WOODFUEL DEMAND AND SUPPLY IN A RURAL SET UP: A CASE OF NAITIRI SUB-LOCATION BUNGOMA DISTRICT

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DECLARATION

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

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DEDICATION

This Thesis is dedicated to my husband, Mr Stephen Mugo, the children: George, Samson and Dorcas.

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ABSTRACT

This study addresses itself to rural energy supply and demand in a medium agricultural potential area which has a medium population density.

The predominant source of rural domestic energy in the third world as a whole, and in particular reference to the study area is woodfuel. These sources have, however diminished leading to poverty and human hardship. This scarcity of woodfuel is evidenced by its commercialisation and the greater use of crop residues as woodfuel substitutes. Efforts to correct the situation have not been very fruitful and it appears that this failure is due to lack of knowledge as regards the magnitude of the problem and the factors that determine the production and use of woodfuel.

This study has therefore, endeavoured first to establish the magnitude of woodfuel shortage, second the causes of woodfuel depletion, third the alternative sources of domestic energy that are available in the study area and the potential for introducing new ones examined and fourthly, the methods that can be used to conserve energy in the study area.

It has been established that there is a woodfuel shortage of up to 21.5% in the study area and this has been projected to grow to 42% in the year 2008. The

causes of this shortage have been identified, i.e. clearing trees for agriculture, increase in population hence use of wood for fuel, mismanagement whereby supply is too far below demand hence the difference is obtained from the stock.

The study has established the possibilities of increasing the production of woodfuel through agroforestry, woodfuel stands and biogas technologies. Besides increasing the woodfuel levels, these technologeis help to preserve and improve the environment. In addition, solar has been indentified as a possible source of energy, but the high cost of solar equipment is a constraint. Wind was also considered but the study area does not have a high windspeed to run wind mills.

The study has also established that energy conservation is possible through the use of improved wood stoves.

Following the research findings, and the projections made, policy recommendations have been prepared. These have been based on the major problems in the study area, i.e water and woodfuel. The three major recommendations are agroforestry systems, woodfuel stands, energy conservation and revival of the water project. With the knowledge of the magnitude of the problem and its causes, the policies thus adopted will encourage public participation in the effective planning and implementation of the plans. Then through reduced resource depletion and increased availability of woodfuel hence energy rural development will be enhanced, and human hardship and poverty will be reduced accordingly.

It is expected that the research methodology used in this study can be applied in similar medium agricultural potential areas with medium population density and therefore help in effective planning and implementing of woodfuel programmes, hence alleviate the problem of resource depletion evidenced as woodfuel scarcity.

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CHAPTER ONE

1.1 INTRODUCTION

Eckholm [1984] reports that in many developing nations, over 90% of domestic energy is from wood.[1] He notes that in most of these countries, virtually every rural family relies on wood for all or part of its cooking and heating. For example, a study done by O'Keefe in 1984 revealed that 94% of the total wood produced in Kenya is used as woodfuel both in urban and the rural sectors. The remaining 6% is used as rural poles [2%] and industrial wood [4%].[2] The same study has established that 98% of the rural sector energy is obtained from wood while the other 2% is met by use of kereosene [mainly for lighting]. O'Keefe's findings further reveals that, in the majority of developing countries, the bulk of the domestic woodfuel supplies in rural areas is still obtained on non-commercial basis. The wood is collected from forests, common lands or private holdings without any cash payments. Increasingly however, these traditions are giving way to commercialised wood market in which woodfuel is bought and sold. This is a sign of scarcity, he concludes.

1.2 STATEMENT OF THE PROBLEM

The study problem has been sub divided into three sections i.e. the deficit, the government policy, and the information gap. This last one is further sub divided into three subsections i.e. consumption stage, community promities and area specific information.

1.2.1 The Deficit

Kenya being a developing country is one of the countries experiencing the woodfuel scarcity problem. Wood fuel as both a commercial and non-commercial source of energy accounts for 75% of the total energy base of Kenya.[3] Although economic development normally encourages a move from woodfuel to more flexible and liquid fuels like oil, gas, and electricity, the high cost of such fuels on the world market retards the rate of such a transition. As a consequence, woodfuel will continue to play a dominant role within the energy economy of Kenya for many years to come. This calls for a sustainable supply of wood resources. The present and future supply of wood resources in Kenya will depend on the interaction between wood demand, the stocks and yields of woody biomass, the competing uses of land, geographic factors influencing access to and transportability of woodfuels, socio-economic factors such as access to tools, household labour economy and land tenure. These conditioning factors determine the rate at which wood resources are depleted. This is important since due to the supply - demand interaction, wood is not strictly a renewable resource except under conditions of either natural abundance or wood management where supply is maintained above the levels of demand. In Kenya, since 1980 the supply level has increasingly remained below the level of demand and it is projected to go even lower by the year 2000. The serious woodfuel deficit that is developing is illustrated in the following wood supply and demand projections table for the period 1980 to 2000 as shown below:-

Table 1:1 National Demand - Supply projection 1980 - 2000

	1980	1985	1990	1995	2000
Demand	18.7	24.5	30.3	38.6	47.1
Supply total	18.7	19.1	20.5	20.6	16.5
From yield	13.1	12.6	10.7	7.8	5.2
From stock	5.6	6.5	9.8	18.8	11.3
Supply shortfall	0	5.4	9.8	12.0	30.6
Standing stock	1004	974	932	864	800

Source: procedings of Agroforestry workshop for highland - Potential Areas in Kenya 1985

In a resource analysis survery carried out by the Beijer Institute in 1980, it was established that woodfuel consumption in Kenya was already exceeding the sustainable yearly yield.[4] Total demand then was 20.41 million tonnes and total sustainable supply was 11.07 [54.2%] million tonnes of wood was supplied from the standing stocks. [This is a reflection of the rate of wood resource depletion], still leaving a shortfall of 0.08 [0.4%] million tonnes which was met by other miscellaneous sources like crop residues [this also reflects the level of soil nutrients depletion]. Besides the already existing wood resource depletion, it is estimated that the total energy demand will grow at an annual rate of 4.6%, wood and charcoal enduse consumption will grow at 3.8% and 5.9% per annum respectively.[5] As standing woodstocks will increasingly be depleted to meet this growing demand, yields will further decrease and stock depletion will be accelerated creating very serious social and environmental problems like destabilization and devolution of the rural economy. On supply side, standing stocks are expected to decline by about 20% over the year 2000 and at the turn of the century, a shortfall of 32.6 million tonnes [about 65% of the national wood-fuel demand] is expected to occur if prevailing conditions and practices remain unaltered.[6]

1.2.2. Government Policy

Wood is by far the most widely used household fuel in the developing world. Given its importance in the rural sector energy supply, it is necessary that proper and appropriate policy recommendations and implementation procedures be adopted to effect sustainable supply of woodfuel hence environmental conservation.

Until the mid- 1970's the firewood crisis was largely ignored by third world governments and international agencies alike.[7] More recently, however, firewood scarcity has become a major topic of concern. Third world energy planners have now started taking seriously the fuels most critical to as much as 90% of the national populations. Governments and aid agencies have been mobilized in an attempt to deal with the woodfuel problem by supporting community- oriented tree growing programmes and experimenting with fuel saving cook stoves but they have had to learn the hard way, though some programmes have been successful, the majority have not achieved much.

In an attempt to arrest the deficit problem, the government of Kenya in her sessional paper number 1 of 1986[8] has outlined the planned programmes of increasing woodfuel production and strengthening the energy conservation efforts but the implimentation has been very poor. It is recognised by the government of Kenya in principle that woodfuel is the source of the energy for the majority of Kenyans yet when it comes to implementation of wood production projects in practice, there seems to be a shift from woodfuel to other energies like eletricity and petroleum. In other words, woodfuel production in practice is not given the emphasis it deserves.

Besides this shift, the government policies relevant to wood energy resources are too broad and vague especially for implementors since it. is not clear who should do what,where and when. As regards the specific government expectations it is not clear what achievements are expected at what time such that it is not even possible to evaluate the performance of the programmes.

