practice to be considered agroforestry, (Nair (1985) in Leslie, 1989:3)

COMMERCIAL ENERGY: That which circulates in international markets and involve use of foreign exchange. The units of such energy transacted are generally easier to count and often well documented, (Khamati, 1988:48).

CONVENTIONAL SOURCES OF ENERGY: Include fossil sources and traditional sources of energy, (Kamara, 1986:7)

FAMILY SIZE: Includes members of the immediate family i.e offsprings of one couple plus one or both of the parents.

FOSSIL SOURCES OF ENERGY: Provide the bulk of energy for modern industry and domestic energy for some high and middle income households, for example coal and petroleum (gasoline, diesel, kerosene and Liquified Petroleum Gas (LPG)) , (Kamara, 1986:7).

FUELWOOD: Refers to firewood, while woodfuel refers to firewood and charcoal (Mung'ala, 1984:102).

HOUSEHOLD SIZE: Is a group of people regularly eating together. They might not be of the immediate family, but include relatives, workers or friends, (Kamara, 1986:40).

NON-COMMERCIAL ENERGY: That which circulates within localised markets where no records are kept and the price is highly responsive to small market dynamics, (Khamati, 1988:48).

NON-CONVENTIONAL SOURCES OF ENERGY: Include energy sources such as biomass derived fuels (alcohol), solar energy, wind energy, geothermal and micro-hydro units, (Kamara, 1986:7).

NON-RENEWABLE SOURCES OF ENERGY: Consists of the conventional exhaustible energy sources such as petroleum and coal.

RENEWABLE SOURCES OF ENERGY: Are those which can be reproduced through specific management and technological systems such as firewood, solar, wind and small units of hydro-power, (Kamara, 1986:7).

TRADITIONAL SOURCES OF ENERGY: Provide the bulk of energy which large segments of the rural and poor populations in developing countries depend, for example firewood, charcoal, dung and crop residues freely collected or collected under control or bought, (Kamara, 1986:7).

CHAPTER TWO

LITERATURE REVIEW

Introduction

Wood is and will continue to be the single most important fuel especially for domestic consumption for as far into the future as one cares to predict. This is true in developing countries where approximately two billion people have not entered the age of fossil fuels, largely because of poverty. These people solely depend on wood for their residential needs.

The current dependence on wood has led to unprecedented use of woodfuel consequently leading to its scarcity. Adverse negative human and ecological impacts resulting from woodfuel scarcity cannot be over-emphasized. The causes, effects and solutions to woodfuel scarcity are many and varied depending on the geographical position of the area concerned, the local population density, the land holding size and socio-cultural factors.

In the following chapter, a critical analysis of the causes of woodfuel scarcity, the resulting human and ecological impacts, and the possible solutions to the scarcity as per literature reviewed will be undertaken.

Causes of Woodfuel Scarcity

The need of land for agriculture and settlement has led to wanton destruction of trees hence heightening the process of devegetation. This largely contributes to the problem of woodfuel scarcity. The Kenya Development Plan (1988) points out that attempts to reduce the rate of deforestation are thwarted by the ever-increasing demand for woodfuel, and other needs. Specifically, the plan indicates that,

> One factor that is critical for the management and preservation of forest is the ever-growing demand for woodfuel for rural and urban areas ....(Kenya Development Plan, 1988:178).

Rapid population growth has also aggravated the fuelwood situation. This has resulted in continuous sub-division of land and over exploitation of woody biomass resources for provision of domestic energy. Parcels of land have become extremely small that planting of cash and food crops is preferred to planting of trees.

Inefficient use of the forest resources and outright waste coupled with the increasing international market for wood and wood products also escalate the wood scarcity situation. And, according to Approvecho Institute (1984), poor planning and lack of long term reforestation programmes further compounds the problem, and above all, the "unnecessary quantities of wood cut to feed wasteful cooking fires" contribute more to the problem more than any other factor.

In a way, the announcement of new oil prices by the OPEC countries in 1973 helped to step-up the woodfuel scarcity. In the absence of such high increases, at least many people in oil importing countries could afford to use kerosene hand in hand with wood for domestic and other purposes. However this increase and the subsequent increases have pulled kerosene even farther out of the reach of the world's poor.

Overdependence on wood for domestic fuel contributes to its scarcity and consequently its soaring prices. Infact, Eckholm (1975) says that firewood prices have risen much faster than kerosene prices, reflecting the growing difficulties with which wood is procured. Those who can pay for high wood prices must forego consumption of other essential goods.

Ngugi (1988) revealed that as a commodity on the cash economy, wood has become so valuable that trees are not necessarily expected to meet the family's fuelwood requirements. According to her, fuelwood in Murang'a District is viewed as a by-product from trees planted for other economic purposes. This attitude induces artificial shortages even where per capita wood quantities are very high.

Socio-cultural factors which constrain women from involvement in tree planting activities partly contributes to wood shortage. For instance as noted by Ngugi (1988), the agroforestry survey in Kakamega District,

> ......provided firm grounds for believing that the observed fuelwood shortage is not the result of a shortage of woody biomass on individual farms, but is due to social and cultural forces within the household that determine control over, and access to the wood produced on the farm (Ngugi, 1988:165).

Khamati (1988) said that problems of production and distribution of petroleum based fuels results in sporadic shortages occasioned mainly by delays in deliveries, and constrained supply due to lack of storage facilities. This forces people who could have used alternatives fuels like kerosene and LPG to continue using woodfuel.

Electricity, even if it were affordable, it is often not available in rural areas due to distribution costs. Similar sentiments were portrayed by Mbaaria (1988) who revealed that only 11.9% of household in Nyathuna 'B' sub location in Kiambu District used electricity, a factor associated with distribution costs. Thus high installation costs, not to mention the high monthly charges hinder the use of electricity in rural areas.

In a way the high rate of urbanization contributes to woodfuel scarcity in the rural areas. As Foley (1986) argues, the production and distribution of woodfuel is influenced by the urban dwellers. Hence the commercialisation of wood is mainly induced by the urban demands for energy. Therefore trees are indiscriminately felled in rural areas to burn charcoal which is then transported to urban centres. This charcoal is mainly used by the poor residents, who make up the bulk of the urban centres' population.

The problem of urbanization versus deforestation is epitomised by the fact that charcoal which is mainly used in urban areas is produced in wasteful earth kilns. Despite the energy lost, it remains imperative that wood be converted to charcoal. The high bulk and low energy density of fuelwood preclude it from long distance transfer because it is uneconomical. However, wood converted to charcoal lends itself well to transportation. Therefore, charcoal remains an attractive fuel in Kenya and promises an increase in importance, noted Litell (1985).

Ignorance of alternative energy production and conservation methods significantly contribute to woodfuel scarcity. Open three-stone hearths are used for much of the cooking in developing countries. According to Mbaaria (1988), the chief constraint as to why people don't use fuel efficient stoves seems to be general ignorance or lack of awareness of the fuel saving methods.

Another reason for failure to use fuel efficient cookstoves is the high cost of the stoves. For instance without counting the initial cost of stoves, the efficiency of respective cookstoves differs such that Liquefied Petroleum Gas (LPG) is a cheaper fuel to use than charcoal (Khamati, 1988). However, charcoal is more popular because the stove is cheaper and charcoal can be bought in very small quantities whereas LPG cannot.

Human and Ecological Impacts of Woodfuel Scarcity

Globally, an ecological threat to human well being is the undermining of the productivity of land through soil erosion, increasing floods, creeping deserts, and declining soil fertility. All these problems are accentuated by deforestation, which is spreading as lands are cleared for agriculture and as rising populations continue their search for firewood.

Although the vegetation and forests in Kenya are potentially renewable, the rate of exploitation is very high, rendering them practically non-renewable. The destruction of forests threatens their critical functions such as prevention of soil erosion, protection of water catchments and wildlife habitats, and conservation of valuable gene pools. For instance, the Kenya Energy and Environment Organizations - KENGO (1983), observed that, in high potential areas of Kenya, the rate of soil loss is 0.2 to 0.3 tonnes per ha per year when forests exist. This figure jumps to 20 to 40 tonnes when forests are destroyed.

With increased frequency of floods, with denuded watersheds from which rainfall rushes quickly and with excessive load of sediments in rivers, deforestation impacts negatively on agriculture which is vital to the national economy. The rising load of silt carried by rivers chokes up expensive reservoirs and irrigation works. This threatens water supply for a large proportion of the population and causes siltation problems for the hydro-electric and irrigation schemes.

Foley (1986) says that in recognition of the fact that wood has become scarce, wood has become a commodity on the cash economy. This has profound consequences on the rural households, since most people see it profitable to ferry wood to urban centres where it will fetch higher incomes.

One would assume that commoditization of firewood raises the hope that entrepreneurs will see an advantage in planting trees to develop a sustainable, labour intensive business. Instead, Okeefe (1985) argues that a depletion of woodlands has been the more common result.

Kuyper (1984), in a study carried out in Kisii District revealed that firewood is no longer collected freely. He indicates that if firewood cannot be obtained from the farm, it has to be bought at high prices. Wood commercialization as already mentioned leads to artificial shortages even where per capita wood quantities are high.

Despite the scarcity, at least in the rural areas, firewood can usually be gathered free of charge, though the time required to gather takes longer and longer. This makes the cost of firewood in terms of foregone activities high. Mwandosya (1985) reveals that in Tanzania, collection of firewood accounts for about 400 person days per family per year. This inhibits expenditure of human labour to meet other basic needs such as agricultural production.

The weight of foraging for household's fuelwood is mainly felt by women because they have the responsibility of collecting firewood for the household. The time and effort spent by women in search of firewood undermines their health and the economic well being of the family. As Smith (1981) puts it, "the quality of meals and homelife, as well as agricultural yields, inevitably suffers."

Data on Kenya rural households show that when free wood is scarce, people tend to divert to use of agricultural residues, a free good, rather than purchased energy forms, (Barnes, 1984). The removal of animal wastes and crop residues from the soil as a substitute for fuelwood denies the soil the much needed nutrients.

The thinning of woodstocks also erodes nutritional qualities by diverting income for food purchases to fuel and by reducing the amount of time available to raise crops and prepare meals. For instance, Mbaaria (1988) says that maize and bean mixture which constitute the stable food in Kiambu District but takes a long time to cook has been replaced by foodstuffs that cook faster but are less nutritious. This change in cooking and eating habits will most likely adversely affect the working capacity and health of people, mostly women and children.

Scarcity of wood has compelled people to burn poorly dried wood which burns poorly and produces alot of smoke. Smith (1985) argues that even though little systematic research has been carried out, there's evidence that smoke and other pollutants from biomass fuels affect adversely the health of households. Apart from the problems of gases and particulate associated with smoke, Littell (1985) reveals that fuel switch responses such as increased use of dung for cooking could increase bacterial intake and disease potential. Further, the use of non-traditional fuelwood species like Euphorbia species have harmful effects since they produce carcinogenic smoke.

Acute firewood shortage has also undermined administrative control in many countries. In China, Richardson (1966) reported that trees on commune plantations were sometimes surreptitiously uprooted for fuel almost as soon as they were planted. And, in India both the needy and the entrepreneurs were forced to poach for fuel in the legally protected national forest reserves, (Palmedo, 1978). The gravity of poaching is reflected in the formation of mobile guard squads and mobile courts to try captured offenders. However, in most cases, law enforcement measures have little effect in such an untenable situations.

Management of Woodfuel Scarcity

Woodfuel scarcity can be redressed through the management of both supply and demand.

a. Management of Woodfuel Supply

Human suffering caused as a result of woodfuel scarcity can be alleviated if there's a concerted effort and increased levels of financing on both global and national levels directed towards woodfuel production and conservation. El-Hinnawi (1986), summarises the need for energy alternatives in developing countries as follows,

> Energy importing developing countries have to take the challenge of exploiting all their energy resources and develop wise conservation measures which don't interfere with their healthy economic growth, (El-Hinnawi, 1986:16).

While developed countries have used their greater wealth to tackle the oil supply difficulties, oil importing developing countries have no prospects of doing the same. Importing petroleum, considerably drains their foreign exchange earnings that it is not feasible to consider filling the gap between the demand for woodfuel and its supply with petroleum products.

On the other hand, mere increase in the supply of woodfuel is not in itself a complete solution to the fuelwood scarcity problem. The unfortunate truth is that the amount of wood burned in most rural areas is almost completely determined by the number of people who need to use it. The government therefore should spotlight the urgency of slowing population growth in several ways, for example, making planning services universally available and acceptable, and re-orienting social and economic incentives to promote smaller families.

It is fortunate for the woodfuel scarcity problem because unlike oil, trees are a renewable resources when properly managed, (Hall, 1982). The logical immediate response to the firewood shortage is to plant more trees in plantations, on farms, along roads, in shelter belts, and on unused land throughout the rural areas. For many regions, fast growing tree varieties are available that can be culled for firewood even within two years of planting.

Though the concept of planting trees is simple, its implementation is not. For instance, the Kenya Renewable Energy Development Project (KREDP) has revealed that by 1980, "only one tree was planted for every two felled", (Energy/Development International - E/DI, 1986). The report adds that the researchers expect that unless afforestation and efficient wood burning technologies are seriously pursued by the year 2000, then only one tree would be planted for every three or four taken.

Since one way of reducing woodfuel scarcity is to encourage people to plant trees on community lands, community members should be encouraged to establish village woodlots, to plant roadside and boundary trees, plus planting on agriculturally sterile lands, (Barnes, 1984). Mung'ala (1979) points out that, to tackle woodfuel scarcity, the largest plantings should take place on the farm. He emphasises that agroforestry systems, that is planting trees interspersed with agricultural crops or in belts should be encouraged.

Therefore, proper implementation of agroforestry programmes in rural areas should endeavour to strategically increase the community awareness on the practice. Of vital importance in monitoring agroforestry programmes will be the development of training and extension programmes in agroforestry (Litell, 1985). He emphasizes sufficient supply of high yield tree species as of equal importance.

Barnes (1984) argues that apart from being provided with suitable seeds and/or seedlings, farmers should be shown how to grow and tend the trees, and perhaps even be given monetary incentives to carry out such work. Mung'ala (1979) supports this by saying that such costs will be far less than the inputs of food, fertilizers, fuel and health incurred by the government if success cannot be achieved.

Although reforestation and tree planting programmes have been started in many countries, new plantings appear to have no hope of catching up with clearance. For example, in the Sahel, plantings make up for only 2% of the loss annually, (Aprovecho Institute, 1984). To explain the frequent failures of tree planting projects, Eckholm (1975) says that such projects become deeply enmeshed in the political, cultural and administrative tangles of a rural locality, and that they touch upon and are influenced by, daily living habits of many people.

It therefore appears that supply expansion alone cannot adequately counter woodfuel scarcity. There is need for supply management to be augmented by demand management.

b. Management of Woodfuel Demand

Provision of technologies based on renewable and environmentally sound indigenous energy is crucial to the development of rural areas. This if implemented could ease pressure on the existing woodlands. Increasing attention is therefore being given to research development for the harnessing and utilization of renewable sources of energy notably solar, wind, biomass, geothermal and micro-hydro electricity.

However, many of the technologies lack simplicity that is essential for their application especially in rural areas where most of the people have minimum technical training and know-how, (El-Hinnawi, 1986). Therefore most of these technologies are not yet economically competitive with conventional sources of energy such as petroleum.

Despite the shortcoming outlined, efforts are being directed towards the development of renewable sources of energy inorder to meet domestic energy needs. The transition from conventional sources of energy to new and renewable sources has to be achieved in an orderly manner that has to be culturally, socially, economically and environmentally sound. This is necessary for developing countries who have to rely on imported technologies which may not be tailored to their socio-enocomic and cultural lifestyles.

Alternative energy sources must be viewed in respect of how adequately they can substitute oil based resources and dependence on biomass energy for domestic energy needs. Hence, before any energy technology is considered a substitute, studies must be carried out to find out its suitability to the local conditions.

In the past electricity has been concentrated in the larger urban areas. But, if introduced in rural, areas it could reduce the pressure on the existing woodlands. In 1973, through Rural Electrification Programme, the government decided to extend these facilities to make rural areas more attractive. However, because of high installation costs, the majority of the people find such undertakings expensive.

High installation costs are mainly attributed to the problems of distribution from the national grid system. In this case solar energy which is naturally decentralised can come in to fill these gaps. Its abundance, renewable, non-depletable and environmentally acceptable character indicate that it will become one of the most important contributors to commercial energy supplies.

In Kenya to meet the target of "power for all by the year 2000" requires not only enormous near impossible capital outlay, but urgent, cheaper and flexible alternative sources of energy (Daily Standard, 1990). He says that solar energy is cheaper and picking up for use in homes, institutions and industries. He adds that companies like Alpha Nguvu have established an indigenous solar technology suited to the African climate and that the goods produced are adopted to local conditions, are long lasting, maintenance free and available at reasonable costs.