1.2.3. Information Gap

1.2.3.1 Consumption Stage

One and a half decades ago, patterns of wood fuel production and uses were virtually unknown and accurate data on consumption and production were non-existent. This lack of information hampered many of the early initiatives aimed at solving the woodfuel crisis. Though some programmes have been successful many have had numerious problems. These problems have varied from place to place and ranged from socio-economic and cultural to political and land tenure. The world bank and various development agencies for example got into solving the problem quickly over the period of 1978-1983 and some US$ 500 million in aid went into tree planting[9] but much was not achieved because of lack of knowledge of the actual problem and its magnitude. After failing, it was realised that there are peculiar relationships between woodfuel supply and demand systems which have to be established for specific areas. It has been established that where woodfuel is plentiful, there is a lot of wastage and where it is scarce people are already using as little as possible. Where it is too scarce, the poor turn to dung, stalks, husks and other agricultural residues while the well to do can shift to alternative energy sources like kerosene,liquid petroleum gas, eletricity, etc. According to Kamweti[10] 1980, there is a general sequence of consumption of woodfuel. Where it is plenty most rural people simply collect dead wood. As wood becomes scarce, people start utilising branches of trees. The next stage is utilisation of the tree itself and when there are no more trees, stumps and roots follow in the next stage. It is from this stage when all the ligneous materials has been exhausted that people resort to utilisation of wastes such as sawdust, agricultural residues and cowdung in some cases. One therefore can predict the stage of woodfuel supply in any place by idenfitying the consumption stage as described above. The knowledge of the consumption stage hence supply level will assist in establishiment of the supply-demand level of woodfuel. This will bring out the degree of shortage or magnitude of the problem. The above and knowledge on causes of the shortage together with information from the community on what they think is the best way to solve the woodfuel shortage problem is very useful in designing remedial programmes otherwise the programme may be solving a problem which does not exist, or if it does exist it may be under or over estimated because of not knowing its magnitude and causes and in both cases, losses will be incurred.

1.2.3.2 Community Priorities

A community may have many problems, like water shortage, inadequate or lack of health and educational services; and insufficient food and woodfuel supply.

If the problem of woodfuel shortage is not among the priority problems, then it may not receive as much attention as is expected by outsiders [usually programme implementors]. According to Almigir [1984] as reported by Foley the type and level of response by people to any problem depends on the magnitude of the problem and its priority as a problem when compared to other community problems. The bigger the magnitude of a problem and the higher it is on the priority list of community problems, the higher the reponse by the people as regards finding solutions to the problem. The community may not need to be told that there is a woodfuel problem in Kenya, for example, the people will respond by starting their own self help projects and even looking for external assistance be it material or technical to try and solve whatever they consider a serious problem unless there are major constraints beyond their abilities. Therefore, knowledge of community problem priorities is important in designing development programmes if effective implementation is expected.

1.2.3.3. Area Specific Information

A study carried out by the Food Agricultural Organisation [FAO] in 1980 examined the woodfuel situation in the developing world to establish the level of shortage. From their findings, the countries were placed in three categories. The first category is where the scarcity was so severe that even if the current wood supplies were overcut, the supply would not be sufficient. The second category of countries is where overcutting would facilitate meeting the minimum requirements while the third category is where there was just enough but with increasing demand.[12] This kind of categorization can facilitate the use of different approaches to each one of the categories as regards solving the woodfuel scarcity problem. Kenya falls within the second category where by currently, 30% of the woodfuel energy demand is supplied from standing stock. Narrowing down to Kenya as a country categorisation of woodfuel scarcity has been done up to the provincial level. The provinces of Kenya are fairly large in size making the geographic, economic, demographic and cultural differences so varied that any approach considered for solving people's problems will have to narrow down to as low as the divisions which may be more uniform in terms of the above mentioned characteristics. This may improve the effectiveness of programme implimentation and lessen failing of projects. As mentioned earlier, the woodfuel demand-supply relationships are so complex and area specific that to achieve production of sustainable supplies it will require detailed studies of the areas in question so as to establish the actual situation just as it is. Studies on supply-demand in Kenya have been carried out at national and provincial levels. The results of these are too general to be effectively useful at the village, sublocational, locational and even divisional level. Naitiri sublocation is in a medium agricultural potential medium population density, newly settled scheme. Most of the studies done earlier were carried out in high agricultural potential and high population density areas like Kisii, Kakamega and Muranga. According to the national survey done on woodfuel, the low agricultural potential and low population density areas of Kenya still have supply level equal to the demand level,[13] i.e. in 1980 the wood resources demand in North Eastern Province was 0.54 million tonnes the sustainable supply was 0.54 million tonnes, unlike Western Province whose total wood resources demand was 2.32 million tonnes with a sustainable supply of 0.31 million tonnes, supply from stock 2.00 million tonnes and a shortfall of 0.01 million tonnes. The reason for this big difference is mainly because of the low population level in sparsely populated areas. This explains the reason of choosing a medium agricultural and medium population density area in which there is evidence of woodfuel scarcity problem and little if any information available on the level of scarcity and causes of the same.

1.3 Summary of Problem Statement and the Study Objectives

From the information given, it is clear that currently, Kenya has a woodfuel deficit of about 30% which will grow to 65% by the year 2000. The government has formulated policies to address the deficit but the policies are too broad and vague to be effectively implimented. In addition to this, there is no sufficient information for planning projects and implimenting the same at local level where local refers to district, division, location and sublocation. It is in the context of these issues that this study was carried out in Naitiri Sublocation to:-

i] Assess woodfuel demand and supply levels and factors that affect both in the study area

ii] Examine the causes of woodfuel shortage which is evidenced by the use of crop residues in the study area and suggest possible remedies.

1.4 STUDY ASSUMPTIONS

This study has been carried out on the assumption that:-

i] The majority of Kenyans will continue to use woodfuel for many years to come hence there is need to increase and sustain supply of wood energy.

ii] Govermemt subsidies on kerosene and liquid petroleum gas [lpg] will not increase significantly to render woodfuel less competitive when compared to kerosene and liquid petroleum gas.

1.5 RESEARCH METHODOLOGY

The research involved the collection of both primary and secondary data.

1.5.1 SECONDARY DATA

This was obtained from studies and publications on, Natural resources, Energy in general terms, wood energy and Energy in development. These publications were obtained from various sources including central and local government authorities [e.g. Research Stations, Forestry Departement, Ministry of Energy, etc.] and other non-governmental agencies working on woodfuel production and conservation.

1.5.2 PRIMARY DATA

The primary data was obtained first by administering questionnaires to [i] 29% of the households and, [ii] Key informants who in this case were the District Rural afforestation extension officer of Bungoma district the Chief of Naitiri location, sub-chief of Naitiri sub-location which is the study area and eight of the nine village headmen and second by:-

a] General observation

b] Informal conversations with the local leadership [i.e. those mentioned above plus three assistants

c] Use of photographic films

d] Use of a weighing balance for measuring weights and a clinometer for measuring tree heights of standing trees.

The questionnaire was designed in such a way as to gather informaiton on the current demand and supply of woodfuel and factors affecting both supply and demand, crop residue use, energy conservation, initiatives and potential in solving the woodfuel problem.as shown in Appendix 1.

1.5.3 SAMPLE DESIGN

The sample frame of this study consists of all members of Naitiri sublocation and the household was the unit of enquiry. The sublocation consists of 9 village clusters consisting of a total of 346 plots. Out of these the survey covered an average of 11 plots per village cluster so the total number of plots covered in the survey was 99 which represents about 29% of the total number of plots in the sublocation. The plots for detailed survey were equitably selected by taking each 3rd plot within each village. This was considered necessary to make the sample survey more representative.

1.5.4. DATA ANALYSIS TECHNIQUES

The collected data was organized compiled and analysed both cartographically and statistically. Qualitative and quantitative presentation of data has been observed in this study. Facts collected in the field have been discussed and presented qualitatively while quantitative data has been presented in form of tables, bar charts, graphs, scatter grams, maps and percentages.

1.6 SCOPE OF THE STUDY AND THESIS ORGANISATION

The study looked at the types of domestic fuels used in the study area and the level of consumption of these fuels on daily basis. Factors like household size, incomes, land size and type of farming were also looked at since they are expected to affect consumption. The availability of the various fuels used in the study area was also looked into. The constraints to wood production like the tree seed and seedlings supply, water availability and customs were considered and also efforts by the community to increase wood production and improve on wood conservation were assessed by looking at the number of trees grown annually and the number of households that use energy conservation measures in wood utilisation. Finally the level of community organization and level of awareness as regards tree planting were looked at by considering the communities involvement in self help projects and the number of households that receive extension services from the relevant agencies.

The thesis consist of six chapters in the order shown below.

Chapter 1 - has introduced the study problem, objectives, the assumptions, the methodology used in the study and finally the scope of thesis organization.

Chapter 11- deals with the theoritical aspects of the study problem as established from literature review.

Chapter III - has information on the study area. This includes a brief historical background, location and size, the physical features, climate, soil, vegetation and the socio-economic profile.

Chapter IV - is devoted to data analysis and research findings. The chapter has covered community characteristics, the major community problems according to the peoples views and how they think these problems can be solved. Covered also are the current level of demand and supply and the factors affecting the two, the causes of woodfuel shortage and the existing alternative energy sources:

<u>Chapter V</u> - contains the demand and supply projections and policy recommendations as regards the same.

<u>Chapter VI</u> - study conclusions and recommendations which followed by the <u>Bibliography and appendix</u>

1.7 STUDY LIMITATIONS

1] Very few households were willing to give information on income hence the given income is estimated from the agricultural produce and the jobs done for those who are in formal employment.

2] Information on annual yields of wood for the various species was not available except for Eucalyptus [exotic and fast growing tree] and for Terminalia [indigenous and slow growing species].

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CHAPTER 2

2.1 THEORETICAL FRAMEWORK

Foley in his report on farm forestry has commented that despite the importance of woodfuel in most developing countries, there are serious deficiences in consistency and reliability of much of the published data on its use[1] Although the position has improved in recent years he notes that this remains an area where considerable amount of further work is required. Foley has observed that a number of surveys have been carried out to date on the woodfuel daily requirements; the knowledge of demand versus supply has resulted in a much greater economy exercised in the use of woodfuel as it is illustrated in a report from Senegal where it is stated that "Economy is second to nature".[2] In this area, women quench the fire with water or bury the embers in ash or sand immediately after the cooking is through.[3]

According to Kamweti [1980], woodfuel consumption pattern tends to follow some general sequence.[4] He reports that where fuelwood is plenty, most rural people simply collect dead wood. Such wood he suggests is easy to burn having lost most of the moisture and also the fact there is little work involved in cutting it. As wood becomes scarce Kamweti has observed that people start utilising branches of trees, again much easier to chop than to fell whole trees. The next stage is utilisation of the tree itself followed by stumps and roots. He argues that it is when all the ligneous material is exhausted that people resort to utilisation of wastes such as sawdust, agricultural residue and cowdung in some cases. He concludes that one can predict the state of woodfuel in any place by examining the consumption stage according to the stages described above.

Foley has reviewed several studies on woodfuel and has commented on various aspects that determine and affect its domestic consumption. He has commented on its consumption in various parts of the world and the factors that affects this consumption which he sites as:-

i] woodfuel availability
ii] family size
iii] income
iv] availability of alternatives as the major ones and:-

i] climate
ii] types of food cooked
iii] methods of cooking
iv] types of stoves used
v] availability of alternative sources of light other than the cooking fire and
vi] ceremonies

Beside these he sites home based industries as a major contributor to domestic woodfuel demand. Foley has further considered the supply of woodfuel and the factors that affect it. He has sited the factors that affect supply as:-

i] clearance of land for agriculture
ii] excessive cutting of trees for woodfuel
iii] overstocking with livestock
iv] population growth
v] poor policies and
vi] poor climate

There are also constraints that inhibit the increase of woodfuel supply through growing of trees and these he suggests are: antipathy, land tenure, seasonal competition for labour, lack of incentives, lack of tree seeds and seedlings, poor extension services, growth cycle of wood resources, other community problems and availability of alternatives.

Various incentives for woodfuel resource expansion have been suggested and comments made on the nature of changes that occur in woodfuel demand and supply.

2.2. WOODFUEL DEMAND AND FACTORS AFFECTING IT

From detailed surveys carried out in 1983 in six villages in Mali and Niger, Bonnet found that wood consumption ranged from 440-660 kg. per head per year.[5] He observed that in the villages where fuel is hardest to get people switch to non-preferred tree species and try to economise.

this area, the figure of 440 kg. per head per year appears to be the lowest. Below it, people find it difficult to reduce consumption.

Similar findings are reported by Samanta [1982] from areas of wood scarcity in India. The annual consumption figures in five villages in the state of Orissa [India] where people rely on fuelwood for virtually all their domestic energy requirements are in the range of 509 to 826 kg. per head with an average of 680 kg. per head.[6] Another study by SFMAB 1982 indicate that from the 17 villages surveyed in Tamil Nadu, per capita annual consumption of woodfuel was found to be 344-676kg with an average of 481 kg. In Kenya, Hoseir [1984] reports that consumption was found to range between 683-1368 kg per head with an average of 726 kg. The consumption level of woodfuel can be used as an indicator of woodfuel availability e.g. while some countries like Niger and Mali have an annual per capita consumption of 660 kg as the maximum, others like Kenya has 683 kg as a minimum.

As well as fuel availability, Fox [1983] says that factors such as family size also have important influence on per capita fuel requirements.[7] He argues that larger families cooking bigger meals tend to be more affected in their use of fuel. He sites a case in Nepal where families with between one and four members used an average of 890 kg of firewood per person per year and families with nine members or more used only about 340 kg per person in a year. Beside this, Foley has added that there are other influecnes on consumption. They include climate, the types of food cooked, the methods of cooking, types of stoves used and the availability of alternative sources of light other than the cooking fire.[8] In many places, he says there are seasonal variations with consumption increasing in the period after harvest when labour is readily available and wood is easy to obtain and dropping during the planting period when collection is difficult and people are heavily occupied with farming tasks.

Foley explains further that home-based industries and commercial activities can add to the domestic demand for wood e.g. brewing beer, baking bread, small scale brick and pottery making. Wood may also be used in large amounts for special family occasions such as festivals and weddings. In India, for example, cremation of the dead is a substantial consumer of woodfuel with upto 400kg being used for a single body.

As woodfuel scarcity increases, wheatherly reports that the process of energy involution can be observed. This is where by inferior quality materials which would not otherwise be regarded as suitable for fuel tend to come into use. This include thorny tree species which are difficult to collect and prepare and others which have a low calorific value or burn with a smoky flame. Twigs and leaves are used to a greater extend together with crop residues and animal dung. A family may change from using stemwood to coconut husks, bamboo roots, rice hulls, maize stalks,tobacco stalks and finally dried leaves.[9] In other words, the value of energy sources decreases with time until it reaches a time when no burnable bit of biomass is immune from inclusion in a cooking fire. This is a level at which the system is completely involuted. This is useful in that identification of the level of involution in any area can be used in designing the most appropriate programme.

2.2.1 Woodfuel Demand from Industries and Commerce

Foley 1984 argues that in many countries, small scale rural industries consume large amounts of fuelwood. Such industries include tea and coffee drying. brick-making, sugar making etc.[10] He further suggests that in towns, commercial enterprises, laundries can also add substantially to demand for woodfuel.

A study by Nkonoki 1983 has identified tobacco curing particularly as a heavy user of woodfuel. He sites a case whereby in some parts of Tanzania 50 -60 cubic metres of wood are required to cure a 475 kg. batch of green tobacco leaves while brickmaking requires 35 cubic metres of wood for 25,000 bricks needed for a family house. The same study considered the amount of wood required in brewing and found that I cubic metre of wood is required per 400 litres of beer.[11] Foley has commented that for some industries, the availability of tree fuel may be essential for their continued financial viability.[12] This is true of both the tea and tabacco industries in some countries. Foley argues that if the industries were to pay for the fuel they require, they would no longer be competetive on the international market.