However, the Aprovecho Institute (1984) contends that although solar cookers are already available, their initial cost makes them unaffordable by the poor. Furthermore, no inexpensive means of storing heat for cloudy days and for evenings has so far been devised, adds National Academy of Sciences NAS (1983).

Biogas has been promoted as another alternative means of providing heat for cooking. It is appealing because it uses manure and other organic wastes to generate gas while leaving a usable compost for fertilizer. However, the Aprovecho Institute (1984) points out that biogas is not suited to small scale production, for installation costs are often too high. Further, for successful implementation, sufficient livestock dung and other organic wastes are required.

Officials from Shachiao Biogas Office, China, say that it is impossible to adopt a technology without adopting it to the local conditions, (GTZ,1987). For success, use of local material to reduce costs must be emphasized. They suggest that outside support, both technological and financial should be strictly subsidiary.

Wastes from agricultural industries could also be used as a possible substitute to fuelwood. Over 7 million cubic tones of industrial wastes including saw dust, rice husks, bagasse, coffee husks, coconut shells among others are produced annually whose disposal causes problems (Khamati, 1988). Most of the waste is eventually burned as rubbish, thrown into rivers or left to decay.

Some wastes are already in use as fuel. For instance bagasse is used to fire boilers in sugar industry and coffee husks are made into carbonised briquettes by Kenya Planters Co-operative Union (KPCU) for use in domestic cookstoves. Other wastes could be used similarly.

Apart from increasing fuelwood production and using alternative energy technologies, efforts should be made to increase fuel conservation in wood conversion and utilization process. This should involve provision of information and advice through extension services and demonstration to appropriate groups. The conservation awareness should involve the use of improved, more efficient conversion and utilization practices and devices for example in charcoal kilning and cooking. In addition, there should be profusion of information on improved cooking tips and kitchen management both for household and for institutions.

Thermal efficiencies notwithstanding, improved cookstoves should also be designed to reduce the dangers of exposure to smoke. El-Hinnawi (1986) says that, such designs made by addition of a chimney show promise of reducing smoke exposure.

For better results, when solving woodfuel scarcity problems, conservation should include both demand management and moderation, otherwise Khamati (1988) alleges that when utilisation devices are made more fuel efficient, the most likely result is more fuel use. For instance, more long cooking food may be prepared, more water may be warmed or there may be increased space heating.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

Introduction

The study looked into the causes, human and ecological impacts and the possible solutions to woodfuel scarcity in Sabatia Division. Specifically the study investigated the following:

a. The causes and effects of domestic fuel problems.

b. The energy choices and alternatives that are possible.

c. The energy production and conservation methods used.

The study employed both the primary and secondary data collection methods. The primary data was collected by two major instruments, namely, interview schedule and questionnaire.

The data collection method adopted a field survey approach in which systematic observations and measurements were made over a series of cases. This was followed by analysis of the variables in the matrix to show any meaningful patterns. The secondary data was gathered through a desk study which involved collection of data from relevant textbooks, newspapers, magazines, conference reports, and journals among other sources.

The study was conducted in two stages. The first stage was a pre-survey, which tested the research instruments to ensure that the questionnaire and the interview schedules would elicit the type of data anticipated.

Sampling Technique

The population in the study comprised rural households in Sabatia Division of Kakamega District. The division was selected as a representative area experiencing a serious domestic energy deficit. According to KENGO (1983) Western Province where Sabatia Division is located is deficient in woodfuel and imports from other provinces. One half of the wood consumed in this province is supplied from non-sustainable stocks and currently there is insufficient wood available on a sustained yield basis.

Emuhaya, Sabatia, Vihiga and Hamisi Divisions in Kakamega District exhibit population densities of 1000 persons per square kilometre, (Kakamega District Development Plan - DDP, 1988). This is among the highest population density in the country.

The study employed a sample size of 180 households. All the 4 locations in Sabatia Division were sampled. The researcher administered questionnaires to 45 households in every location, namely West Maragoli, Izava, East Maragoli and North Maragoli. In each household, the respondent was either the male or female head of the household. In the absence of the two, a grown up son or daughter with knowledge of household fuel consumption activities was interviewed.

Besides the household questionnaire, interviews were held with farmers using biogas and solar energy technologies, Divisional Forest Extension Officer, officials from Bukura Agroforestry/Energy Centre, Kenya Woodfuel Agroforestry Programme (KWAP) and Kanu -Maendeleo ya Wanawake.

Four farmers for solar energy technology were interviewed, only one farmer for biogas technology was interviewed. Interviews with the Forest Extension Officer and with officials from Bukura Agroforesty/Energy Centre, Kenya Woodfuel Agroforestry Programme (KWAP) and Kanu Maendeleo ya Wanawake gathered data on advice these officials give to the farmers as far as woodfuel production and conservation is concerned. This also helped in confirming the validity of the farmers responses on the issue of advice given from the above officials.

Data Collection Instruments

The study used two main data gathering instruments, namely questionnaire and interview schedule (See appendices I and II). The questionnaire was divided into five sections, namely socio-economic activities; energy consumption activities; causes, effects and solution to domestic energy problems; woodfuel production and conservation methods; and the alternative energy sources available.

Section one dealt with household socio-economic activities including the household size, farmers' occupation(s), farm size and data on any other source of income. Section two gathered data on the household's energy consumption activities, such as the type, cost and quantity of fuel used. Items in section three investigated the causes, effects and solutions to woodfuel scarcity.

Questionnaire items in section four sought data on woodfuel production and conservation methods used. Items in section five elicited the farmers' knowledge of alternative sources of energy and their willingness to adopt these technologies.

Questionnaire items required different responses from the interviewees. Where several alternatives were provided, the respondents were expected to tick the suitable alternative. Other items required the respondent to provide a brief written statement and to fill in tables provided. For details of the questionnaire see appendix I.

Data from farmers using biogas and solar energy technologies were gathered by interview schedules, which elicited data on current purchasing and installation costs for biogas and solar units. It also sought data on the nature of advice the farmers got from firms that sell solar and biogas appliances, from government agencies, and from non-governmental organizations.

Interview schedules were also used to elicit data from the Divisional Forest Extension Officer, from officials of Bukura Agroforestry/Energy Centre, Kenya Woodfuel Agroforestry Programme and Kanu-Maendeleo ya Wanawake. The kind of advice given to the farmers by these officials as far as woodfuel production and conservation is concerned was also sought.

The items in the interview schedules were open ended but nevertheless structured questions. The interviewees responses were either a single word or a lengthy oral discussion. The schedule provided a leeway for probing incomplete response or those that appeared ambiguous. For details of the interview schedules, see appendix II.

Data Collection Procedure

Each sample household was visited once and the questionnaire was administered to the respondent. Some households were revisited to counter check information. Before administering the questionnaire and interview schedules, the purpose of the study was explained to the respondents.

Apart from the verbal response to the interviews, the respondents were asked to set aside the amount of charcoal and firewood used in a day for weighing. To estimate the quantity of the fuels, a spring balance was used. The quantity of kerosene used was estimated by considering containers of known capacities used per given time. A physical investigation of energy production and conservation methods used in every household was carried out to supplement the respondent's verbal responses.

The extent to which biogas and solar energy technologies were in use in the study area were aslo investigated. The Divisional Forest Extensin Officer and the Chairlady Kanu-Maendeleo ya Wanawake

Organization in the division were also interviewed. The Interview schedule for Kenya Woodfuel Agroforestry Programme and Bukura Agroforestry/Energy Centre were posted.

Data Analysis Procedure

Both the descriptive and the inferential statistical methods were used to analyse the data using Statistical Package for Social Sciences (SPSS) software. The descriptive statistics were used to organise and summarise data into frequencies, percentages and averages. The relationships between household energy consumption, income and household size; and between education level and the predisposition to adopt effective methods of woodfuel production and conservation were established using simple regression and correlation analyses.

The independent variables include household income, household size, male and female educational level. The dependent variables were household energy consumption and the predisposition to adopt appropriate methods of woodfuel production and conservation. The regression coefficient (b), correlation coeficient (r) and coeficient of determination (r^2) were also calculated. Tests of significance were conducted to determine the degree of correlation.

CHAPTER FOUR

DATA PRESENTATION AND ANALYSES

Introduction

This chapter presents a summary of findings of a rural domestic energy survey in Sabatia Division in two parts. Section one presents findings on aspects of rural domestic energy production, procurement, utilization and conservation. It is ordered in the following categories:

- i Socio-economic activities.
- ii Household energy consumption activities
- iii Causes, effects and possible solutions to woodfuel scarcity
- iv Woodfuel production and conservation methods.
- v Advice given to farmers
- vi Alternative sources of energy

Section two deals with rural domestic energy consumption as a function of household income, family size, male education level, female education level and farm size. Relationships between fuel production and conservation methods and these variable were also established.

Frame of Analysis

Due to differences in natural resource endowments and several socio-eonomic factors, the study area was differentiated into two areas with two locations each, as follows:

Group A	Group B
North Maragoli	West Maragoli
East Maragoli	Izava

In figure 2, Group A locations, being a catchment area for Rivers Garagoli and Izava, has a large concentration of streams, marshes and swamps compared to

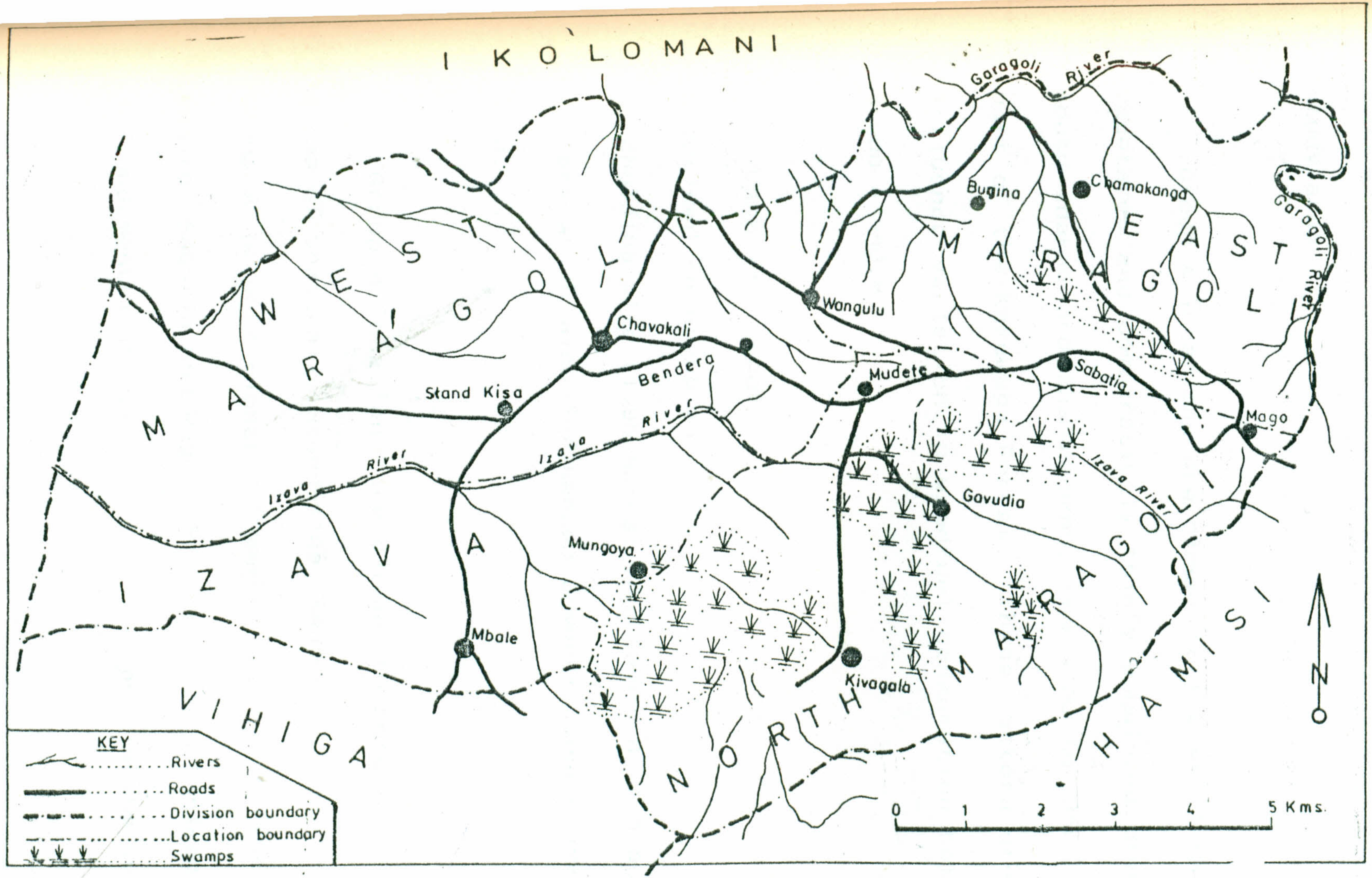

Fig. 2. Study Area; Sabatia Division.

Group B locations. This difference influences production and subsequent consumption of domestic fuel in the study area.

Group A locations are closer to the still thickly vegetated and comparatively thinly populated areas of South Idakho and Shamakhokho, and also to the Tiriki part of the Kakamega Forest. These factors greatly influence variation in woodfuel consumption between Group A and B.

Cash crop (coffee and tea) farming is mostly practiced in Group A, which on average has a larger landholding size (1.95 acres) than Group B (1.5 acres); factors which also influenced domestic energy consumption.

Group B locations are closer to more urbanised areas of Chavakali, Stand-Kisa, Bendera and Mbale, while Group A is only closer to small trading centres like Mudete, Sabatia and Mago. Proximity to urbanised areas is fundamental in explaining variations in the consumption, production and conservation of fuel in the two areas.

Group A, with numerous river valleys, experiences more transportation problems than Group B, especially in the rain season. Transportation of paraffin, charcoal and firewoood from major outlets to the interior is therefore easier for Group B households than for Group A.

With the above frame of analysis used as a major guide in data interpretation, survey findings, are presented in the order already mentioned.

SURVEY FINDINGS

I Socio-economic Activities

The study assessed social and economic conditions in the study area. It was felt such factors may be influencing not only the present but also the future supply and demand for rural domestic energy.

Estimates for income were inferred from the respondent's occupations, remittances from family members and income from crop or livestock sales. Since most respondents were not ready to divulge their cash incomes, and sales of farm products is usually erratic, income estimates should be seen as having a doubtful degree of accuracy.

Income generating crops included coffee, tea, bananas, avocado, passion fruits and vegetables. Domestic animals and their products sold included cattle, sheep, poultry, milk and eggs. Despite the shortcomings in obtaining income estimates, the methods used (see Appendix I), being the most possible means available was considered useful for the purpose of this study.

Despite the small landholding (average 1.7 acres), the main occupation in the area is farming (Table 1). Cash income was mainly derived from permanent employment (41%), wage employment (22%) and business (35.6%). Very few (6.1%) had small industries which comprised mainly brick making, only done in Group A.

Table 1: Occupation of the male head of the households.

Occupation \ Location % Frequency	North Maragoli	East Maragoli	West Maragoli	Izava	Division
Unemployed	42.30	44.5	33.3	26.6	37.0
Farmer	100.00	97.8	95.5	93.3	96.6
Business	22.20	31.1	53.3	35.6	35.6
Small Industry	13.30	11.1	-	-	6.1
Permanent Employment	31.10	42.2	46.7	44.5	41.0
Wage Employment	26.60	13.3	20.0	28.9	22.0
N	45	45	45	45	180

NB: Some respondents had more than one occupation hence the total percentage is not 100

The average monthly household income was estimated at Ksh. 2365. The figure is however highly skewed by a few large incomes, considering that the mode is only Ksh. 900 per household per month.

The Sabatia Division populace is considerably well educated with an average of eight years of schooling for males and six years of schooling for females. The figures are however skewed by a few old respondents who had little or no formal education at all.

The average family size and household size were 7.2 and 6.7 persons respectively (Tables 2). The difference is because most family members were away pursuing education or employment. This is attributed to the small landholding which does not provide sufficient employment för all members of the household, hence most adults migrate to cities in search of jobs.

Table 2: Mean, mode and median for household income, male education, female education, family size, household size and farm size.

Variable	Location	N=45 North Maragoli	N=45 East Maragoli	N=45 West Maragoli	N=45 Izava	N=180 Division
Household Income	Mean	1869.0	2375.0	2839.0	2377.0	2365.0
	Mode	600.0	819.0	1800.0	1400.0	900.0
	Median	1125.0	1666.0	2200.0	1625.0	1658.0
Male Education	Mean	6.7	7.6	7.7	7.9	7.5
	Mode	2.0	11.0	8.0	8.0	8.0
	Median	7.0	8.0	8.0	8.0	8.0
Female Education	Mean	4.8	6.0	6.8	6.8	5.9
	Mode	4.0	7.0	11.0	11.0	7.0
	Median	5.0	7.0	6.0	7.0	7.0
Family size	Mean	7.8	7.8	7.2	6.1	7.2
	Mode	8.0	6.0	8.0	8.0	8.0
	Median	8.0	8.0	7.0	6.0	7.0
Household size	Mean	6.1	7.6	6.7	6.3	6.7
	Mode	6.0	5.0	5.0	6.0	6.0
	Median	6.0	7.0	5.0	6.0	6.0
Farm size	Mean	1.9	2.0	1.4	1.6	1.7
	Mode	2.0	1.5	0.5	0.5	0.5
	Median	1.5	2.0	1.5	1.0	1.5

II Household Energy Consumption Activities

Common end-uses of domestic energy in Sabatia Division include cooking, spaceheating, waterheating, ironing and lighting. For these end-uses, households use either one or several of the available fuels like fuelwood, charcoal, paraffin (kerosene) and in some instances Liquid Petroleum Gas (LPG), electricity, agricultural resides, solar and biogas energy. Apart from the last two, findings for each fuel will be discussed in this section; the last two will be discussed later.

a. Fuelwood

Wood is the most commonly used fuel not only because it is still plentiful but also because it is still usually free or cheap. Of the homes surveyed, 98.3% cooked with wood. Hence, improvement in wood-burning technology would benefit many in the rural areas.

Most households (85.6%) felled trees for firewood on their farms, which they supplemented with trees bought from neighbours or firewood bought from the market, a proportion of 72.1% of the sample size (Table 3). Several households (75.6%) gathered wood from own or neighbours farm, along river valleys and along hedges. Firewood collection in neighbours farm was done with permission.

Table 3: Source of fuelwood.

Source \ Location	% frequency				
	North Maragoli	East Maragoli	West Maragoli	Izava	Division
Fell tree own farm	88.9	93.3	84.4	75.6	85.6
Buy tree from neighbour	40.0	33.3	53.3	15.6	36.6
Buy from market	19.9	-	55.5	66.6	35.5
Gather own farm	13.3	15.5	24.4	11.1	16.1
Gather neighbours farm	33.3	17.8	33.4	11.1	23.9
Gather riversides	28.9	13.3	20.0	33.3	23.9
Gather along hedges	20.0	6.6	-	20.0	11.7
N	45	45	45	45	180

NB: Some households had more than one source of fuelwood.

The duty of scrounging for firewood is an activity specific for women and children, but more so children. Of those interviewed, 36.8% said firewood gathering is done by children alone, 19.8% women alone, while 40.8% said both women and children collect firewood. While the respondents (all adults) argued that by gathering wood, children learn to be "duty conscious", this in the long run might not be healthy to their academic achievements; it cuts deep in their time for studies.

In Group A locations, 91.1% of the homes surveyed fell trees from their own farms as compared to 80% in Group B (Table 3). This is because Group A is densely wooded, mainly due to the large landholding size and the presence of numerous steams (figure 2). This is deeply rooted in the belief that trees are mostly planted along river valleys while the remaining farm portions are spared for agricultural productivity.

The proportion of people who buy fuelwood from the market is higher in Group B (61.1%) than Group A (9.9%). It therefore, appears that, wood, as a commodity on the cash economy increases in value from Group A to B. Infact, firewood usually sold as 3-4 pieces of split wood at Ksh. 1 weigh 1 Kg in Group B, while in Group A, the weight varies from 1.5 - 2 kg. The pattern showing wood commercialization from A to B can be associated with the availability of the product. A similar pattern occurs when households that gather firewood are considered.

In Group A, 30% of the households gathered firewood as compared to 41.1% in Group B. The difference indicates the difficulties with which people in Group B secure firewood; most of them have to forage for it. The relative scarcity of firewood explains why in Group B, people tend to swing to other alternatives (charcoal and kerosene) whenever there is an opportunity to do so.

Of the six firewood vendors interviewed in Group B, all but one imported wood from other divisions. The remaining one, cuts trees from own farm or bought a tree from neighbours then splits and sun-dries it ready for sale. Similarly, of the four firewood vendors interviewed in Group A, all but one imported wood from other divisions; one vendor imported wood from another district, Nandi. The remaining two purchased round wood from Kaimosi in Hamisi Division.

Most firewood sold to the firewood vendors is illegally poached from the nearby Kakamega Forest. This is confirmed by the long lines of women and children seen carrying heavy headloads of firewood, indigenous in nature (not usually grown on people's farms) on market days to look for prospective buyers. Men are also seen carrying bicycle-loads of firewood to markets not easily reached by women and children.

The average daily fuelwood consumption in the division is 12.7 kg (Table 4). This figure is skewed by a few small quantities, considering that the mode is 14.5 kg. The division average of fuelwood used for cooking, spaceheating and waterheating is 10.5 kg, 1.9 kg and 1.7 kg respectively.

Table 4: Mean and mode of total quantity of fuelwood used daily; and amount used daily for cooking, space heating and water-heating.

Quantity (kg) \ Locations		North Maragoli	East Maragoli	West Maragoli	Izava	Division
Used Daily	Mean	12.1	13.6	12.3	12.6	12.7
	Mode	10.0	14.0	8.5	15.5	14.5
	N	45	45	45	42	177
Used For Cooking	Mean	10.6	11.7	9.6	10.1	10.5
	Mode	8.0	12.0	6.5	12.5	8.0
	N	45	44	45	42	176
Used For Spaceheating	Mean	2.0	1.7	1.8	2.0	1.9
	Mode	2.0	1.5	2.0	2.0	2.0
	N	28	40	36	33	137
Used For Waterheating	Mean	1.4	1.0	1.8	1.7	1.6
	Mode	1.5	1.0	2.5	2.0	1.0
	N	8	18	30	24	80

The total fuelwood consumed is higher for Group A (12.9 kg) than Group B (12.5 kg). The same trend recurs when considering firewood used daily for cooking, that is, Group A (11.2 kg) and Group B (9.9kg). High fuelwood consumption in Group A can be attributed to fuelwood availability, relative insignificance of commercial fuels, and the relatively lower incomes in Group A as compared to Group B.

Unlike firewood used for cooking, the situation changes for other end-uses, spaceheating and waterheating. Scarcity of firewood makes these end-uses luxuries unaffordable by those less economically able. Hence, Group B with relatively higher incomes (average Ksh. 2608 per month) than Group A (Ksh. 2122 per month) used more firewood for spaceheating and waterheating. It therefore appears that an increase in income, not only increases quantity of firewood used, but also increases diversification in the end-use systems.

b <u>Charcoal</u>

All charcoal used in the division is imported from other divisions in the district and from other districts. Specifically these areas include Nandi District, Hamisi Division and Shinyalu Division where charcoal is secretly burned in government gazetted forests. In Hamisi Division, people even poach wood from traditionally sacrosanct forested areas set aside for the highly respected circumcision rites. The cutting of whole trees for charcoal burning in wasteful earth kilns accelerates deforestation.

Although charcoal production was not done in the study area, but was a subject of this study, the researcher investigated charcoal production from various sites that serve the area. Charcoal burned in the forests is transported at night in lorries and pick-ups to avoid the watchful eye of forest guards. Charcoal is sold at a wholesale price of Ksh. 40 to 45 per sack.

The charcoal laden vehicles unload their cargo at various charcoal outlets in the division where charcoal is sold to vendors at almost a double price of Ksh. 80 to 85 per sack. The vendors sell charcoal to customers at Ksh. 90 and Ksh. 24 per sack and "debe" respectively. since a sack has about six "debes", then the cumulative cost per sack for those who buy in "debes" is Ksh. 144.

The escalating cost of charcoal mostly affects Group B households. This is attributed to the high demand for charcoal in Group B (82.2% of the households surveyed use charcoal) than in Group A where only 70% use charcoal (Table 5). In Group A, charcoal is sold to vendors at Ksh. 70 per sack, who then sell to customers at Ksh. 80 and Ksh. 18 per sack and "debe" respectively.

Table 5: Charcoal Usage.

Locations		% frequency of households which: Use charcoal	Doesn't use charcoal	Total
North Maragoli	N=45	73.3	26.7	100.0
East Maragoli	N=45	66.7	33.3	100.0
West Maragoli	N=45	84.4	15.6	100.0
Izava	N=45	80.0	20.0	100.0
Division	N=180	76.1	23.9	100.0

The variation in the price of charcoal reflects the relatively greater scarcity of fuelwood in Group B, which means the demand for other fuels will be greater than in Group A. The differences in demand dictate that prices respond to market conditions.

Unlike in Group B, charcoal users in Group A have the alternative of buying charcoal directly from charcoal burners. Charcoal burners trek for more than 10 kilometres from areas like Kamulembe in Hamisi Division to sell charcoal in Group A. This is common during rainy seasons when demand for charcoal shoots up. These people sell a sack of charcoal at prices ranging from Ksh. 55 to 65.

This advantage is however enjoyed by Group A households only during rainy and cold seasons, because 38.9% of those interviewed in this area said charcoal is not always available, compared to only 1.3% in Group B. The high demand for charcoal in Group B assures vendors and burners a steady market all the year round, hence charcoal is always available.

The total amount of charcoal used daily is higher for Group B (2.9 kg) compared to 2.3 kg in Group A (Table 6). A similar pattern is shown when charcoal used for cooking is considered. This finding is not surprising, especially if the quantity of charcoal used should reflect charcoal availability, relative income levels and fuelwood scarcity. As already seen, in Group B locations, charcoal is more available, incomes are relatively high and own-farm fuelwood is lesser.

Therefore people have to buy charcoal to supplement the scarce fuelwood.

Table 6: Mean and mode of total quantity of charcoal used daily; and amount used daily for cooking, space heating and water-heating.

Quantity (Kg)		North Maragoli	East Maragoli	West Maragoli	Izava	Division
Charcoal used Daily	Mean	2.1	2.4	2.9	2.8	2.7
	Mode	1.5	2.0	3.0	2.5	2.0
	N	33	36	39	30	138
Charcoal used for Cooking	Mean	1.8	1.8	2.0	1.9	2.7
	Mode	1.5	1.5	2.0	2.0	2.0
	N	33	36	39	29	137
Charcoal used for Spaceheating	Mean	1.4	1.1	1.0	1.3	1.1
	Mode	0.5	1.5	1.5	1.0	1.0
	N	23	21	31	25	100
Charcoal used for waterheating	Mean	0.7	1.1	0.8	0.8	0.8
	Mode	0.5	0.5	1.0	0.5	1.0
	N	11	7	18	16	52

However unfamiliar patterns are seen for other charcoal end-uses. For instance, charcoal used for spaceheating is higher in Group A locations (1.3 kg) than in Group B (1.2 kg). The same trend appears for waterheating charcoal. It could be explained that most people in Group A bought charcoal mainly for spaceheating and waterheating. This is because the study was carried out during a rainy and cold season, April - July. This is the period when Group A households get charcoal cheaply from charcoal burners.

In Group B, prices for charcoal remain fairly stable in both cold and warm seasons. Hence only a few financially able households can commit extra cash for space and waterheating charcoal.

c. Paraffin

Domestic use of paraffin (kerosene) is mainly for cooking and lighting, with only 0.6% of the homes surveyed using it for waterheating (Table 7). More people (43.3%) use kerosene for cooking in Group B compared to only 17.8% in Group A. Most households (98.9%) use kerosene for lighting, while the difference representing two households use electricity alone.

Table 7: Uses of paraffin

Uses \ Location	% frequency				
	North Maragoli	East Maragoli	West Maragoli	Izava	Division
Lighting	95.6	100.0	100.0	100.0	98.9
Cooking	13.3	22.2	44.4	42.2	30.6
Water-heating	2.2	-	-	-	0.6
N	43	45	45	45	177

NB: Some households use paraffin for more than one purpose.

It is evident that there is a definite switch to kerosene for cooking when there is an increase in cash income . A large proportion of homes in Group B with an average income of Ksh. 2608 per month use kerosene for cooking as compared to Group A with an average monthly income of Ksh. 2122. The switch to kerosene could be attributed to the fact that it is easily transported, is relatively inexpensive compared to other commercial fuels, can be utilized by less expensive equipment and is bought in small quantities.

Paraffin availability is a problem in the study area, since 82.7% of the respondents said it isn't always available. Petrol station managers said transportation from major depots is the main constraint. This is because the main depot serving the area, Nairobi, is too far that any small problem in production and distribution is highly magnified.

It might look exceptional that 33.3% of the respondents in North Maragoli said paraffin is always available (Table 8). This is because until recently, this area did not enjoy close services of a petrol station. Hence they are used to buying kerosene in small quantities from shops. These second-hand dealers ferry kerosene from far, such that, at times of shortages they get it from as far as Kisumu. Therefore, despite the high charges, they ensure that paraffin is always available.

Table 8: Paraffin Availability

Availability / Locations		% frequency			
		Always available	Not always available	No Response	Total
North Maragoli	N=45	33.3	62.3	4.4	100.0
East Maragoli	N=45	6.7	93.3	-	100.0
West Maragoli	N=45	2.2	97.8	-	100.0
Izava	N=45	6.7	93.3	-	100.0
Division	N=180	16.2	82.7	1.1	100.0

A large proportion of those interviewed in Group B (43.3%) use paraffin for cooking compared to only 17.8%

in Group A. Similarly Group B households use more paraffin per day (average 237.5 ml) than Group A with an average of 165.5 ml per day. This is mainly attributed to the fact that Group B households experience more fuelwood scarcity problems than Group A. Hence the tendency to switch to alternative fuels is higher.

d. Liquid Petroleum Gas (LPG)

The better-off rural households invest in LPG stoves, mainly used for cooking. However, LPG, because it is expensive contributes less to rural cooking. Of the households surveyed, only three used the gas.

All the households using LPG for cooking indicated that they only use it occasionally, especially when fast cooking is required or when the household has "special guests". Therefore, it appears that the use of LPGas in the rural areas, though a necessity, was also an indication of one's increasing social status.

e. Electricity

Electricity, though not a typical rural domestic energy, is used by a small (6.1%) but increasing proportion of households. All households using electricity are connected to the national electricity grid, hence enjoy continuous supply.

All households use electricity for lighting and to run electrical equipments like radio and television. Only two households used electricity for ironing. Monthly charges vary greatly depending on the consumption of individual households. None of those interviewed paid more than Ksh.40 per month.

Of those interviewed, 72% were interested in electricity arguing that with better lighting their children would study properly and perform better in school. Infact, the need for electricity is so high that most people who have build permanent houses have had them wired, in expectation of connection to the main electricity grid through the Rural Electrification Programme proposed by the government in 1976.

f. <u>Agricultural Residues</u>

Agricultural residues as a substitute to woodfuel was used by 91.2% of those interviewed (Table 9). This is an indicator of the difficulties with which households procure fuelwood, especially for cooking. The most commonly used agricultural residues are maize cobs (91.1%) and maize stalks (83.4%). This is because maize is the most commonly and frequently grown food crop in the area and hence the residues are easily generated.

Table 9: Agricultural Wastes used as Fuel

Waste \ Location	% frequency				
	North Maragoli	East Maragoli	West Maragoli	Izava	Division
Maize cobs	95.5	91.1	91.1	86.7	91.2
Maize stalks	91.1	80.0	88.9	73.3	83.4
Tea prunings	57.8	46.7	40.0	31.1	43.9
Coffee prunings	57.8	42.2	26.6	15.5	35.6
Cow dung	2.2	-	2.2	8.9	3.3
None	4.5	8.9	8.9	13.3	8.8

NB. Some households used more than one agricultural waste

Other residues used are tea prunings (43.9%) and coffee prunings (35.6%). Tea prunings are used despite the Agricultural Extension Officer's advice that they should be left on the plantation to form organic manure. Most farmers were aware of this advice, but nevertheless felt they had no choices but to use the residues.

Not all farmers who use these residues had planted coffee and tea or maize. Most of them borrow from neighbours and relatives. Some respondents said they get a substantial supply of maize cobs from as far as Kitale in Trans Nzoia District where residents have little use for them.

Only six households used cow dung. These were mainly old women. They however did not use cow dung to cook, but to preserve fire. They asserted that dry cow dung has the rare property of burning extremely slowly that by the next morning, fire could still be glowing. Therefore, they didn't have to spend money on matches. Most of them, however, admitted that their mothers used cow dung specifically to cook maize and beans mixture overnight.