More commonly however, Foley suggests that wood must be purchased locally, wood for brick making in southern Thailand, for example, is bought from owners of rubber plantations who fell tree prior to replanting. In Costa Rica, wood for coffee drying is supplied from nearby farms. Industrial demand therefore is superimposed upon those generated by local domestic consumption.

In O'Keefe's report of 1983 it is mentioned that quantities of wood used by local industries can be surprisingly a high proportion of the total consumption of wood in a country.[13] In Kenya, for example, he notes that the demand from industries and small commercial enterprises present around 23% of the total woodfuel use. Jones 1981 reports that in central America, industries are estimated to account for 18% of the total[14] while in some south African countries, Bhagavan [1984] found that it can be as high as 40% of National woodfuel consumption.[15] A study done by O'Keefe on woodfuel consumption by the rural informal industry in Kenya shows that the average annual consumptioon of woodfuel in those industries is

2440 tonnes or 2.42 GJ per capita.[16]

The foregoing information suggests that whenever woodfuel production is considered, the demands from industries and commercial enterprises should be included to avoid pressure on domestic woodfuel supply.

2.3 WOODFUEL SUPPLY AND FACTORS AFFECTING IT

In his discussion on woodfuel supply Foley comments on the traditional systems by which people manage and preserve the wood resources on which they depend. He mentions that these systems are breaking down in many parts of the world.[17] Tree resources in open woodlands and around farms and villages are coming under intense pressure he notes. Large areas of closed forests are also being lost each year. The reasons for this breakdown vary. In many cases, the greatest pressure is that of land hunger, the need to clear woodland for agriculture. Excessive cutting of trees for fuelwood [both for direct use and for sale to urban dwellers] or overstocking with livestock which reduces the regenerative capacity of local wood resources pushing them into an accelerating process of depletion.[18] Various other sources may also be at work like population growth, poor policies and poor climate. Discovering why wood supply is diminishing in a particular area is not always easy. Often, a number of causes are super imposed on each other. At times, there is a sequence of events in which one type of wood resources removal creates the condition for another and it is then superceded by it.[19] Though all result in the loss of wood resources, the nature of the processes involved and their practical consequences can be very different. But in all cases, a clear diagnosis of the causes of the breakdown of traditional systems is essential if effective remedies are to be found. Only when it is known can the potential role of production as a counter measure be assessed and programmmes designed which tackle the real problems at hand.

Wood resources depletion when it occurs is not that rural people are not aware. In most cases, they are well aware of their surroundings and perfectly capable of recognising the depletion of these resources. If they appear indifferent or neglectful to this, it is rarely because of ignorance or lack of concern about their own future. It is far more likely that they are constrained by a variety of factors and that for one reason or another, growing trees as a solution does not make sense when viewed from local perspective. Some of the reasons that have been found as reported by Eckholm to inhibit people from increasing wood supply by planting trees are: Antipathy, land tenure tree ownership shortage of land, seasonal competition for labour, lack of incentives, lack of tree seeds and seedlings, poor extension services, growth cycle of wood ressources, and presence of other more serious community problems.[20]

2.3.1 Antipathy to Trees

He explains this can arise as a result of inherited cultural traditions or it may be for strictly pratical and contemporary reasons e.g. in some African countries the normal method of controlling tsetse-flies has been to cut down the trees which harbour the insects hence planting trees will appear like a threat to the people. Other places people fear planting trees near the crops because they provide a haven for birds. In other areas still trees are believed to lower the water table and can also compete with adjacent crops for nutrients and sunlight. In some countries, certain types of trees are associated with malign spirits or taboos. In India, for example, tamarind trees growing close to a village may house evil spirits and in some areas of Kenya croton trees growing directly infront of the house or at the gate are believed to bring bad omens to the family such that at times, all the members of the family may die. Surveys done in India also show that people fear trees because they are thought to be potential hiding places for thieves and robbers.

The prevalence of such negative attitudes to trees and the degree to which they represent a barrier to planning programmes is hard to assess. Investigation by Skutsh of a number of villages in Tanzania where it was expected that some of these fears would be expresssed found no evidence to an innate dislike to trees. The only exception was one village where people said they were afraid of owls; which represents spirits and would not have trees which might harbour them close to their houses.[21] It has, however, been pointed out by Musava that this might be no more than an excuse not to participate in tree growing which is disliked for other reasons.[22]

2.3.2 Land Tenure

Land tenure problems is another constraint where one does not own the land one lives own, it does not make much sense to plant trees e.g. in case of tenant farmers, landless people, communal land ownership. There is also the question of tree ownership. Some tree species which are very valuable are protected by the state. Farmers are very reluctant to plant such because cutting them requires evidence that the farmer planted them himself and even then he has to get a permit. This happens in Sahel as reported by Thomson [1979],[23] and in Haiti as reported by Murray [1983].[24] Cernea reports that some farmers in Pakistan fear alienation of their land by the state.[25] Murray further reports that in the Dominican Republic and Honduras all trees belong to the government and no tree is to be cut without permission from the government. This legislation is counter-productive when efforts are being made to engage farmers in tree growing.[26] This applies to Philippines also but here it is directed to commercial logging industry reports Bulletin Totay, 1982[27] while in Kenya it applies mainly to indigenious tree species.[28]

2.3.3. Seasonal Competition for Labour

Eckholm observes that competition for labour especially in arid areas has been found to constraint growing of trees. Tree planting always coincides with agricultural activities, this may also conflict with opportunities for off farm income. In the early years of tree growth, plantations require substantial amounts of work leading to a reduced desire for people to plant trees.[29]

2.3.4. Lack of Incentives

Another constraints he suggests may be lack of incentives, where there is still plenty of fuelwood or where specific individuals may have adequate wood resources on the farms they may not see the need to plant more. The idea of depletion of resources may appear totally beyond their control or irrelevant in the time scale within which they are able to plan their lives.[30]

2.3.5 Lack of tree seeds and seedlings

Some governments have almost made it appear as if tree seeds and seedlings for planting can only be provided by the forest department at subsidized prices as such, there is very little motivation for individuals to produce their own seedlings for planting or collecting seed from existing trees for planting. People in some areas have seen the inability of the government to provide enough seedlings for everybody at the right time and in the right place. This has led to some communities producing their own tree seedlings for planting while others have remained dependent on the government as a tradition with a result of tremendous reduction in available wood supply since consumption rate is higher than supply rate.[31]

2.3.6 Poor Extension Services

Until recently Eckholm notes that Forest departments in developing countries tended to concentrate on the management and production of existing forests and forgot about the woody perennials on private and community land. This could have been due to one, the abundance of wood resources then and two, mear lack of foresight or both. But currently, the consequences of such exclusion have been highlighted and extension services on tree plantining and conservation are being provided. Though this is happening there is a possibility of targeting the wrong group hence achieve very little therefore, there is need of identifying the proper target group.[32].

2.3.7 Growth Cycle of Wood Fesources

The time between planting of trees and harvesting is so long as compared to other crops that many people get discouraged. The time constraint may not be so much of a barrier to tree planting. It is only when people think the operation is futile and too risky or simply too much trouble that the time constraint becomes a dominant consideration. In such a case, by demonstrating new faster -growing species and suggesting management techniques that allow useful products to be harvested after a shorter period that tree growing programmes may have an important role in tipping the balance and persuading formers that tree growing is worthwhile.[33]

2.3.8 Community Problem Priorities

In some areas, planting of trees may be very low on the peoples' list of priorities simply because of the weight of other problems. This comes out clear in a commentary discussing basic needs in the community in Sahel as reported by Hoskiro. The people of this community indicated that there were things more urgently needed than forestry products. They stated that unless they could have water, health care, education for their children , jobs for young adults and enough food and income to keep their families together it did not matter if they planted trees or not.[34]

2.3.9 Availability of Alternatives

Finally, another major factor which affects the supply of woodfuel is availability of alternatives

Wheatehrly found that shifting to alternative biomass materials opens up considerably other resources of potentialy burnable materials. Under Indonesian conditions [alot of rice growing] he calculated that the total amount of fuel which can come into use in this way is about four times greater than that available when people rely on stemwood alone. What the figure would be for other areas depend on local patterns of biomass productivity and the amount of crop residues available for use.[35]

The switch to lower grade fuels may allow people to spend less time in collecting fuel and therefore help solve their immediate fuel problem, but it also involves a number of direct and indirect costs. These fuels are often less convenient to use and require more work from the cook in feeding and tending the fire. There are also various environmental and economic costs when organic materials that would other wise be returned to the soil, or used for animal feed and other purposes has to be burnt. Not much is known about the exact nature of these trade - offs or how people themselves view them. If the people feel the freely or easily available lower grade fuels provide a reasonably acceptable alternative to wood, they will have little motivation to plant trees when the wood-fuel resources are depleted.[36]

2.4 Incentives for Woodfuel Resource Expansion

Studies done in various countries have come up with various incentives to increase wood production hence supply. The fact that woodfuel represents the largest quantitative demand for wood has at times diversed attention from its other uses. In many places, wood also meets a variety of basic needs for which there are no readily available subsitutes. In these particular applications, it will often command a higher price than when sold for fuel [Foley 1984].[37] Poles for building purposes are widely used and are often in scarce supply. In some countries, they provide the framework for the walls which is then coated in mud or covered with thatch or woven mats. Larger poles are used as centre or corner poles they may also be used for fencing and handles of implements. They are also cut for use as roof beams and structural members in permanent buildings. Other local demands for wood, ie. sawmills, furniture making and packing cases and agricultural implements making. The requirement of wood in this sector may be very low but it forms a strong incentive to grow trees by the local people.

Large wood using industries can also add substantially to the local demand for wood. In some cases, they dominate the wood market. In Karnatake state in India, pulp and rayon mills are willing to buy large quantities of wood from farmers the prices of Eucalyptus offerred to the farmers.

is above the price of firewood this acts as an incentive for wood production specifically for the Industries.

One of the most important reasons for lack of incentives to plant trees is that in the poor countries 90% of the total woodfuel demand is not yet commerciali-sed. For example, it has been noted in Tanziania by Alkoneki that it is only the salaried 'public servants' such as teachers or rural extension officers who purchase their fuelwood. These families make up less than 2.4% of the rural pupulation.[38] In Malawi a nationwide survey by Energy Studies Unit 2 indicated that only 7% of the rural families buy any fuelwood and of these only 1% rely on bought wood entirely.[39]

A survery by Aulagi [1982] of the village of Ibb in the southern uplands region of the Yemen Arab Republic on the other hand, showed that 65% of the households obtain a quarter or more of their fuelwood from the market[40] In Nicaragua, estimators suggest that more than half the country's woodfuel consumption is commercialised with 70% of all household buying at least some fuelwood [Van Buren 1984].[41]

The development of a woodfuel market in an area can radically change local attitudes towards the question of woodfuel supplies. Studies in the Mbere [Embu] area of Kenya by Brokensha found that selling fuelwood was regarded as a sign of poverty when it first began in 1976 but within two years it came to be seen by the whole community[42] as an acceptable way of earning a living. As long as commercialisation of woodfuel continues to increase, farmers will grow more trees and its slow rate of growth will reduce the incentive for tree growing for sale. Wood prices tend to rise as the depletion grows. As this trend continues, tree growing should eventually become viable. The level of this price threshhold will however vary substantially from place to place. It will depend on growth rates, inputs, costs, and returns from alternative uses of land and resources. Projections of what is likely to happen in any particular case will have to be based on a detailed local analysis. Examination of areas of different stages of commercialisation and wood depletion provides some pointers to the probable pattern of future events.

The trend observed in other areas is that when wood resources are being depleted, poles or other specialised wood products become commercialised earlier than fuelwood. This is because they are inherently scarcer, consequently, people are prepared to pay for them, whereas they can obtain all the fuel they need without spending money. As scarcity increases, and pole prices rise at some stage, it becomes attractive to grow them for the market thus, farmers begin to plant trees for poles. Since the marginal cost of growing a few trees is small this tends to happen even when the prices are still very low. Larger scale planting requires a price level which justifies the more significant investments inputs and diversion of land involved. The level has been reached in Gujarati and other parts of India. At a later stage in the depletion of wood resources, fuelwood in its turn becomes commercialised and with increasing scarcity its price begins to rise. At a certain stage, it becomes economically viable to plant trees for fuel. Though if there is already a market in which poles command a higher price than fuelwood this will tend to dominate the farmers decision when the market for poles becomes saturated and the price for poles and fuelwood begins to coincide, that is when planting explicitly for fuel starts to take place on a large scale. This appears to be the position in Madras [India] and some neighbouring areas where the price of poles is now roughly equal to that of fuelwood. This just illustrates one possible path of change, it also demonstrates the complexity of the wood market system. Without a clear picture of the nature and dynamics of this system, it is virtually impossible to predict the likely out come of initiatives to promote tree planting, reports Foley.[43]

2.5 Summary

Fuelwood demand changes with time often in a very complicated fashion e.g. there is an upper limit on fuelwood prices which is set by the price of alternative fuels such as kerosene and LPG. People will switch away from woodfuel if it is cheaper to cook with modern, Commercial fuels. when changing, decision is not based only on the unit cost of available energy in the fuel but it will include other factors such as convenience, flexibility in use, security of supply and the associated prestige. A rise in income is also enough reason for a switch from woodfuel.

In India, it has been noted that the more affluent sections of the society always prefer cleaner and more convenient cooking fuels to wood. The well off know that there is a nierarchy of cooking fuels and they view changes from fuelwood to charcoal to kerosene, eletricity or gas as steps in the improvement of the quality of their lives. [Reddy 1983].[44] Among the poor, the reverse occurs as the price of woodfuel goes up, they turn to twigs, roots, vegetable residues dung and leaves. They tend to go lower and lower on the economic scale.

The overall effect may be to create a price zone the lower limit set by the production cost of wood while the upper limit is defined by the price of fuelwood substitutes. Within this zone, fuelwood production is a viable commercial exercise. Outside it, growing of trees for firewood will either be uneconomic because of low wood prices or very restricted because the price of wood makes it non competetive with other fuels. Transportation costs may increase the price of wood while government subsidies on kerosene and LPg may keep their prices too low for wood production to be viable.

When projecting woodfuel demand therefore, it cannot be assumed that the demand will continue to increase in line with population increase. Calculations of future woodfuel deficits based upon fixed links between population figures and woodfuel consumption must be viewed with extreme caution this can produce an exaggerated picture of the likely future demands for wood fuel, distorting planning goals and leading to an undue emphasis on trying to grow trees to meeet fuel needs.

Given that fuel needs is not the only purpose of trees, there will be need to continue planting trees even where there appears to be plenty since uses are many and continous and there is the aspect of the ecosystem balance To date, Kenya is already experiencing a deficit and relies on standing stocks to meet her wood demands. Therefore here is need to emphasize on an increase in production at least to a sustainable level. Strategies have been formulated in the National Development Plan of 1984-1988 and Sessional Paper No 1 of 1986 on how wood production will be increased and by how much it should increase but from the information given here, it is clear that unless detailed studies of specific localities are carried out to establish the level of the shortage, and the problems prevailing in this specific areas as regards wood production, much may not be achieved as planned.

According to the district development plan of Bungoma, Forestry sector, it is planned that at least one tree nursery should be established per division to provide tree seedlings for the farmers but it has been established that provision of seedlings by the government may be playing a very minor role in the fact that trees are not being planted to increase woodfuel supply.[45] A study done in Kakamega by Kenya woodfuel development project in 1985, showed that 65% of the people raised their own tree seelings by obtaining seeds from the local trees [KWDP Working Paper No. 5, 1985].[46] Hence other reasons why people do not plant trees in this country should be researched into.