III Causes, Effects and Solutions to Woodfuel Scarcity

a. Causes of Woodfuel Scarcity

An observation of the woody biomass density revealed that Sabatia Division is a heavily wooded area. It was hence concluded that, the observed fuelwood shortage might be due to social and cultural forces within the households that determine control over wood production and utilization on the farm.

Most respondents said that there were no socio-cultural factors which restrained women from cutting trees for fuelwood on the farms. However the respondents, both male and female, added that only a small tree can be cut with the woman's authority and by a woman.

All those interviewed admitted that a large tree cannot be cut for firewood alone. Instead, one buys a small tree to cater for temporary fuelwood supply; to last for as long as a buyer for the tree is found, after which, the branches can be used for firewood. Therefore, the use of trees which have the potential to generate cash income or to provide construction materials is considered unacceptable in this area. This induces artificial fuelwood shortages.

Of those interviewed, 82.2% said that it is a taboo for a woman to plant trees. To explain this, old men said that in old days planting of a tree, a banana or shrubs demarcating the boundary symbolized land ownership; unlike procurement of a land title deed today.

The old men prestigiously emphasized that in their customs, a woman is not supposed to own land, hence by inference she is not supposed to plant trees. If this is done, she will be undermining the man upon whom the authority to own land is solely bestowed. For this behaviour, the woman evokes the wrath of the spirits of the dead, which punishes not only the woman but the entire family, especially the man. Hence, the man vigilantly guards the woman to ensure that this taboo is not violated.

Only 17.8% of those interviewed denied perpetuation of such taboos and beliefs. However, all female respondents who denied the existence of these taboos had not planted any trees in the homestead. And, the male respondents did not allow their wives and daughters to plant trees. Hence, it can be concluded that while a few respondents (especially the educated and the religious) denied the existence of such beliefs, the truth is, these taboos and beliefs are still perpetuated.

Although 82.2% of the respondents admitted the existence of these taboos, 43.2% did not know the reason behind the restriction. Some of the reasons advanced for the perpetuation of these taboos in order of importance included: failure of the wife to give birth, death of husband, girls fail to get married, women die early, and it is a sign of disrespect to the husband (Table 10). All these reasons converge on the focal point of marriage, where in the Luhya customs, failure to give birth or to get married was and to some extend is still considered anathema..pa

Table 10: Reasons given for Traditional beliefs.

Reason \ Location	% Frequency				
	North Maragoli	East Maragoli	West Maragoli	Izava	Division
Husband can die	31.5	32.5	12.5	24.3	25.7
Woman die early	27.7	5.0	12.5	8.1	12.2
Wife can't give birth	26.3	30.0	31.3	40.5	31.8
Girl not married	23.7	25.0	21.9	24.3	23.6
Disrespect to husband	23.7	10.0	6.3	5.4	11.5
Reason unknown	42.9	42.5	53.1	40.5	43.2
N	38	40	33	37	148

NB: Some respondents gave more than one reason.

Deliberate agroforestry where woody plants are interplanted with agricultural crops was practiced by only 17.8% of those interviewed. Only one tree species Sesbania sesban was planted, for fuelwood production alone. More people (30%) practiced agroforestry in Group B locations compared to only 5.6% in Group A. It appears that the hardships experienced by Group B households to procure fuelwood has sensitized them into accepting the hitherto unaccepted methods of woodfuel production.

The respondents said they don't interplant trees and crops because as a rule, crops are not planted on the same farm unit as trees because crops might have retarded growth. This is attributed to the little awareness the farmers have about agroforestry.

The scanty knowledge on agroforesty practices held by the farmers is reflected on tree species commonly planted in the area. _Eucalyptus_ species was by far the most common tree species, planted by 93% of those interviewed. It was liked because of its fast growth rate and large size when fully grown. People, however, showed a disliking to this tree species especially when grown along land boundaries or close to farm portion set aside for crops. It was believed that this tree had a drying effect on the soil because it absorbs large quantities of water and makes it to lose its fertility faster.

Cupressus species are the second common trees, planted by 55.1% of the study sample. It was liked and disliked for similar reasons as Eucalyptus species.

Eucalyptus species are often planted in marshy areas and along river valleys where the supply of abundant water is assured. This explains why respondents in Group A, naturally endowed with many streams, marshy and swampy areas, plant more *Eucalyptus* species (average 95 trees per year per household) than respondents in Group B (90 trees) which has fewer streams, marshy and swampy areas.

The desire to plant *Eucalyptus* species around wetlands is so high that one respondent commented that,

> During the demarcation of land to allocate to the family members, brothers fiercely quarrel and sometimes it ends up in a physical confrontation as

each claims the right for the portion close to the wetlands, (Akenga, 1991 personal communication).

Despite the observed preference for Eucalyptus species, its planting close to rivers has been banned by the government. This was confirmed by the Divisional Forest Extension Officer. Other than Eucalyptus and Cupressus species, people planted indigenous trees (13.9%) like, Croton megalocarpus, Markhamia, species, Elgon teak, Croton macrostachyus and Ficus species among others. Fruit trees planted include guava, loquats, avocado and oranges among others. Fruit trees not only supplied fruits, but their branches were coppiced to supply fuelwood. Shade trees commonly planted include, Terminalia madagascariensis, Jacaranda mimosifolia, Lantana camara, Nerium oleander and Schinus molle among others. Other trees planted include Maesopsis eminii, Pinus patula and Sesbania sesban

An average of 136 trees per household were planted in 1990. This figure appears high enough to replenish the trees cut for various purposes. However, the figure is exaggerated since 65% of those interviewed said survival rate was lower. Survival rates are low because of poor care, erratic rainfall and grazing or trampling by livestock.

Of the homes surveyed, 12.2% did not plant any trees in the year 1990. Topping the list of reasons given for not planting trees is shortage of labour or plainly put, lack of somebody to plant (40.9%). This finding is not surprisng because most respondents were women whose husbands and children were away from home for long periods. Since, as already observed women do not plant trees, any growing season without a male member of the family at home goes without any tree being planted. Other reasons which were prevailed include, land scarcity, lack of money to buy seedlings and laziness (Table 11)

Table 11: Reasons given for not planting trees.

Reason \ Location	% Frequency				
	North Maragoli	East Maragoli	West Maragoli	Izava	Division
Land Scarcity	27.3	25.0	25.0	-	22.7
Labour Shortage	27.3	75.0	50.0	33.4	40.9
Lack Seedling Money	27.3	-	-	-	13.7
Laziness	18.1	-	25.0	66.6	22.7
Total	100.0	100.0	100.0	100.0	100.0
N	11	4	4	3	22

The yearly average of trees planted is high (140) for Group A than for Group B (132). This does not appear proportionate to the average income and education level for the two areas. Farm size, however, appear a strong determinant of the number of trees planted; because Group A with larger landholding (1.95 acres) planted more trees than households in Group B with landholding of 1.5 acres per household.

The respondents identified six major purposes of trees planted (Table 12), of which fuelwood, building and sale prominently featured. Since the majority of the respondents were women it is understandable that fuelwood should feature strongly. Ninety eight per cent of the respondents used trees for fuelwood and building, while 93% said trees are for sale.

Table 12: Purpose of Tree Planted

Purpose \ Location	% Frequency				
	North Maragoli	East Maragoli	West Maragoli	Izava	Division
Fuelwood	88.2	100.0	100.0	100.0	97.5
Building	91.2	100.0	100.0	100.0	98.1
Sale	76.5	97.6	97.6	4.8	93.0
Fence	23.5	19.5	-	28.6	12.7
Shade	14.7	9.8	14.6	14.2	12.7
Fruits	20.6	9.8	24.3	11.9	19.6
N	34	42	41	42	158

NB: Some respondents stated more than one purpose

The conflicting competition for trees makes them so valuable on the market economy that their use for fuelwood is relegated to the periphery. Trees are seen to have been "put on constructive use" when sold for money or when used for construction. This introduces artificial shortage of fuelwood.

Several causes of woodfuel scarcity as summarised in Table 13 were given by the respondents. Most, have been discussed in the preceding text.

Table 13: Causes of woodfuel scarcity

Cause \ Location (% frequency)	North Maragoli	East Maragoli	West Maragoli	Izava	Division
Population pressure	20.0	31.1	33.3	46.7	32.7
Laziness	37.8	66.7	49.0	79.9	58.3
Land scarcity	53.3	60.0	51.0	80.0	68.4
No replanting	22.1	15.6	15.5	13.3	16.2
Preference to crops	28.9	49.0	24.4	15.6	30.0
Lack river valleys	22.2	8.8	4.4	2.2	9.4
No more bushes	28.9	8.8	20.0	15.5	13.3
Brick burning	8.9	11.1	2.2	-	5.6
Overdependence on wood	15.5	8.9	15.5	17.8	14.5
Priority for cash	20.0	13.3	13.3	2.2	12.2
Neighbour Complains	6.6	28.9	-	-	2.8
Lack money for seedlings	13.3	4.4	4.4	2.2	6.2
Lack of care for seedlings	13.3	2.2	2.2	15.6	9.5
N	45	45	45	45	180

NB: Some respondents stated more than one cause.

b. Effects of Woodfuel Scarcity

Traditionally the Maragoli people used to keep firewood in a store locally referred to as "ilungu" for two reasons, to dry-up and to store firewood for needy days. However, only 19% of those interviewed kept firewood in store. Even then, of those who stored firewood, only 2% kept to use it in future. The rest (98%) put firewood on "ilungu" to dry it up.

More households (28.9%) stored firewood in Group A as compared to only 14.5% in Group B. This is because Group A has a large landholding, has numerous streams and therefore had more trees for firewood. Group B households mostly buy dry firewood from markets. The small number of people storing firewood is an indicator of the embedding woodfuel scarcity in the area.

That most people don't store firewood does not mean they always use dry wood. The truth is, firewood is so scarce that there's none to store. Instead, wet wood is hurriedly sun-dried before being used half dry. Perhaps, this is why 67.8% of those interviewed experienced smoke problems in the kitchen. Those who did not experience the smoke problem (32.2%) used wood that was completely dry, had well ventilated kitchens, mostly used charcoal and kerosene or had built smoke dispelling chimneys.

About seventy nine per cent of Group A households experienced smoke problems compared to only 56.7% in Group B. This is because most people in Group B use dry wood readily available on market, and further, most of them had a high propensity of changing to charcoal and kerosene for cooking in times of extreme scarcity. This is in contrast to the relatively low income household in Group A who mainly use firewood for cooking.

Smoke problems were mostly experienced when people cooked with poorly dried firewood and gathered materials. Specific smoke associated problems include eye irritation, coughing, headache, utensil and roof darkening and smell in clothes. These problems are associated with high indoor air concentrations of biomass fuel smoke, which yield high emissions of a number of air pollutants including suspended particulates, hydrocarbons of several categories and carbon monoxide.

While its hard for many people to contemplate using wet wood for cooking, some people in Sabatia Division find it hard to get even poorly dried wood. When the already bad situation comes to this point, many families go without cooked meals. Of those interviewed, 25.6% admitted that on several occasions they miss to cook.

Extreme scarcity of firewood is experienced during rainy seasons when collection of any burnable material is hindered. Of the 74.4% that never miss to cook because of firewood scarcity, most of them struggle hard to cook. Indeed, one woman said that,

> I would rather, split up a piece of furniture or pull down the fence for fuelwood than allow my kids to go without a meal, (Lanogwa, 1991, personal communication).

Increasing fuelwood scarcity is also reflected in the escalating prices of charcoal and firewood. For instance a decade ago one sack of charcoal cost only Ksh. 25 in this area. This, compared to the present price of Ksh. 90 represent a price increase of 260% inside of a decade.

Unlike the present state where almost 35.5% of the households buy firewood, only 5.5% of those interviewed bought firewood 10 years ago. The rocketing prices of woodfuel indicates that the woodfuel situation will reach critical levels faster than it was previously suspected.

c. <u>Solutions to Woodfuel Scarcity</u>

In order of importance the respondents felt the increasing domestic energy problems could be alleviated as follows, planting more trees, use of alternative fuels, planning of families, securing more land, subsidizing the cost of petroleum based fuels, government providing more land, use of improved stoves, practicing agroforestry, provision of seedlings by government, and using firewood conservatively (Table 14). A few (4.5%) seemed to have given up hope of finding solutions and declared that they did not know how the woodfuel scarcity problem could be alleviated.

Table 14: Solutions to woodfuel scarcity

Solution \ Location	% frequency North Maragoli	East Maragoli	West Maragoli	Izava	Division
Plant More trees	68.9	86.7	82.2	71.1	77.2
Government give land	31.1	15.5	8.9	22.2	19.5
Plan families	24.5	24.4	24.4	37.7	31.7
Use alternative fuels	33.4	35.5	24.4	42.2	33.9
Practice agroforestry	8.9	4.4	22.2	28.9	16.1
Buy more land	24.4	11.1	35.5	26.7	24.4
Government provide seedlings	31.1	11.1	6.7	13.3	15.6
Use improved stoves	8.9	20.0	22.3	13.4	16.2
Subsidize fuel cost	13.3	35.5	15.6	20.0	21.0
Conserve firewood	20.0	17.7	17.8	6.7	15.5
None	2.2	8.8	6.7	2.2	4.5
N	45	45	45	45	180

NB: Some respondents stated more than one solution

Most people (77.2%) felt the most appropriate measure against the prevailing woodfuel scarcity was by planting more trees. However, most of these people were suggesting the planting of Eucalyptus and Cupressus species, mostly planted for commercial gains rather than to satisfy domestic energy needs. This is supported by the fact that only 16.1% of those interviewed saw agro-forestry as a solution.

Increased use of alternative fuels like kerosene, LPG and electricity for cooking, especially for those who can afford them could alleviate the scarcity problems. Those who cannot afford the cost of the fuels prayed for government subsidies.

Few people (16.1%) felt deliberate agroforestry, if practiced is a potential solution to the problem. However most people (96.8%) felt the government should provide seedlings of agrofrestry trees. This is a set back in the planting of these trees because unlike for Eucalyptus and Cupressus species whose nurseries were prepared by the farmers, none of those interviewed had a nursery for agroforestry trees.

A small (31.7%) but significant proportion of the respondents felt that family planning is a solution to woodfuel scarcity. This solution is handy because increasing the supply of woodfuel or reducing the demand through appropriate conversion technology alone cannot be a solution to the fuelwood scarcity. Since the amount of wood burned is determined by the number of people using it, then population control measures should be considered.

Almost half (43.9%) of the respondents felt acquiring more land can alleviate the scarcity problem. Of these, 24.4% felt they should buy their own land, while 19.5% felt the government should provide land. It follows that, while many people feel land is a priority solution to fuelwood scarcity, many people cannot afford buying their own pieces. Therefore, to face the problem, strategies tailored on the principle of wise and constructive use of the available small farms should be employed.

As a solution to wood scarcity problems, 16.2% of those interviewed stated use of improved stoves, while 15.5% stated conservation of firewood. When the respondents were asked how they could conserve wood, the peculiarity of the last solution is identified. The respondents said firewood should be conserved by using more agricultural residues and by missing some meals.

The diversity of solutions given by the respondents show that people in Sabatia Division are aware of the embedding woodfuel scarcity. That these people suggested diversified solutions, and yet domestic energy problems are still rampant suggests presence of awareness but lack of motivation to redress the problem.

IV <u>Woodfuel Production and Conservation Methods</u>

More than half (67.3%) of the households surveyed got seedlings from their own nurseries, (Table 15). More people (72.2%) get seedlings from their own nurseries in Group B compared to Group A locations (62.2%). It could therefore be said that, Group B households have learned to be self reliant due to comparatively more serious fuelwood scarcity.

Table 15: Sources of Tree Seedlings

Source \ Location	% frequency				
	North Maragoli	East Maragoli	West Maragoli	Izava	Division
Own Nursery	51.1	73.3	73.3	71.1	67.3
Buy from neighbour	57.8	37.8	33.3	35.5	41.1
Buy from government nursery	4.4	8.9	13.3	17.7	11.1
N	45	45	45	45	180

NB: Some households got seedlings from more than one source.

More households (47.8%) bought seedlings from neighbours in Group A compared to only 33.4% in Group B. This could be the reason why in Group A, 20% of the respondents said seedlings are not easily available as compared to only 2.2% in Group B. This is because in Group A, most people got seedlings from other sources hence the timing of the planting period was poor.

Seedling availability is not a major obstacle to tree planting in the area. Of the 180 households surveyed, only 20 found it a problem. Failure to get enough seedlings was attributed to irregularity of rainfall by 70% of the respondents. This reason is easily disputable because Kakamega District is one of the wettest parts of Kenya, receiving rains for an average of 9 months in a year. Other reasons given for failure to get enough seedlings include, long distance to government nurseries and lack of money to buy seedlings.