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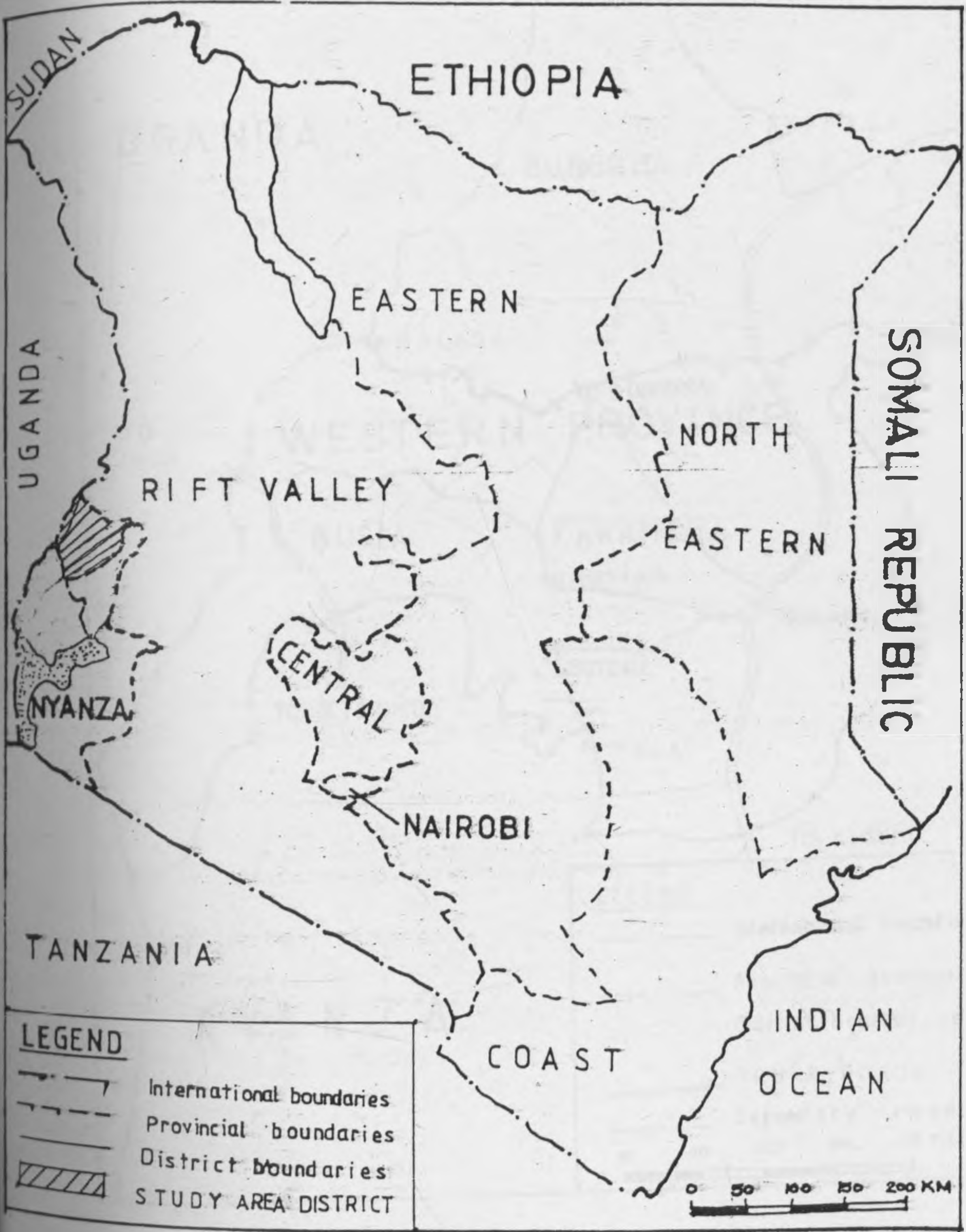
CHAPTER THREEE : STUDY AREA

3.1 LOCATION AND SIZE

Naitiri sublocation is situated in the extreme east of Naitiri location, Tongaren division, Bungoma district in the Western Province of Kenya. It is at an altitude of about 6200ft [1890 metres] at latitude 00° 45'N and longitude 35° 59'E.[1] The whole of its western boundary borders the Sikhendu -Naitiri road, the northern side borders Trans-Nzoia district while the southern and eastern side border the Naitiri Tongaren road and Kiminini river [a tributary of trans-nzoia river] respectively. Naitiri sublocation covers an area of 36.34 sq. km [Figure 3.1. to 3.4].

3.2 HISTORICAL BACKGROUND

During the colonial days, this area was occupied by European farmers. However, after independence, the land was subdivided and the local people [mainly from the then congested parts of Western Province] were settled in it in 1965. The finance used for the purchase of the land was provided by the government and was to be repaid in 30 years. The land tenure is freehold though titles are obtained only after completion of loan repayment. Land in this community is owned by the man who is also the head of the household. Traditionally, tree planting is considered to be exclusively the responsibility of men. It is therefore taboo for a woman to plant a tree for it