Cooking in Sabatia Division is mostly over open-fires. This was true for 98.3% of those interviewed, (Table 16). This cooking is supplemented in various homes with improved firewood stove (1.75%), improved charcoal stove (23.9%), ordinary metal charcoal stove (81.2%), paraffin stove (57.2%), and LPG stove (1.7 %).

Table 16: Cookstoves Used

Location / Types of Stove	% frequency				
	North Maragoli	East Maragoli	West Maragoli	Izava	Division
Three stone stove	100.0	100.0	100.0	93.3	98.3
Improved firewood stove	-	-	2.2	4.4	1.7
Improved charcoal stove	6.7	22.2	40.0	26.6	23.9
Ordinary metal charcoal	93.4	86.7	75.5	68.8	81.2
LPG-stove	2.2	-	4.4	-	1.7
Paraffin stove	31.1	55.6	64.5	77.8	57.2
N	45	45	45	45	180

NB: Some households used more than one type of cookstove

The tendency to change to fuel efficient stoves was largely influenced by the household income and fuelwood availability. The tendency is higher in Group B locations which have higher incomes than Group A. And, Group B locations with a small land holding, have a small per capita woody biomass available.

The three households using improved firewood stoves were in Group B. Similarly, the largest proportion (33.3%) of those using improved charcoal stoves was in Group B compared to only 14.5% in Group A. This can be seen to mean that people tend to adopt energy conservation measures faster when the fuel scarcity is almost critical.

Just like the improved firewood and charcoal stoves, LPG and paraffin stoves follow the above trend. However, this trend reverses with the ordinary metal charcoal stove. More people (90.1%) use this stove in Group A households compared to only 72.2% in Group B. This stove is made of uninsulated material and therefore wastes alot of energy. It can therefore be concluded that Group A people are relatively more ignorant of fuel conservation methods.

It is of interest to note that not every household that owned the above stoves used them. For instance, of the 103 households that owned paraffin stoves, only 40% used the stove regularly. This suggests that, while many households had at one time relied heavily upon kerosene and charcoal, the more than 100% increase in price had forced numerous households to use substitutes for both cooking and heating. On the other hand, all the 43 households owning improved charcoal stoves used them regularly. This means that once a person is convinced to buy an improved stove, then he/she uses it maximumly.

Only a quarter (25.6%) of the homes surveyed used improved stoves. It was imagined this could be because of lack of awareness. However, 78.3% of the respondents had heard of or seen these stoves. The source of this awareness includes, heard on radio or from friends, seen in market areas, or read about them in newspapers and books.

Although many people (78.3) were aware of these stoves, an equally high proportion (74.4%) did not use them. Hence being aware of the stoves alone does not appear to be the main reason behind adoption of these stoves. For, a large proportion had heard of or seen these stoves, but were not aware that they could considerably save charcoal.

As reason for not using fuel saving stoves, 33.8% of the respondents said the stoves are very expensive (Table 17). However, it was found out that there wasn't much difference in the cost of improved stoves and the ordinary charcoal stoves. The retail price for the improved charcoal stove at Chavakali Market was Ksh. 95 compared to Ksh. 65 for a similar ordinary metal charcoal stove. The difference of Ksh. 30 could be recovered within a short time through charcoal savings realised.

Table 17: Reasons given for not using improved stoves

Reason \ Location	% frequency				
	North Maragoli	East Maragoli	West Maragoli	Izava	Division
Cost	17.1	33.3	37.9	40.0	33.8
Availability	28.6	23.1	6.9	5.7	17.7
Awareness	42.9	25.6	34.5	22.9	33.1
Not necessary	25.7	15.4	27.6	28.6	25.4
Easily break	20.0	2.6	3.4	5.7	8.5
N	35	34	29	32	130

NB: Some respondents gave more than one reason

Other reasons given for not using fuel saving stoves include, inavailability (17.7%), lack of interest (25.4%), stoves are delicate (8.5%) and 33.1% blamed it on lack of awareness. Most people said the stoves are sold far, and when commuting costs are added, the stoves become unaffordable. At least 25.4% of those interviewed were satisfied with their present cooking methods and did not see the need of buying improved stoves. This could be attributed to ignorance of the advantages and benefits that accrue from using improved stoves.

Advantages of improved stoves given by those using them, in order of importance include, they save charcoal, they cook faster, are accident free and keep the room tidy. As expected, most of them (96%) said improved stoves are energy efficient, hence at any one time a small amount of charcoal is used compared to the ordinary metal cookstoves.

At least 46% of the respondents said that improved stoves cook faster than the ordinary metal stoves. These two advantages are realised because the improved stove encloses fire, which prevents wind from carrying heat away by forced convention. This also enables more of the hot gases in the fire to transfer their heat to the cooking pot. Therefore the wall built around the fire limits heat loss by radiation to the atmosphere and re-directs heat onto the cooking pot.

Fourty-four per cent of the respondents said improved stoves are accident free. This is due to the presence of a ceramic lining which insulates the fire, hence children are less likely to suffer burns. It is also attributed to the stability of the stove by the nature of its structure. The bell-bottom design ensures great stability, and its extended bottom provides enough room for ash, and by so doing keeps the room tidy.

Other disadvantages given by the respondents include, they are dedicated (58%), they don't spaceheat (34%), are heavy and therefore hard to handle (20%), are irrepairable (14%), and are expensive (14%). It was explained that, if the stoves fall, they break easily and that when water spills on the clay lining, they easily disintegrate. They further complained that the stoves are irrepairable.

Although the heavy nature of the stoves increases their stability, it was argued that they cannot be handled easily by children; hence the chances of breaking were high. Thirty-four perper cent of the respondents argued that during cold seasons, the stoves are disadvantageous since they could not spaceheat.

Use of efficient kitchen management techniques can conserve energy. This is true because the ways in which cooks manage kitchens determine each kitchen's energy efficiency. The respondents were interviewed on the kind of energy management techniques practiced in the kitchen. Table 18 gives the results.

Table 18: Selected Kitchen Management Techniques Practiced.

Technique \ Location	% frequency				
	North Maragoli	East Maragoli	West Maragoli	Izava Maragoli	Division
Cooks with steam	26.7	17.8	37.8	37.8	30.0
Soaks long cooking foods	64.4	66.7	48.9	75.6	63.9
Extinguish firewood	93.3	88.9	93.3	100.0	93.9
Extinguish charcoal	62.2	53.3	62.2	97.8	68.9
Plans cooking	75.4	81.8	94.4	98.7	91.3
Covers cooking pots	100.0	100.0	100.0	100.0	100.0
Uses aluminium pots only	2.2	-	6.7	8.9	4.4
Uses wood instead of charcoal	22.2	31.1	55.5	51.1	40.0
Always uses drywood	55.5	53.3	88.8	95.5	73.3
Uses split wood	88.8	95.5	93.3	95.5	93.3
Uses a wind shield	17.7	20.0	24.4	13.3	18.9
Makes fire big enough for a meal	82.2	77.8	91.1	86.7	84.4
Boils food slowly	17.7	15.6	22.2	13.3	17.2
Cut food into small pieces	66.7	71.1	73.3	60.0	67.[illegible]
Teach children to conserve	100.0	100.0	100.0	100.0	100.0
N	45	45	45	45	180

NB: Percentage frequencies indicate only those who practice the technique.

Most of the selected kitchen management techniques are practiced. All techniques apart from four are practiced by more than 50% of the households surveyed. The four include, use of steam to cook food, exclusive use of aluminium pots, use of wood instead of charcoal whenever possible and use of a windshield for a lighted fire.

The proportion of people practicising these methods is higher in Group B households than in Group A. This finding is as expected because Group B households are found in an area where fuelwood scarcity is more severe than in Group A. Hence most of them buy firewood and charcoal usually imported from other areas. It is expected that they be more conservation conscious than their Group A counterparts.

V. Advice given to Farmers

The study investigated the role played by government and non-government agencies towards establishing effective methods of domestic energy production and conservation. Responses to this item are given in Table 19.

Table 19: Households that got advice on woodfuel production and conservation

Category \ Location	% frequency				
	North Maragoli	East Maragoli	West Maragoli	Izava	Division
Gets advice	35.6	33.3	40.0	44.4	38.3
Doesn't get advice	64.4	66.7	60.0	55.6	61.7
Total	100.0	100.0	100.0	100.0	100.0
N	45	45	45	45	180

More than half (61.7%) of the respondents were not advised by these officials. The rest (38.3%) got advice on woodfuel production but not conservation. Sources of advice were varied, but most got advice at barazas and funerals.

Most people were not adviced because in the study area, it is not usual for women to actively attend public barazas, hence advice is mostly given to men. The few women who were advised, usually got this advice at funeral services. It is usual for a government representative to address mourners on recent government policies.

At the chiefs' baraza, several government officials like Forest Extension Officer, Agriculture Extension Officer and Officials of Kanu-Maendeleo ya Wanawake are invited to address the public on new ideas in development and technology. Among the advice given to farmers include, that they: should plant trees during every rainy season, should not unnecessarily cut trees, should plant trees on sloping lands, should plant indigenous trees, should not plant Eucalyptus species along river valleys among others.

To confirm the responses made by those interviewed, further interviews were organized for the Divisional Forest Extension Officer, the chairlady, Kanu Maendeleo ya Wanawake; the Manager, Kenya Woodfuel Agroforestry Programme, and the centre manager, Bukura Agroforestry/Energy Centre.

Both the Kenya Woodfuel Agroforstry Programme and Bukura Agroforestry/Energy Centre, communicate to farmers through Divisional Forest and Agricultrual Extension Officers, Chiefs and their assistants and women leaders through seminars and workshops organized by the government, non-governmental agencies or by these centres. Apart from the seminars, the centres send handouts and booklets on matters deliberated upon to ensure a concerted follow up. The Bukura Centre has training programmes in agroforestry, improved stoves and biogas; given free to willing parties.

The Divisional Forest Extension Officer said that, due to shortage of personnel, it isn't possible to conduct awareness tours to every household. Therefore, advice on woodfuel production is usually given at chiefs' barazas. The assistant chiefs are also briefed and also adviced to brief village headmen on the new practices. However, none of the respondents was adviced at home by the headmen.

The chairlady, Kanu-Maendeleo ya Wanawake said message from these seminars is conveyed to the members of the organisation in their regular meetings. However only a few women were affiliated to the organization. It is therefore not surprising that very few women at the grass root get the message meant for them.

Officials concerned with establishment of agroforestry accepted that its rate of adoption is slow. This is because, despite the fact that agroforestry and indigenous seedlings at the centres are given free by whoever goes for them, people prefer seedlings for exotic trees like Eucalyptus species, which are sold.

VI. Alternative Sources of Energy.

Installation of biogas and solar units could ease the drain on the meagre cash income by reducing the amount of money spent on buying fuel. Almost half (47.2% and 47.8% for solar and biogas respectively) of those interviewed were aware of these energy technologies. They had either heard or read about these technologies from mass media, from friends, and in schools. At least 28.3% of those interviewed had seen these technologies, Table 20.

Table 20: Awareness of Solar and Biogas Energy Technologies

Category \ Location		% frequency				
		North Maragoli	East Maragoli	West Maragoli	Izava	Division
Solar	Heard of it	28.9	66.7	55.6	37.8	47.2
	Seen it	15.6	46.7	44.4	33.3	28.3
Biogas	Heard of it	40.0	51.1	64.4	35.6	47.8
	Seen it	26.7	20.0	48.9	17.8	28.3
N		45	45	45	45	180

NB: Figures indicate only those respondents that have heard of or seen solar and biogas energy technologies

Respondents willing to adopt these technologies represented 60% of the study sample. Among them, 30.6% expressed their wish to own solar or biogas units individually; while 29.4% preferred joint ownership. Several reasons were advanced for each nature of ownership.

Those who preferred joint ownership said this could make them pool their incomes so as to afford the purchasing and installation costs. Also, raw materials like livestock dung could be made readily available from various sources.

Those preferring individual ownership said this could make them solely accountable to the management of the units. They claimed group ownership would make it difficult to manage and maintains these units. They also said people differed in their lighting and cooking demands, some might use more fuel than others.

It was found that people in this area like doing things individually. Of the people interviewed only 20 belonged to social organizations, 15 of them women. The women belong to a local grouping called "Lisanga" organized to assist each other on their farms, or on other peoples farms at a fee. Other women belonged to Kanu Maendeleo ya Wanawake Organization. Men were members of cooperatives for coffee or dairy farmers.

Thirty per cent of the respondents expressed their wish to own Biogas or solar units individually, 29%experessed otherwise. Therefore when formulating strategies to introduce these energy technologies, efforts should be directed towards individual ownership.

Forty per cent of the respondents showed disinterest in owning solar or biogas units. Sixty per cent of them said they didn't know how to manage the energy units, 29% cited expenses involved and 11% said they could not get the necessary raw materials. The problem of cost might have been a major constraint since most respondents (65%) earn less than Ksh. 2499 per month. They cannot adopt these technologies without denying themselves some essential needs.

Interviews with solar electricity dealers cum electricians at Chavakali and Mbale Markets revealed that the total cost of purchasing and installing solar appliances for domestic purposes, was, on average, Ksh. 21,800 for a 10 watts (2 bulbs and a socket) power capacity. Inclusive is the cost of a panel, battery, fluorescent tu tube, switches, cables and installation.

Four households using solar energy were interviewed. The average cost of purchasing and installing appliances of a solar unit was given as Ksh. 19,500. All the four used solar energy for lighting and running electronic appliances. No household used solar energy for cooking or water heating.

One person in the area was currently using biogas. Two households had once used biogas, but the units had been dismantled. One respondent blamed this on lack of cow dung. He had four indigenous cattle which were grazed by tethering, hence cow dung could not be collected from one spot. The other respondent st said the husband was away on employment, and she was being "disturbed" by many people coming to see how animal dung could be used for lighting and cooking.

The respondent using biogas installed the unit in 1976 at a cost of Kshs. 6500. He uses biogas for cooking and lighting. For lighting, biogas lamps are used; while for cooking, the normal LPG burners with enlarged jets are used. Most components of the unit were locally assembled.

The only money spent was Kshs 100 per year for painting the gas holder black for maximum heat absorption and prevention of corrosion. The slurry was used as fertilizer for napier grass and Sesbania species used as fodder in the zero grazing unit. Asked if any problems were experienced with the unit, he said the only problem was inavailability of biogas lamps and stoves.

A Relational Analysis

One of the objectives of this study was to establish relationships between variables. Specifically they are:

a. how household energy consumption varies in relation to income and household size, and

b. the relationship between the respondent's education level and the tendency to adopt appropriate methods of woodfuel production and conservation.

Simple regression analysis was conducted and pearson's correlation ceffficient (r) computed. The coefficient of determination (r^2) was also computed.

A correlation matrix (Table 21) was used to show the strength of the relationship between variables. An examination of the corrèlation matrix, therefore, will indicate those variables which are associated to greater or lesser extent. The coefficient of determination (r^2)

Y-Variables X-Variables		V.17	V.18	V.19	V.20	V.23	V.24	V.25	V.26	V.41	V.91	V.92	V.93
V.90	r	0.537	0.486	0.257	0.206	0.625	0.449	0.551	0.514	0.425	0.425	0.167	0.383
	r^2	0.289	0.237	0.066	0.042	0.390	0.201	0.304	0.264	0.181	0.060	0.028	0.147
V.5	r	0.305	0.289	0.064	0.150	0.542	0.353	0.549	0.415	0.408	0.165	0.123	0.492
	r^2	0.093	0.083	0.004	0.022	0.294	0.124	0.302	0.172	0.166	0.027	0.015	0.242
V.6	r	0.249	0.249	0.090	0.101	0.499	0.347	0.469	0.397	0.418	0.184	0.199	0.523
	r^2	0.062	0.062	0.008	0.010	0.249	0.120	0.220	0.157	0.175	0.034	0.040	0.273
V.3	r	0.332	0.316	0.178	0.002	0.083	0.037	0.118	0.105	0.068	0.020	0.142	0.162
	r^2	0.110	0.099	0.032	0.000	0.007	0.001	0.014	0.011	0.005	0.170	0.020	0.026
V.4	r	0.529	0.491	0.226	0.185	0.046	0.068	0.027	0.0003	0.046	0.180	0.003	0.009
	r^2	0.280	0.241	0.051	0.034	0.002	0.005	0.001	0.00000	0.002	0.032	0.00001	0.0001
V.10	r	0.279	0.219	0.204	0.081	0.159	0.108	0.202	0.109	0.192	0.120	0.003	0.039
	r^2	0.078	0.048	0.041	0.007	0.026	0.012	0.041	0.012	0.037	0.014	0.00001	0.002

X-Variables

V.90 - Income
V.5 - Male Education Level
V.6 - Female Education Level
V.3 - Family Size
V.4 - Household size
V.10 - Farm Size
V.17 - Total firewood consumed
V.18 - Cooking firewood
V.19 - Spaceheating firewood
V.20 - Waterheating firewood
V.23 - Total Charcoal Consumed

V.24 - Cooking Charcoal
V.25 - Spaceheating Charcoal
V.26 - Waterheating Charcoal
V.41 - Number of trees planted
V.91 - Total paraffin Used
V.92 - Woodfuel Production Methods
V.93 - Woodfuel Conservation Methods

is also given in the table. It explains the proportion of variation in the dependent variable explained by a specific independent variable. The relationships are discussed as follows:

a. Income versus household energy consumption.

b. Household size versus household energy consumption.

c. Educational level versus methods of domestic energy conservation.

d. Educational level versus methods of woodfuel production.

a. Income versus household energy consumption

Three fuels commonly used in rural households were considered in this analysis. These are fuelwood, charcoal and paraffin. For fuelwood and charcoal, an analysis of the three end-use systems of cooking, spaceheating and waterheating were separately considered. This was to determine whether fuel consumption for the end-uses was sensitive to variation in income.

The use of paraffin for cooking and waterheating was only done occasionally. Hence, respondents found it hard to estimate paraffin used daily for lighting, cooking and waterheating. Therefore, only the average, total paraffin used daily was considered.

A large proportion (72.1%) of people in this area bought fuelwood used. It was, therefore, expected that people will consume more firewood as income increases. The results of simple regression support this line of reasoning.

A strong positive relationship (r=0.537) exists between total firewood consumed and household's monthly income. And, household income alone explains 28.9% of the variation in daily wood consumption (r^2=0.289). This moderate relationship between total firewood consumed daily (TFW) and household income (HINCOM) is expressed in the following equation.

$$TFW' = 9.96 + 1.053 \text{ (HINCOM)}$$

This can be interpreted as, for each additional shilling a household acquires per month, daily firewood consumed goes up by 1.053 kg.

A moderate relationship also exists when considering household income versus cooking firewood used daily (r=0.486). By itself, income explains 23.7% of the variation in cooking firewood used daily. However, unlike cooking, the results of simple regression show a weak relationship between income and other end uses; spaceheating firewood (r=0.257) and waterheating (r= 0.206).

It was anticipated that an increase in income would lead to increased diversification of end-uses. The results of analysis do not support this hypothesis, since income explains only 6.6% and 4.2% of variations in amount of firewood used daily for spaceheating and waterheating respectively.

This unexpected finding can be explained in two ways. One, this study was carried out during a rainy and cold season (April-July), when everybody found it imperative to spaceheat and warm water. Therefore, it was not possible to see the effects of household income on these end-uses. Secondly, fuelwood is not 100 percent commercialised; it is still got free or gathered or bought cheaply. Therefore, spaceheating and water-heating firewood cannot be very sensitive to changes in income.

Despite the weak relationships expressed between the amount of fuelwood used for spaceheating and waterheating, the positive relationships between fuelwood consumption and income were found to be statistically different from zero for all the three end uses ($P \leq 0.05$).

Firewood used daily	F = 72.3	DF=(1, 178)
Cooking firewood	F = 55.1	
Spaceheating firewood	F = 12.5	
Waterheating firewood	F = 7.9	

None of the homes surveyed burned charcoal for own use or for sale. All charcoal used in this area was imported, hence the commoditization of charcoal is 100% . It was therefore expected that households with high incomes will tend to use more charcoal. The results of regression analysis support this, since a high correlation exists between household income (HINCOM) and total charcoal used daily (TC), r=0.625. And, monthly household income alone explains nearly 39% of the variation in charcoal consumed daily (r^2=0.390). The strong relationship between household income and charcoal consumed daily is summarised by the following equation.

$$TC = 0.932 + 4.555 \text{ (HINCOM)}$$

This means that for every one shilling increase in the monthly household income, charcoal consumption goes up by almost 4.6 kg.

Strong associations were also expressed between monthly household income and other three charcoal end-uses. That is, charcoal used for, cooking (r=0.449), spaceheating (r=0.551), and water heating (r=0.540). The strong relationship between income and the last two end-uses can be contrasted with the weak relationship observed with fuelwood, spaceheating (r=0.257) and waterheating (r=0.206).

The comparison can be explained. As already pointed out, the study was carried out during a rainy and cold season when spaceheating and waterheating was extremely necessary. But, while firewood for these purposes could be got freely, charcoal had to be bought at even higher prices than when spaceheating and water-heating was not necessary. Therefore individual house-hold's income dictated who should use more charcoal, hence the observed strong relationship.

The observed positive relationships between house-hold income and charcoal consumption were all found to be statically significant ($P<0.05$).

charcoal used daily	$F = 113.4$	$DF=(1,178)$
cooking charcoal	$F = 44.9$	
spaceheating charcoal	$F = 77.7$	
waterheating charcoal	$F = 63.8$	

The last fuel to be examined is paraffin. Because households with higher cash income levels can afford more paraffin, they tend to diversify its functions. It is therefore expected that households with higher cash income should use more paraffin. However, the observed relationship appears to be relatively weak (r=0.245). Only 6% of the variation in paraffin consumption is explained by monthly household income.

For every one shilling increase in a household's monthly income, daily paraffin consumption increases by 0.040 ml only, as expressed in this equation: (TP means total paraffin consumed daily in every household).

$$TP = 119.5 + 0.0404 \text{ (HINCOM)}$$

The large constant term (119.5) in the equation reflects the difficulties of accurately estimating the amount of paraffin consumed in a greatly diversified population studied. It therefore represents the error term and also the variables not included in the equation.

The unexpected weak relationship (r=0.245) between household income and paraffin consumption despite the 100% commercialization of paraffin is attributed to the fact that paraffin is almost limited to provision of light for illumination, with few people using it occasionally to provide heat for cooking and warming. Therefore due to limited diversification and intensification of use, its consumption remains relatively insensitive to variation in cash income. The weak positive relationship between income and paraffin consumption was, however, found to be statistically significant from zero ($F_{0.05(1, 178)} = 11.4$).

b. Household size versus household energy consumption

It was the subject of this study to investigate the relationship between household energy consumption and both the family size and the household size. Family size constituted members of the immediate family including the male head, the female head and their children; while household size was taken to mean members eating in the house regularly, this includes workers, relatives and members of the immediate family.

Simple regression results revealed that family size did not significantly affect household energy consumption. Further, correlation analysis of the independent variables to test for multicollinearity (high correlation between independent variables) revealed that household size and family size, are highly correlated (r=0.477), Table 22.

Table 22: A correlation Matrix showing multicollinearity test results

	v.90	v.3	v.4	v.5	v.6	v.10
v.90	1.000	-0.033	0.105	0.635	0.540	0.22
v.3		1.000	0.477	-0.239	-0.305	0.126
v.4			1.000	-0.034	-0.027	0.119
v.5				1.000	0.783	0.078
v.6					1.000	-0.30
v.10						1.000

Variable Names

v.90	Household Income	v.5	Education level-male
v.3	Family size	v.6	Education level-female
v.4	Household size	v.10	Farm size

These results reveal that members of the immediate family don't always stay at home, most of them leave home to seek for education or employment. Therefore in this section, will be discussed the results of regression analysis with respect to household size as the predictor variable.

It would be expected that a large household should consume a greater amount of fuelwood than a small one. This is true because more firewood will be needed to cook for a large household. As expected, there was a strong positive relationship between household size (HHS) and total firewood used daily (TFW), r=0.529. Household size alone explains for nearly 28% of the variation in firewood consumption. The moderately strong relationship between household size and firewood consumed daily is expressed in the following equation.

$$TFW = 7.26 + 0.7783\ (HHS)$$

This equation can be interpreted to mean that, each additional household member requires nearly 778.3 grammes of extra firewood per day.

Household size also relates strongly with the amount of firewood used daily for cooking (r=0.491). This finding is reasonable, because any additional household member will require that more energy be used to cook. On itself, household size explains for about 24% of the variation in the amount of wood used daily for cooking.

Unlike for the relationship between household size and firewood used for cooking which is moderate, the relationships with the amount of wood used for spaceheating and waterheating are relatively weak, ($r=0.226$ and $r=0.185$ respectively). This is understandable because firewood is not regularly used for these end-uses. Further, not everybody spaceheats or warms water. Only the old and the young seriously require warm houses and warm water. Therefore, due to irregularity of use for these end-uses, they cannot be sensitive to variations in the household size.

However, all the positive relationships observed between household size and firewood consumption were statistically significant from zero ($P<0.05$).

Firewood used daily	$F = 69.05$	$DF=(1, 178)$
Cooking firewood	$F = 56.64$	
Spaceheating firewood	$F = 9.60$	
Waterheating firewood	$F = 6.30$	

According to the simple regression results, there's a very weak relationship between household size and charcoal consumption. The correlation coefficients are as follows, total charcoal used daily (r=0.046), cooking charcoal (r=0.068), spaceheating charcoal (r=0.029), and waterheating charcoal (r=0.00034). This is a reasonable relationship because in this area charcoal has become a normal market commodity. Therefore, its consumption is mainly dictated by the household's cash income and not the household size.

The weak relationship could also be attributed to the fact that charcoal used in this area is exclusively imported. Hence all charcoal used is bought. And as already observed, Group A locations with an average family size of 7.8 has low monthly income (average Kshs 2122) compared to Group B locations with a relatively high income of Kshs. 2608, but have an average family size of 6.7. This observation shows that, in this area people with relatively lower incomes tend to have larger families. This explains, the weak relationship between charcoal consumption and household size.

The weak relationship between household size and charcoal consumption was found to be statistically insignificant ($P<0.05$).

Charcoal used daily	$F = 0.381$	
Cooking charcoal	$F = 0.837$	
Spaceheating charcoal	$F = 0.129$	$DF = (1,178)$
Waterheating charcoal	$F = 0.0002$	

Household size was found to have a significant and positive relationship with paraffin consumption. This finding is reasonable because large households will require more paraffin for lighting extra areas and also for cooking. This pattern, however reasonable, is relatively weak ($r=0.180$). This finding is not surprising, because use of paraffin for other purposes other than lighting is limited and always erratic. Therefore sensitivity in paraffin consumption to variations in household size is bound to be relatively low.

The coefficient of determination (r^2) is 3.3%. This indicates that the variability in paraffin consumption reduces by only 3.3% when household size is considered. The weak relationship between household size (HHS) and total paraffin consumed daily (TP) is expressed in the following equation:

$$FP = 66.315 + 22.28\ (HHS)$$

This is interpreted to mean that, each additional household member will account for approximately 22 more millilitres of paraffin consumed daily. The large constant term (66.315) can be attributed to the difficulties involved in accurately estimating paraffin consumption of a diverse population. It also represents the many variables not represented in the equation. The relationship though weak, was found to be statistically significant at 0.05 significance level. ($F=5.989$, $DF=1,178$).

c. <u>Educational Level Versus Methods of Domestic Energy Conservation</u>

Education level was rated as years of schooling for each individual. This is because it was expected that the levels of education for the male and female head of the household will significantly affect the households' tendency to adopt appropriate methods of energy conservation differently. It was the researchers' initial opinion that education level be divided into male and female education levels.

However, regression analysis involving the two independent variables as a test for multicollinearity showed a strong correlation between male and female education level (r=0.783)- Table 22. Due to this strong positive relationship, it was decided that apart from a few instances where the difference between the two was reasonably distinct, female education level was considered adequate for this discussion. The female education was preferred because unlike men, women are always at the homestead and in the kitchen.

To slot various households into their conservation status, several conservation methods and kitchen management techniques were selected and ranked. Each conservation method/technique had a corresponding rank. If a household practiced a method/technique, the rank was considered a mark awarded for that practice. A total mark representing a household's conservation status was computed by adding all the marks acquired by practicing each appropriate conservation method or technique.

The selected appropriate methods of conservation and kitchen management techniques were ranked as follows:

Method/Techniques	Rank
a. Use of improved firewood cookstove	14
b. Use of improved charcoal cookstove	13
c. Teach children to conserve	12
d. Use stem to boil food items	11
e. Soak long cooking foods	10
f. Use wood instead of charcoal	9
g. Always use dry wood	8
h. Use aluminium pots only	7
i. Use split wood	6
j. Use a wind shield	5
k. Cut food into small pieces	4
l. Extinguish charcoal after cooking	3
m. Extinguish firewood after cooking	2
n. Cover cooking pots	1
TOTAL	105

It is expected that a well educated person is able to understand new development strategies faster than a less educated one. It is also expected that a well educated person should be able to adopt environmental conservation strategies faster, because he is expected to have a high level of perception.

The results of simple regression analysis between male education level and adoption of appropriate methods of domestic energy conservation supports this line of reasoning (r=0.492). Male education level alone explains nearly 24% of the variation in the tendency to adopt these conservation methods. This is mainly because as one gets more educated, his awareness of the need to conserve energy (and in the process save money) increases.

The relationship between female education level and adoption of appropriate methods of energy conservation is even stronger, (r=0.523). The coefficient of determination of r^2=0.273 indicates that the variability in the tendency to adopt appropriate methods of domestic energy conservation reduces by nearly 27% when female education level is considered. This therefore means that a well educated female in the household encourages fuel saving more than the male counterpart. This is attributed to the fact that, in this area, cooking is exclusively done or supervised by women. Hence they are in a better position to implement their knowledge on energy conservation than males.

The moderate positive relationships between male and female education levels with the tendency to adopt appropriate methods of domestic energy conservation were found to be statistically significant from zero ($P<0.05$), i.e:

$$\left.\begin{array}{ll}\text{Male education level} & F = 56.77 \\ \text{Female education level} & F = 66.91\end{array}\right\} DF=(1,178)$$

The relationship between education level and the tendency to adopt appropriate methods of energy conservation has been established to be strong, positive and significant ($r=0.490$ and $r=0.523$ for males and females respectively). Therefore, by implication, it would be reasonable to expect that as education level increase, the average fuel consumption slightly reduces.

The results of simple regression between female education level and daily firewood consumption supports this theory. There was a weak positive relationship between education level and firewood consumption as shown below.

Firewood used daily	F=11.760; r=0.240g
Cooking firewood	F=11.735; r=0.249
Spaceheating firewood	F= 1.465; r=0.098
Waterheating firewood	F= 1.842; r=0.101

Therefore unlike the high increase observed when firewood consumption was considered against variation in income, variation in education has little influence on wood consumption. Of this weak positive relationships, the last two were found to be statistically insignificant from zero ($P<0.05$).

However, the results of regression analysis between female education level and charcoal consumption showed a moderate relationship as follows:

Charcoal used daily	F=58.93;	r=0.4998
Cooking charcoal	F=24.32;	r=0.3467
Spaceheating charcoal	F=50.10;	r=0.4687
Waterheating charcoal	F=50.83;	r=0.4687

This can be explained because unlike firewood, charcoal produces less smoke and charcoal fires can be easily managed. Therefore as education level increases, people tend to prefer convenience in cooking. Hence, they use more charcoal and less firewood. This is why education alone explains for nearly 25% of the variation in charcoal consumption.

However, the strong cross-correlation between income and education cannot be side-lined; since it was established that as people become well educated, their incomes tend to increase (r=0.635). This could be the reason why the relationship between male education level and charcoal consumption was even much stronger,

Charcoal used daily	F=73.74;	r=0.542
Cooking charcoal	F=25.30;	r=0.353
Spaceheating charcoal	F=76.83;	r=0.549
Waterheating charcoal	F=37.00;	r=0.415

There's therefore, a strong relationship between male education level and charcoal consumption compared to that with female education level, despite the strong cross-correlation between the two independent factors ($r=0.783$). This is attributed to the strong relationship between income and education level ($r=0.635$). Further, in most homes surveyed men were the sole bread winners, therefore it is not surprising that male education level greatly influences charcoal consumption than female education. The moderate positive relationships between education level and charcoal consumption proved to be statically significant ($P<0.05$).

Paraffin consumption on the other hand showed a weak but positive relationship with variation in education level, ($r=0.165$ and $r=0.184$ for males and females respectively). This weak relationship cannot be taken to mean that people tend to save paraffin as they get more educated. Rather, this might be because use of paraffin for cooking was restricted to only 30% of the households surveyed. Use of paraffin for other end-uses (apart from lighting) was not only limited but also irregular. Therefore, the weak relationship does not indicate that people tend to conserve more paraffin when they move high in education.

d. <u>Education level versus appropriate methods of woodfuel production</u>

The seventh objective of this study sought to investigate the relationship between education level and the tendency to adopt appropriate methods of woodfuel production. There was no well defined measure for woodfuel production. Therefore the researcher developed arbitral measures as indicators of appropriate woodfuel production methods.