GURE 3.1 BUNGOMA DISTRICT IN ITS NATIONAL CONTEXT

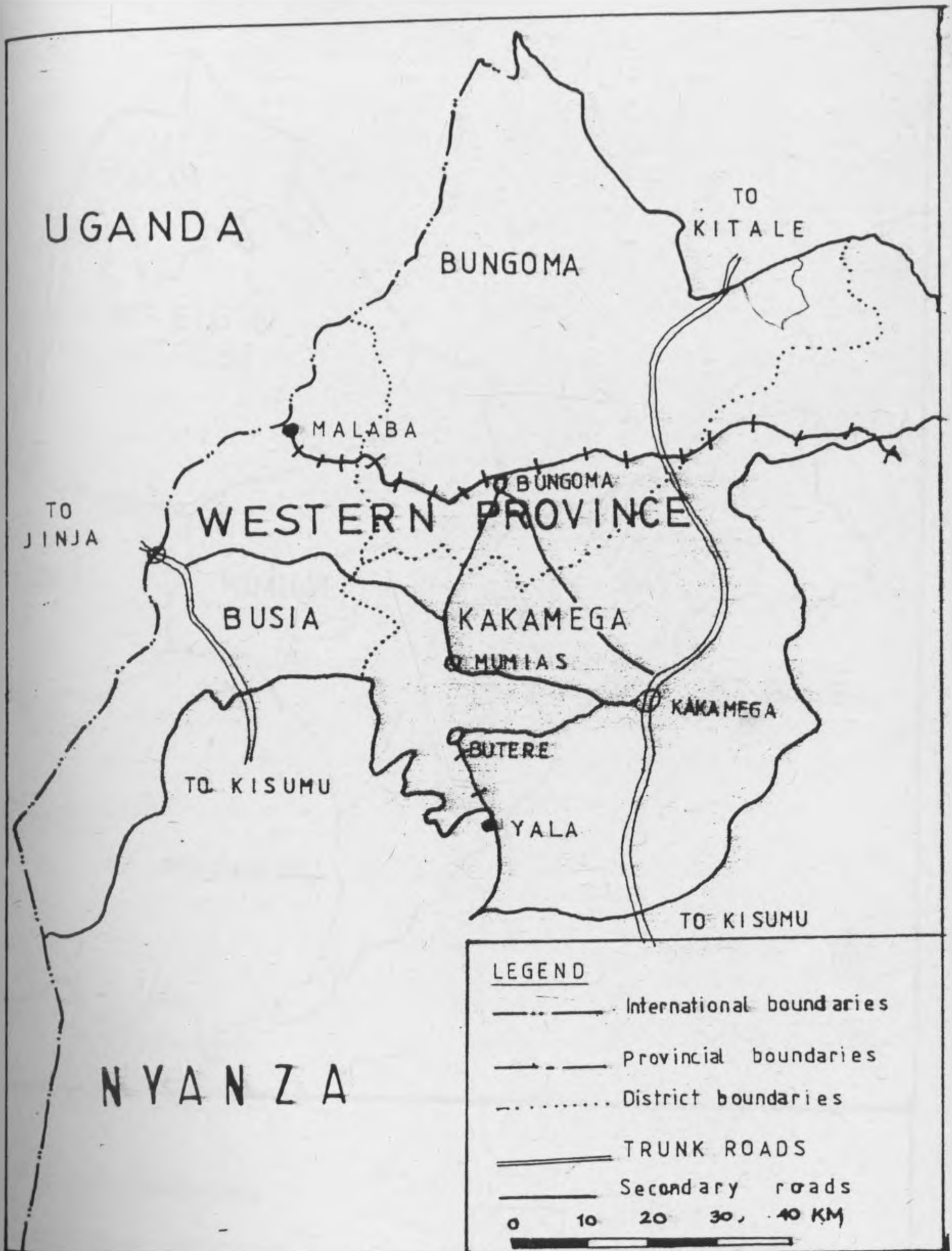
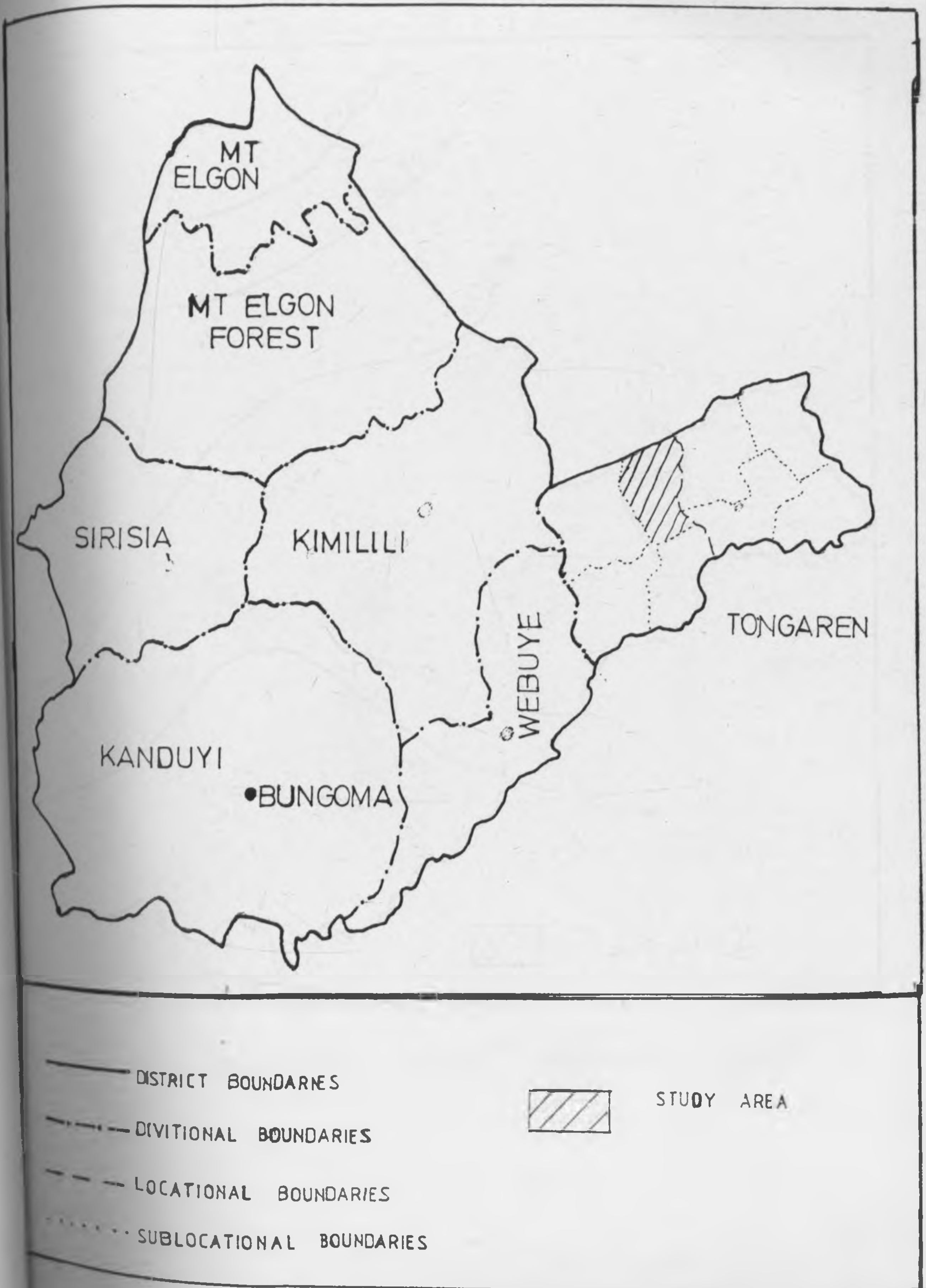
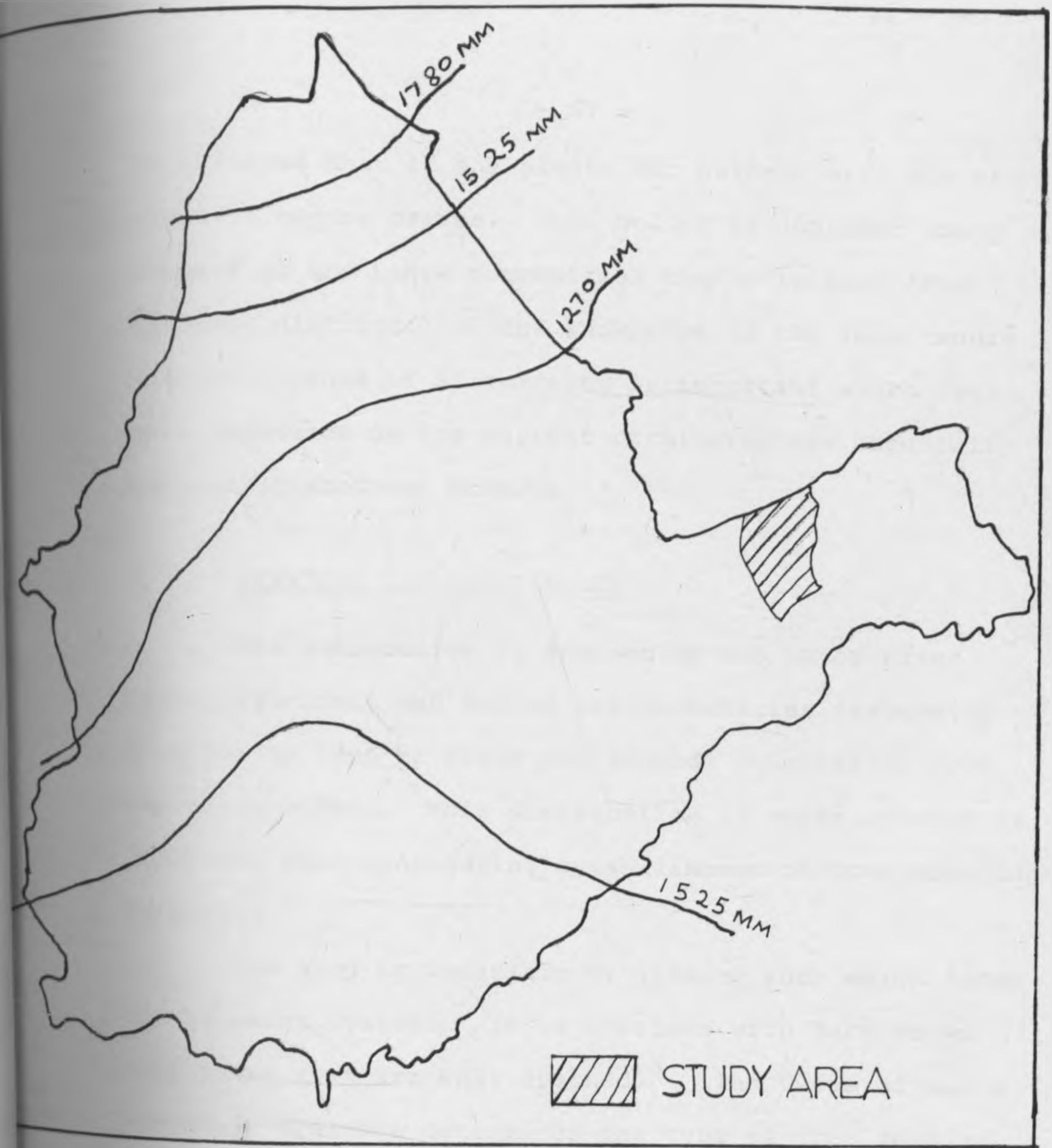


FIGURE3.2 BUNGOMA DISTRICT IN ITS REGIONAL CONTEXT



GURE 3·3 STUDY AREA IN ITS LOCAL CONTEXT



RE NO.3.4 BUNGOMA DISTRICT RAINFALL MAP

is believed that if she plants her husband will die or she will become barren. This belief is dominant among members of the Luhya communities that originate from Kakamega district.[2] The knowledge of the land tenure and the customs of a community is important since they have influence on the current rural problems especially the energy shortage problem.