Several appropriate methods of woodfuel production were selected and ranked as follows:

	Method	Rank
a.	Interplant trees and crops	7
b.	Plant trees that can be lopped, coppiced or pollarded for fuelwood	6
c.	Make own nursery	5
d.	Plant trees every rainy season	4

e.	Encourage children to plant trees	3
f.	Care for seedlings	2
g.	Replace cut trees	1
	TOTAL	28

Each household practising each method was given a mark corresponding to the rank. The total mark was considered as each households' cumulative tendency to adopt appropriate methods of woodfuel production.

Another factor considered independently as an arbitral measure of woodfuel production is the number of trees planted in each household in the year 1990. A regression analysis was done to determine the relationship between education level (in years of schooling) and number of trees planted.

It was expected that increase in education should have a strong relationship with the tendency to adopt appropriate methods of woodfuel production. This is mainly because educated persons are expected to be able to understand environmental conservation issues faster.

Regression analysis results between education level and number of trees planted supported this line of thought. There was a moderate positive relationship between the variables, (r=0.408 and r=0.418 for male and female education respectively). It therefore appears as if education imparts some environmental awareness, a factor which can be attributed to the infusion of environmental issues into the formal school curricula.

However, the relationship between education level and the tendency to adopt appropriate methods of woodfuel production proved to be weak but positive (r=0.123 and r=0.199 for male and female education respectively). This weak relationship could be because few people in the households surveyed praticed these methods. Hence, the sensitivity of the tendency to adopt these methods to variation in education could not be substantial, hence it is not a strong basis upon which conclusions can be drawn. Indeed, this weak relationship between education level and the tendency to adopt appropriate measures of woodfuel production is statistically insignificant from zero ($F_{0.05(1, 1178)}$ = 2.73).

Most respondents argued that lack of land was a major reason why fuel scarcity was a problem. They suggested that the acquisition of more land could alleviate the wood scarcity problem. However, results of simple regression analysis between farm size versus number of trees planted in 1990, and the tendency to adopt appropriate methods of woodfuel production did not support this allegation.

The relationship between farm size and number of trees planted though weak (r=0.192), was positive and statistically significant at 0.05 significance level. (F=6.82; DF=1,178). That between farm size and the tendency to adopt appropriate methods of woodfuel production proved to be very weak (r=0.003), and statistically insignificant ($F_{0.05(1,\ 178)} = 0.002$). Therefore it appears that in the study area, farm size unlike what we have been made to believe, does not greatly influence the per capita woody biomass density available or that which can be generated.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

The study investigated four aspects of rural domestic energy in Sabatia Division, namely, production, procurement, utilization and conservation. The study was guided by the following objectives, to:

a. determine the source, quantity and value of primary fuels used.

b. identify the causes, effects and solutions to existing domestic energy problems.

c. determine the relationship between household energy consumption with income and household size.

d. make a comparative survey of alternative energy choices available.

e. investigate the firewood energy converter technology used.

f. find out the source and type of advice given to farmers concerning woodfuel production and conservation.

g. investigate the relationship between education level and the tendency to adopt effective methods of woodfuel production and conservation.

Both the descriptive and inferential statistical methods of data analysis were used. Regression analysis was used for inferential statistics. This chapter presents summary and conclusions, recommendations for decision and policy makers, recommendations for further research and the emerging environmental concerns.

Summary and Conclusions

It was found that most people still depend on firewood for domestic energy supply hence, improvement in wood-burning technology would benefit a greater proportion of people in rural areas. However, evolution into the use of energy efficient stoves has been very slow. Further, even those using electricity and LPG appear not to have realised that use of these energy forms for cooking is more fuel efficient than using woodfuel.

Despite the fact that many people were aware of fuel efficient stoves, only a few used them. It was therefore evident that other than level of awareness, there exist other factors that constrain the introduction and implementation of these stoves.

Although firewood can be sustainably produced on the existing pieces of land, many people still buy firewood. This is attributed to a deep rooted belief that planting of trees interspersed with crops reduces the productivity of the latter. It was therefore considered that the rate of adoption of agroforestry was very slow due to little or no awareness of the practice.

Agroforestry was practised more vigilantly in Group B than Group A. Also, Group B households generally used more charcoal, paraffin, fuel efficient stoves and were more self reliant in seedling production than Group A households. It should be noted that fuelwood scarcity is more felt in Group B than A. Therefore, it appears that people tend to be sensitive to appropriate methods of woodfuel production and conservation when the problem has almost grown out of proportion.

It was observed that not every household planted trees in the year 1990. However, although majority of the respondents planted trees, the survival rate was minimal as a result of poor care. This situation promises a grim future, due to the fact that presently amount of firewood stored has greatly reduced, which is evidence that woodfuel scarcity is imminent.

It was established that there exist some socio-cultural factors in this area which determine control over woodfuel production and utilization on the farm. These include, restrictions upon women on tree cutting and planting, the belief that trees are planted close to wetlands and the belief that trees are planted to generate income and not to supply fuelwood. These tendencies induce artificial fuelwood shortages.

Owing to the fact that women were mostly at home, perpetuation of these beliefs is a serious drawback to woodfuel production in this area. Just like these restrictions distance women in woodfuel production, it was found that women are also sidelined when it comes to getting advice on woodfuel production and conservation from concerned bodies. This is a major hinderance considering that the relationship between female education level and the tendency to adopt appropriate methods of energy conservation was found to be higher than that with male education level (male education, r= 0.492; female education, r= 0.523).

It was evident that few people were advised on appropriate methods of woodfuel production and conservation. The Divisional Forest Extension Officer blamed this on shortage of personnel to conduct awareness tours to every household. It however became clear that there existed no clear-cut channels of communication that can beat the existing bureaucratic set up.

It was established that a prolonged inavailability of commercial fuels like kerosene and LPG mainly occasioned by problems of distribution from main depots, forces people with the capability of using them for cooking to shift to low energy fuels.

Most firewood and charcoal sold in this area is poached from government gazetted forests. With the current unemployment rate, many people could be forced to enter this business. Further, poaching wood for charcoal production in wasteful earth kilns poses grave dangers to the environment.

Fuelwood scarcity also negatively affects people's working capacity and health as a result of changes in dietary patterns. People were forced to change to fast cooking, albeit less nutritious meals; they miss meals as a result of fuelwood scarcity; and money intended for food is diverted to fuel. In such untenable circumstances, the rapid rate at which wood for fuel is being commercialised is readily blamed for such drudgeries.

It was found that, many people who at one time heavily relied upon kerosene and charcoal for cooking have been forced to use cheaper substitutes. Many tend to use agricultural residues and poorly dried wood or non-traditional fuel species like Euphorbia species. Use of these poor quality wood for fuel exposes people to harmful concentrations of smoke, which Dr. Tolba, the Director of UNEP says is the most serious occupational health hazard known today in Asia, Africa and Latin America, (Brockett, 1989).

Most people in the area showed willingness to adopt solar and biogas energy technologies. They however indicated that this positive tendency is constrained by factors like the initial capital, raw materials and lack of know-how. Expectations for a possible government subsidy was shown.

Recommendations For Decision And Policy Makers

By virtue of findings revealed and conclusions made, several recommendations to decision and policy makers on rural domestic energy production and management have been made. For the implementation of these recommendations to be possible, the participation of all should be sought. Included should be in and out-of-school youth, adults, non-goverment agencies, administrators, decision and policy makers among others.

It was established that rural households will continue to use wood for cooking because it is relatively cheap and is readily available. Therefore improvements in wood burning technology would benefit a greater proportion of the rural folk. Hence, the continued development of cheap, wood-burning stoves should continue to be supported, coordinated and monitored. Researchers should also aim at developing stove designs to cater for different income levels in rural situations.

People tended to buy trees from neighbours and firewood from the market despite the fact that they could produce enough on their farms. All the local administrators, social groups, government agencies and non-governmental agencies should be mobilised to motivate people into planting trees for fuelwod production. At the same time research institutes should identify fast growing fuelwood species such as Leucaena leucocephala and Sesbania sesban, and at the same time consider means of incorporating fuelwood production within existing agricultural systems where pressure on the land is becoming critical. This move will counter the preference given to Eucalyptus and Cupressus species planted because of their fast growing quality.

It was found that Group A households produced more wood from their own farms than Group B. This was due to a deeply rooted belief that river valleys and swampy areas are most suitable for the production of trees. People should therefore be made aware that there exist tree species that can grow properly on any piece of land. This should be done through demonstrations on people's farms to serve as practical examples.

Group A locations which generally had a high per capita biomass density consumes more firewood than Group B locations. And, Group A households adopted conservation measures with little enthusiasm than in Group B households. This implies that people in highly wooded areas use more fuelwood simply because its available. Hence conservation measures should not only concentrate in scarcity areas (as has been the case) but also areas that are still highly wooded. This might arrest the situation before it becomes critical. The same caution should be taken when introducing woodfuel production methods like agrofrestry.

Charcoal burning especially in government forests if not controlled or monitored can cause untold ecological treacheries. The trend of charcoal consumption shows that its production illegally or legally will continue. Therefore strategies should be evolved where charcoal production in improved kilns should be monitored. This might compel the government to think of introducing charcoal making industries strategically placed in charcoal making areas. Then the current charcoal burners can be employees of these industries with assurance of regular wages.

Use of alternative fuels like paraffin, LPG and electricity for cooking and heating can slightly ease the pressure on existing trees. However, the initial capital investment put in buying appliances is unaffordable to many. This can be solved if a scheme is developed where people can pay for the appliances in small interest-free instalments. Further, initiation of a training programme where "jua kali" artisans can learn to produce cheap local models can alleviate the problems of purchasing of cook stoves, most of which imported. Also, the government should consider extending the Mombasa-Nairobi oil pipeline to Western Kenya, to offset the current supply problems. This will ensure that those capable of using these fuels do so maximumly.

Most people who used maize cobs for fuel said there was no other beneficial use that it could be put on. Indeed, maize cobs are hard and they take a long time to decompose and therefore to release nutrients to the soil. Hence it could be more beneficial if it were made into a cheap and healthy fuel inform of briquettes. According to KENGO (1988), briquetting of biomass waste has been proposed as one of the ways in which fuel shortages in the developing countries might be alleviated.

The traditional beliefs that restrict women from planting trees is a major drawback in woodfuel production in this area. Efforts should be put into re-educating the masses of the need for everybody to plant trees regardless of ones's gender. This can be particularly effective when school going children are encouraged to plant trees at the grassroot. In this way they grow up knowing that planting a tree is not a punishable offence. At the same time administrators and women leaders should be used to inculcate these values and attitudes into the adult group.

Most households planted trees in the year 1990, only 22 households failed to plant even a single tree. However the survival rate of the trees planted was found to be low. This was attributed to poor timing of the planting season and poor care of the seedlings. Efforts should be made to advice people on when to plant trees and how to properly care for them. This can be done through practical demonstration, and illustrations through posters.

A significant proportion (32.2%) of those interviewed experienced problems with smoke in the kitchen. This was manifested through experiences like, irritation of the eyes, coughing, headache, darkening of the roof and utensils, and smelling in clothes. The long term health hazards associated with biomass smoke can be incapacitating. Hence, efforts should be made to educate the rural people of the need to budget for domestic energy. Emphasis should also be put on the need for proper kitchen ventilation. And, cheap ways of constructing chimneys in the kitchen should be sought and implemented.

The study established that there is a strong positive relationships between education level and the tendency to adopt appropriate methods of woodfuel production and conservation. Hence, emphasis should be laid on strengthening environmental issues in both the formal and non-formal sectors of education. Perhaps, demonstrations on environmental issues should also be performed in educational institutes.

Those interviewed gave a broad spectrum of the perceived solution to the domestic energy scarcity problem. This indicates that people are aware of the problem and have a diversity of solutions to tackle the problem. They however, appear to be lacking the necessary agility and alertness to implement the solutions. Unlike instances where implementation of strategies to tackle a situation fail to take off because the solutions appear foreign in nature, people in this area have identified solutions to their problem. Therefore, responsible government agencies, non-governmental agencies, women leaders, administrators, research institutes, institutions of higher learning and the local communities in every locality should put in the necessary time and effort to implement these solutions.

To be accorded top priority by the above groups toward solving existing energy problems are the following areas:

* mobilization of rural folks to accept agroforestry as a potential solution
* teach people through demonstrations how to produce agroforestry tree seedlings in their own nurseries . This could be coupled with the provision of tree seeds and seedlings freely or selling them at a nominal fee as an incentive.
* Encouraging family planning by making planning services easily available and reorienting social and economic incentives to promote smaller families.
* Laying emphasis on the wise and constructive use of the available small pieces of land.
* Promotion campaigns towards acceptance of improved fuel saving stoves should be intensified. This, for faster appreciation should be done through demonstrations in market areas, religious meetings, social meetings, and public meetings among other gatherings.
* Devicing cheaper and efficient methods of communicating new technological changes to the common man or woman at the grassroots.

A larger proportion of those interviewed were aware of solar and biogas energy technologies. Almost 60% of those interviewed showed willingness to own these energy technologies either individually or in groups. However, none of those interviewed showed total commitment to the future use of these alternatives. Reasons advanced for lack of total commitment include lack of technical know-how, and most of them felt the costs of purchasing the appliances and installing them were rather prohibitive.

For the successful introduction and implementation of solar and biogas energy technologies, it is recommended that:

* the burden of the initial capital outlay be alleviated through government subsidy, or appliances necessary be loaned, the money to be repaid in small interest-free rates. This would act as an incentive to prospective users.
* farmers should be advised to use zero-grazing units, so that cow dung can be collected from one spot.

* efforts should be geared towards individual ownership, since it was established that people in the area tend to shun joint ventures for fear of possible social problems that might arise.
* cheap artisans (masons, plumbers and electricians) trained among the locals would be more preferable than hiring expensive specialists.
* appliances like stoves and lamps for these technologies should be made easily accessible.
* there should be official follow-up to establish successes or failures of the projects.

Emerging Environmental Implications

As already mentioned in chapter one, rural domestic energy scarcity leads to adverse negative human and ecological disprutions that generally amount to environment degradation. In the course of the current study, six major environmental concerns, which need urgent attention from all circles emerged.

It was established that the study area is a water catchment area for Rivers Garagoli and Izava. Both the two rivers are tributaries of River Yala which is highly depended upon for both agricultural and industrial development in Western Kenya. However if urgent measures are not taken, the river might very soon outlive its usefulness. As already mentioned people in the research area prefer planting Eucalyptus species along river valleys. This tree species absorbs alot of water which is not released into circulation immediately. The result is the drying up of streams which serve as major sources of major rivers in Western Kenya.

Fresh water marshes and swamps which are wherever ground water, surface springs, streams or runoff causes frequent flooding of more-or-less shallow water were common in the study area. These were also preferred target sites for planting Eucalyptus species. Wetlands, as marshes and swamps are commonly referred to, are favoured natural habitats for many organisms of varying and spectacular genetic diversity. Planting of Eucalyptus species in or around them slowly decimates them, and with them goes valuable genetic reservoirs whose importance might currently be unknown.

As Mavuti (1990) puts it, wetlands serve a wide variety of functions including flood control, water purification, shoreline stabilization and habitat for life-cycle stages for many organisms. Hence if wetlands are altered without first taking into consideration their full value, the negative consequences can be felt immediately by local people and subsequently the economy of a region or nation may be adversely affected.

Although the study area did not have any government gazetted forest, most of the woodfuel sold on markets in the area was poached from government forests elsewhere. Charcoal burning is the major culprit, since all the charcoal burners secretly did so in government forests. Charcoal burning if not controlled and monitored might exacerbate the rate of deforestation whose adverse effects are well documented. The rate at which forests will be lost will definitely increase since the number of people using charcoal is rapidly increasing.

Scarcity of woodfuel has forced firewood and charcoal to be sold at prices which can only be afforded in cases of extreme necessity. For many, boiling drinking water and space heating have become expensive luxuries, hard to contemplate. Therefore most rural people take drinking water "fresh" from streams and ponds at the risk of contracting water borne diseases like cholera. When it's cold space heating cannot be done, hence families become more susceptible to diseases like pneumonia.

Use of agricultural residue as fuel as observed has adverse negative effects on the soil fertility and structure. This consequently lowers agricultural productivity.

Recommendations for Further Research

Fiscal budgeting and time planning could not allow investigations into important aspects of this study. Some loose ends should be wound up in order to produce a conclusive whole. It was therefore found imperative to make the following recommendations for further research:

a. A study be carried out to determine the variation in rural domestic energy consumption in both cold and warm seasons. The current study was carried out in a cold season (April-July).

b. A comparative study should be carried out to reveal any possible differences in woodfuel consumption patterns between a wood-rich area and a wood-scarce area. The study area was generally considered a wood scarce area.

c. There's need to investigate the current strategies used in production, distribution, promotion and marketing of fuel efficient stoves, in the area.

d. A detailed analysis on the social and economic aspects in the possibility of introducing alternative sources of energy especially biogas and solar technologies in the area should be undertaken.

e. A feasibility study should be carried out on the possibility of training "jua kali" artisans on the production of cheap but efficient LPG stoves, paraffin stoves, and electric hot plates.

f. An investigation be done on the possibility of using maize cobs and other biomass materials for the production of briquettes for domestic cooking.

g. More research be done to determine health effects involved in rural indoor air pollution as a result of biomass fuel smoke.

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APPENDIX I

I: HOUSEHOLD QUESTIONNAIRE

DATE OF INTERVIEW .... LOCATION............

SUB-LOCATION ....VILLAGE ....

Part I SOCIO-ECONOMIC FACTORS

1. Number of household members ....

2. How many members of the household eat here regularly ....

3. What is the educational level achieved by the following in the household?

   i. Male head ....

   ii. Female head ....

4. What are the main occupations of the male head of the household?

OCCUPATION		SPECIFY	MONTHLY INCOME K.SHS.
a. Farmer	( )		
b. Commercial Business	( )		
c. Small Industry	( )		

d. Employment ( )

e. Others ( )

5. How much money do your children contribute to the household budget per month? K.Shs. ....

6. a. Do you sell domesticated animals or their products? Yes ( ) No ( )

b. If yes, how much money did you get from their sale last year?

K.Shs. ....

7. What is the size of your farm (in acres)? ....

....

8. How much money do you get from the sales of cash crops every year?

K.Shs. ....

PART II HOUSEHOLD ENERGY

A. 1. If you use electricity, how often do you use it for:

i. Lighting Always ( ) Sometimes ( ) Never ( )

ii. Space Heating Always ( ) Sometimes ( ) Never ( )

iii. Water Heating Always ( ) Sometimes ( ) Never ( )

iv. Cooking Always ( ) Sometimes ( ) Never ( )

2. What is your average electricity bill per month

K.Shs. ....

B. 1. Do you use firewood? Yes ( ) No ( )

2. Who normally gathers firewood in the household? Women ( ) Children ( ) Men ( )

3. Indicate the source of firewood,

Own Farm ( ) Neighbour ( ) Communal Land ( )

Forests ( ) Buy from Market ( ) Others ( ) Specify _

____

4. If firewood is bought indicate price per bundle/piece or any other units.

K.Sh. ....

5. Is firewood always available when you want to buy it? Yes ( ) No ( )

6. What quantity of firewood do you use daily for:

i. Cooking ....Kg ii. Spaceheating ....Kg

iii Water Heating ....kg.

vi Other purposes (specify) ....

C. 1. (a) If you buy charcoal for domestic use,

what is the cost per bag? K.shs ....

....

(b) Is it always available when needed?

Yes ( ) No ( )

(c) If no, explain ....

....

....

2. What amount of charcoal do you use daily for:

(i) Cooking ....Kg

(ii) Space Heating ....Kg

(iii) Water Heating ....Kg

(iv) Other purposes (Specify) __________

____

D. 1. Do you use paraffin? Yes ( ) No ( )

2. If yes, what is the cost per litre?

K.Shs ....per litre/other

units (specify) ....

3. What quantity of paraffin do you use daily?

.....................................Litres

4. Is paraffin always available when needed?

Yes ( ) No ( )

E. 1. Do you use a gas cooker? Yes ( ) No ( )

2. If yes, what do you mostly use it for:

(i) Cooking ( )

(ii) Water heating ( )

(iii) Roasting ( )

(iv) Others (specify) ....

....

3. Is gas always available when needed?

Yes ( ) No ( )

E. i. Which agricultural residues do you use as fuel?

(i) Maize cobs ( )

(ii) Maize stalks ( )

(iii) Tea prunings ( )

(iv) Coffee prunings ( )

(v) Livestock dumg ( )

(vi) Others (specify) ....

2. Give reason(s) why you use the above agricultural wastes? ....

....

....

PART III CAUSES, EFFECTS AND SOLUTIONS TO WOODFUEL SCARCITY

1. (a) Is there any traditional belief that restrict who should plant or cut trees in the household?

(i) Plant trees Yes ( ) No ( )

(ii) Cut trees Yes ( ) No ( )

(b) If yes, briefly explain ....

....

....

2. a. How many trees did you plant last year?

....

b. If none, why not? ....

3. What species did you plant and for what purposes?

SPECIES	PURPOSES
i	
ii	
iii	
iv	

4. a. Do you plant trees on same farm as crops?

Yes ( ) No ( )

b. If no, why not? ....

....

5. In your opinion what is the cause of woodfuel scarcity? ....

B. i. a. Do you keep firewood in store "ilungu"?

Yes ( ) No ( )

b. Why do you keep firewood on "ilungu"

i. For fast drying ( )

ii. For future use ( )

2. What can be done to increase the supply of firewood ....

3. What was the price per bag of charcoal 10 years ago? K.Shs. ....

4. a. Is smoke a problem in your kitchen?

Yes ( ) No ( )

b. If yes, with which fuel(s)?

....

c. Which of these problem do you experience?

i. Eye irritation ( )

ii. Coughing ( )

iii. Darkens Roof ( )

iv. Darkens Utensils ( )

v. Smells in cloths ( )

vi. Others (specify)

....

....

5. a. Do you ever miss to cook meals due to scarcity of firewood Yes ( ) No ( )

b. If yes, briefly explain

....

....

PART IV WOODFUEL PRODUCTION AND CONSERVATION METHODS

1. a. Where do you get seedlings from?

....

b. Do you get enough seedlings when you want to plant them? Yes ( ) No ( )

c. If no, why not? ....

....

d. Do you practice the following methods of woodfuel production?

1. Interplant trees and crops Yes ( ) No ( )
2. Plant trees that can be lopped, coppiced or pollarded for fuelwood Yes ( ) No ( )
3. Make own nursery Yes ( ) No ( )
4. Plant trees every rainy season Yes ( ) No ( )
5. Encourage children to plant trees Yes ( ) No ( )
6. Care for seedlings Yes ( ) No ( )
7. Replace cut trees Yes ( ) No ( )

2. Which cooking stove(s) do you use?

i. 3 stone ( )
ii. Firewood saving jiko ( )
iii. Charcoal saving jiko ( )
iv. Ordinary charcoal jiko ( )
v. Paraffin stove ( )
vi. LPG stove ( )
vii. Others (specify) ....

3. a. Have you heard of fuel saving stoves?

Yes ( ) No ( )

b. If yes from who? ....

c. Do you use these stoves?

Yes ( ) No ( )

d. If no, why not? ....

....

e. If yes, state their merits and demerits.

	ADVANTAGES	DISADVANTAGES
i.		
ii.		
iii.		

4. Do you practice the following kitchen management technique?

a. Use improved firewood cookstove Yes ( ) No ( )

b. Use improved charcoal cookstove Yes ( ) No ( )

c. Teach children to conserve Yes ( ) No ( )

d. Use steam to boil food items Yes ( ) No ( )

e. Soak long cooking foods Yes ( ) No ( )

f. Use wood instead of charcoal Yes ( ) No ( )

g. Always use dry wood Yes ( ) No ( )

h. Use aluminium pots alone Yes ( ) No ( )

i. Use split wood Yes ( ) No ( )

j. Use a wind shield Yes ( ) No ( )

k. Cut food into small pieces Yes ( ) No ( )

l. Extinguish charcoal Yes ( ) No ( )

m. Extinguish firewood Yes ( ) No ( )

n. Cover cooking pots Yes ( ) No ( )

5. Do you get any advice on woodfuel production and conservation methods from government officials or officials from non-governmental organizations (NGO)?

a. i. Government officials Yes ( ) No ( )

ii. Names of institutions ....
....

iii. Advice given ....
....

b. i. NGO officials? Yes ( ) No ( )

ii. Names of the organizations? ....

....

iii. Advice given ....

....

PART V: ALTERNATIVE SOURCES OF ENERGY

1. a. Have you ever heard of biogas or solar energy?

   i. Biogas Yes ( ) No ( )

   ii. Solar Yes ( ) No ( )

   b. If yes, from who? ....

   i. Biogas ....

   ii. Solar ....

   c. Have you ever seen these energy technologies?

   i. Biogas Yes ( ) No ( )

   ii. Solar Yes ( ) No ( )

   d. Would you like to use these energy technologies

   Yes ( ) No ( )

e. If no, why not? ....

....

....

....

f. If yes, would you like to own the biogas or

or solar unit alone or jointly with others?

i. Own alone ( )

ii. Own jointly ( )

iii. In each case explain why? ....

....

....

....

2. a. Do you belong to any social organizaiton(s)

Yes ( ) No ( )

b. If yes, name the organization(s)

i. Women group ( )

ii. Church ( )

iii. Cooperative society ( )

iv. Others (specify) ....

....

....

....

APPENDIX II

Part A - Request Letter to the manager, Kenya Woodfuel Agroforestry Programme, Kakamega

Part B - Request letter to the centre Manager, Bukura Agroforestry/Energy Centre.

Part C - Questions for the response of the above two officials.

Part D - Interview scedule for the Divisional Forest Extension Officer.

Part E - Interview schedule for the Chairperson, Kanu-Maendeleo ya Wanawake Organization, Sabatia Division

Part F - Interview schedules for respondents using solar and biogas energy technologies.

Kennedy Anami Alimasa,
Faculty of Enviromental Studi
Kenyatta University,
P. O. Box 43844,
NAIROBI.

8th October, 1991

THE MANAGER,
KWAP,
P. O. BOX 1080,
KAKAMEGA.

Dear Sir,

Ref; Request for Information

I am a postgraduate student in the Faculty of Environmental Studies, Kenyatta University. I have been carrying out my research work in Sabatia Division in Kakamega District. The research was in form of a field survey entitled - Rural Domestic Energy and Its Environmental Implication in Kenya: A case for Sabatia Division.

The main instrument of data collection was a household questionnaire which I have enclosed here for perusal (if found necessary). It is hoped that findings from the study will be able to provide information which will help to improve energy planning and policy formulation within the framework of overall economic development.

It is my opinion that the study will not be complete without gathering some data from your Centre, which serves the study area. Any information given to me will be treated in strict confidence; Therefore openness and honesty should not be compromised. Attached to this request letter is a copy of questions which I kindly request you to answer.

Other than answers to the questions asked, any other material that your office might feel is necessary for the study is welcome. Enclosed is a stamped envelope which your office will use to mail me the sought data and/or materials.

Thank you very kindly for your cooperation.

Anami, K.A.

Encs./

Kennedy Anami Alimasa,
Faculty of Enviromental Studie
Kenyatta University,
P. O. Box 43844,
NAIROBI.

8th October, 1991

The Centre Manager,
Bukura Agroforestry/Energy Centre,
P. O. Box 23,
BUKURA.

Dear Sir,

Ref; Request for Information

I am a postgraduate student in the Faculty of Environmental Studies, Kenyatta University. I have been carrying out my research work in Sabatia Division in Kakamega District. The research was in form of a field survey entitled - Rural Domestic Energy and Its Environmental Implication in Kenya: A case for Sabatia Division.

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Other than answers to the questions asked, any other material that your office might feel is necessary for the study is welcome. Enclosed is a stamped envelope which your office will use to mail me the sought data and/or materials.

Thank you very kindly for your cooperation.

Anami, K.A.

Encs./

PART C

QUESTIONS FOR YOUR RESPONSE

1. (a) What agroforestry trees are recommended for Sabatia Division in Kakamega District?

   (b) Of these trees, which ones are considered the best for the area?

2. Which species are recommended for firewood in the area?

3. (a) What is the current response of farmers in the area towards agroforestry practice?

   (b) How have you been able to assess for the nswer to item (3a) above?

4. (a) During the survey, many farmers indicated that planting of Eucalyptus specifically has been banned. How far is this response true?

   (b) If true what are the reasons for the ban?

5. (a) Do you communicate with the Kanu Maendeleo ya Wanawake Organization as far as woodfuel production and conservation issue is concerned?

   (b) If Yes, which channel of communication is used?

6. (a) Are you in working links with Divisional Forest Extension Officers?

   (b) If yes, what kind of advice is given?

7. (a) In your Agroforestry, Improved Cookstove and biogas training, who are your trainees?

   (b) Is the training free or charged?

8. (a) Do you sell or give free the seedlings produced at the Centre?

   (b) If sold, what is the cost per seedling/any unit(s) used (specify the units).

   (c) Whether sold or given freely which spacies are collected or bought frequently?

9. (a) How many people are currently using biogas in the District? (Please indicate the specific areas).

   (b) Which problems are reported as commonly experienced by farmers using this energy technology?

10. What attempts are made by the Centre to promote use of improved cookstoves?

PART D

INTERVIEW SCHEDULE FOR THE DIVISIONAL FOREST EXTENSION OFFICER

Please, kindly respond to these questions.

1. From your working experience in Sabatia Division, which agroforestry tree species do you consider the best?
2. Which tree species are recommended for firewood in the area and why?
3. What has been the response of farmers towards agroforesty practice.
4. How do you disseminate knowledge of appropriate woodfuel production and conservation methods to the farmers.
5. a. Are you in working links with the Bukura Agroforestry/Energy Centre and the Kenya Woodfuel Agroforestry Programme Centre?

   b. If yes, briefly explain.
6. Do you have demonstration Centre for the following:

   a. Nursery preparation?

   b. Agroforesty?

c. Improved wood conversion and utilization technology?

7. a. How many seedling selling centres are in the area?

b. Which tree species are bought frequently.

PART E

INTERVIEW SCHEDULE FOR CHAIRPERSON, KANU-MAENDELEO YA WANAWAKE ORGANIZATION

Please, kindly respond to these questions.

1. a. Are you in any working links with the following?

   i. Divisional Forest Extension Officer?

   ii. Bukura Agroforesty/Energy Centre?

   iii. Kenya Woodfuel Agroforesty Programme?

   b. If yes, briefly explain

2. a. Are you in any way involved in the production, promotion, marketing and distribution of improved stoves?

   b. If yes, briefly explain.

3. a. Do you play any role in the agroforestry introduction and implementation in the area?

   b. If yes briefly explain.

4. a. Do you have any tree nurseries in the area?

   b. If yes, which tree species are produced?

   c. Are seedlings sold or given freely?

   d. How do you procure the seeds?

APPENDIX II

PART I: FARMERS USING BIOGAS ENERGY

1. Do you own biogas unit alone or jointly? (i) Own alone ( )
(ii) Own jointly ( )

2. What do you use biogas for? (i) Cooking ( ) (ii) Lighting ( )
(iii) refrigeration ( ) (iv) Powering engine ( )
(v) Others (specify) --

3. What do you do with the sludge?--
----

4. What problems do you experience with the biogas unit?
(i) --
(ii) ---
(iii) --

5. How much moeny did you spent to purchase, install or construct parts or appliances for the biogas unit? K.Shs. ----------------------------------

6. How much money do you spent for maintenance yearly? K.Shs. --------------

7. Do you get any advice from firms that sell biogas appliances, from government officials, or from non-governmental organization (NGO) officials?

(a) (i) Selling firms? Yes ( ) No ( )

(ii) Names of the firm(s) --

(iii) Nature of advice ---

(b) (i) Government officials? Yes ( ) No ( )

(ii) Names of the institution(s) ------------------------------------
----

(iii) Nature of advice ---

(c) (i) NGO officials? Yes ( ) No ( )

(ii) Names of the organization(s) --

(iii) Nature of advice --

PART II FARMERS USING SOLAR ENERGY

1. Do you own solar energy unit alone or jointly?

(i) Own alone ( ) (ii) Own jointly ( )

2. What do you use solar energy for?

(i) Crop drying. (ii) Water heating (iii) Solar cooking

(iv) Solar stilling (v) Solar lighting (vi) Space heating

(vii) Other purposes (specify) --

----

3. How much money did you spent to purchase and install appliances for the solar energy unit? K.Shs. --

4. (a) Is the solar energy unit maintenance free? Yes ( ) No ( )

(b) If no, how much money do you spent for maintenance yearly?

K.Shs. ----------------------------

5. What problems do you experience with the solar unit?

(i) --

(ii) --

(iii) --

6. Do you get any advice from firms that sell solar appliances, from government officials, or from officials of non-governmental organizatio

(a) (i) Selling firms? Yes ( ) No ( )

(ii) Name(s) of the firm(s) --

(iii) Advice given --

(b) (i) Government officials? Yes ( ) No ( )

(ii) Name(s) of the institution(s) --

(iii) Advice given --

(c) (i) NGO-officials? Yes ( ) No ( )

(ii) Name(s) of the organization(s) ---

(iii) Advice given --

Thank you for your cooperation.