3.3 PHYSICAL CHARACTERISTICS

The sublocation is drained by one major river [river kiminini] and two of its tributaries [kabuyefwe originating from Mt Elgon and sirende originating from the sublocation]. This distribution of water sources is important when considering establishment of tree seedling nurseries.

The area is underlain by granite rock which forms the basement systems. It is overlain with dark brown sandy loams that are well drained.[3] The types of soils and their drainage determines the type of tree species that can grow well in any given area.

3.4 VEGETATION

Ojany and Ogendo [1987] classifies the natural vegegation of this area as low tree - high grass [scattered tree grass land]. This consists of tall grass 5 to 8 ft [1.5 to 2.4m] high. Densely scattered within it are small treess 10 to 15 ft [3.0 to 4.6m] high although in favrourable areas where there are better ground water resources, the trees may grow to 30feet [9.1m]. Considerable, though isolated areas support forest trees some of which may reach a hight of 90 feet [27.4m]. Protected by the corky bark, the trees composing this community [of low tree - high grass] are broad - leaved and deciduous, being dominated by various species of Combretum,[plate 1]. The others are Terminalia [plate 2] Faurea, Erythrina tomentosa, Ficus species, Ozoroa, Bauhinia and Dombeya. The most predominate grasses giving rise to the high grass nature of this community belong to the Hyparrhenia and Cymbopogon genera with Cymbopogon afronardus predominant in this area.[5] The above described vegetation is what used to exist before 1965 in at least about 3/4 of the sub-location. [The other 1/4 was already being farmed by the white settlers]. However, due to the settlement, and the increase in population, the natural vegetation has been cleared to create land for farming. Below in Plate 3 are the remains of what used to be tree-high grass community. Remains of the overgrazed hyparrhenia grass can be seen on the fore-ground of plate 3.

At the time of the survey most of the vegetation comprised of agricultural crops and overgrazed unfarmed lands as shown in plate 4.

Knowledge of the types of vegetation that initially existed in an area is very useful when choosing the type of tree species to be introduced or propagated in the particular area. Scattered in the area are natural shrub land, bush varying in density from thicket to scattered bush. In valley bottoms and swampy areas and along the rivers the natural vegetation can still be seen but the grass component has been removed.

With the removing of the indigeneous tree types to create room for farming followed the need for people to plant trees to meet various needs, most of the trees planted are Eucalyptus, Cyprus, Pinus and Grevillea plates 5,6,7,8 respectively. The number of indigeneous trees planted by the people is insignificant.

3.5 CLIMATE

The area receives between 889mm - 1619mm of rainfall per annum. It has a bimodal rainfall pattern receiving rainfall the whole year round with peaks in May and August. Taking the average of the last ten years 1978-1988, the May peak is 194.6mm while the August peak is 164.5mm. The long rains start in February - March, reaching the peak in May and decrease in June. The quantity increases again from July and reaches the peak in August and decreases to the minimum as shown in figure 3.6a and 3.6b.

The amount of rainfall and the time of the year when it comes is useful in determining the tree types to be planted and when to be planted. This is because some trees require high quantities of rainfall to grow well while others require very little.

The mean maximum annual temperature is 25.95°C while the mean minimum temperature per annum is 11.6°C. In the last ten years [1978-1987], the hottest month was March with an average mean of 20.1°C and the coldest was July with average mean of 14.3°C as shown in Figure 3.7.[4] Knowledge of temperature levels and variations are useful in tree species selection.

Plate 1: Combretum species is the most common indigennous tree species of the study area. Middle foreground.

Plate 2: Terminalia is the second most common indigenious tree species of the study area.

Plate 3: Remains of the natural vegetation of the study area.

Plate 4: Current vegetation in the area

FIGURE 3.6 MEAN MONTHLY RAINFALL FOR 11 YEARS

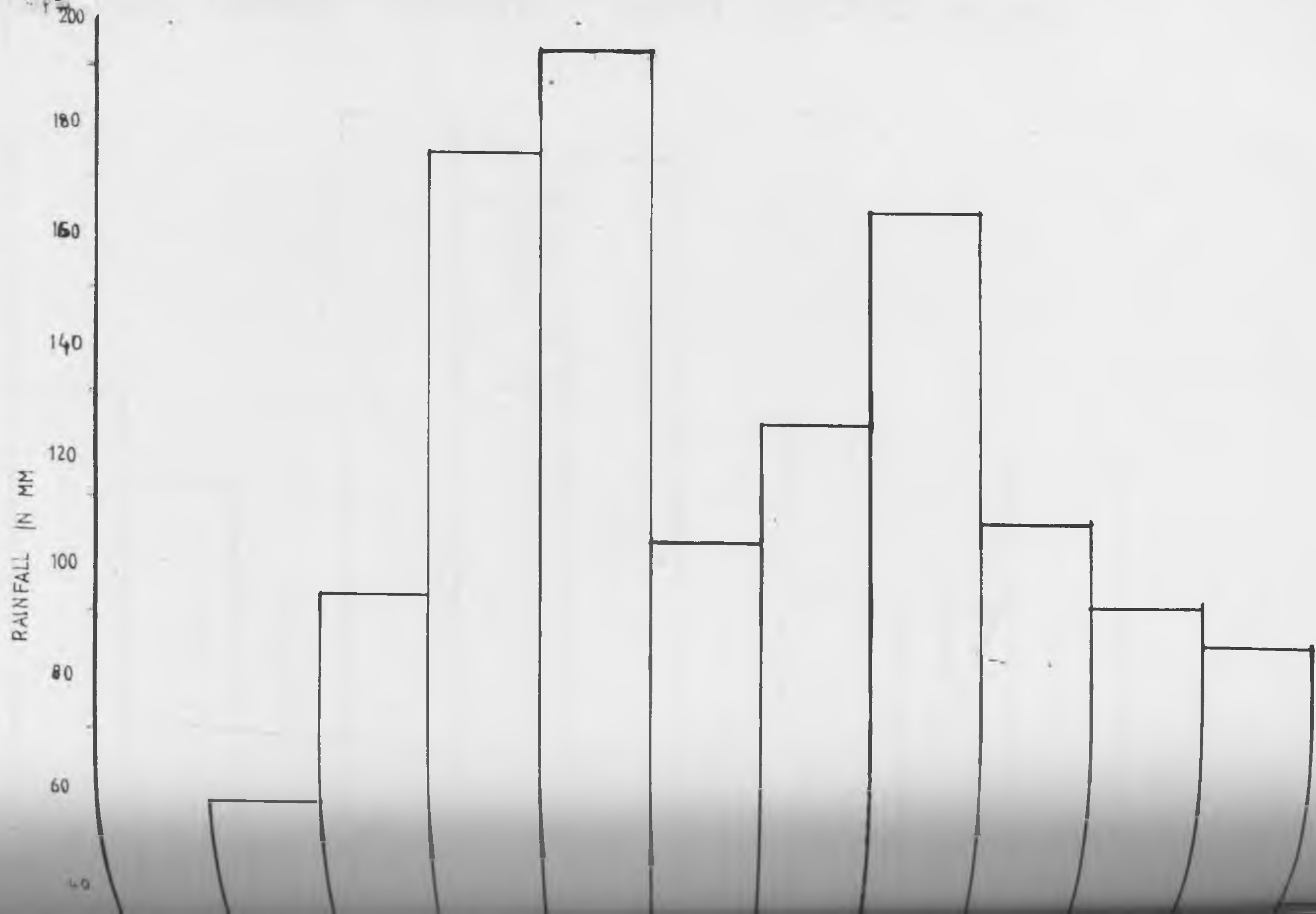
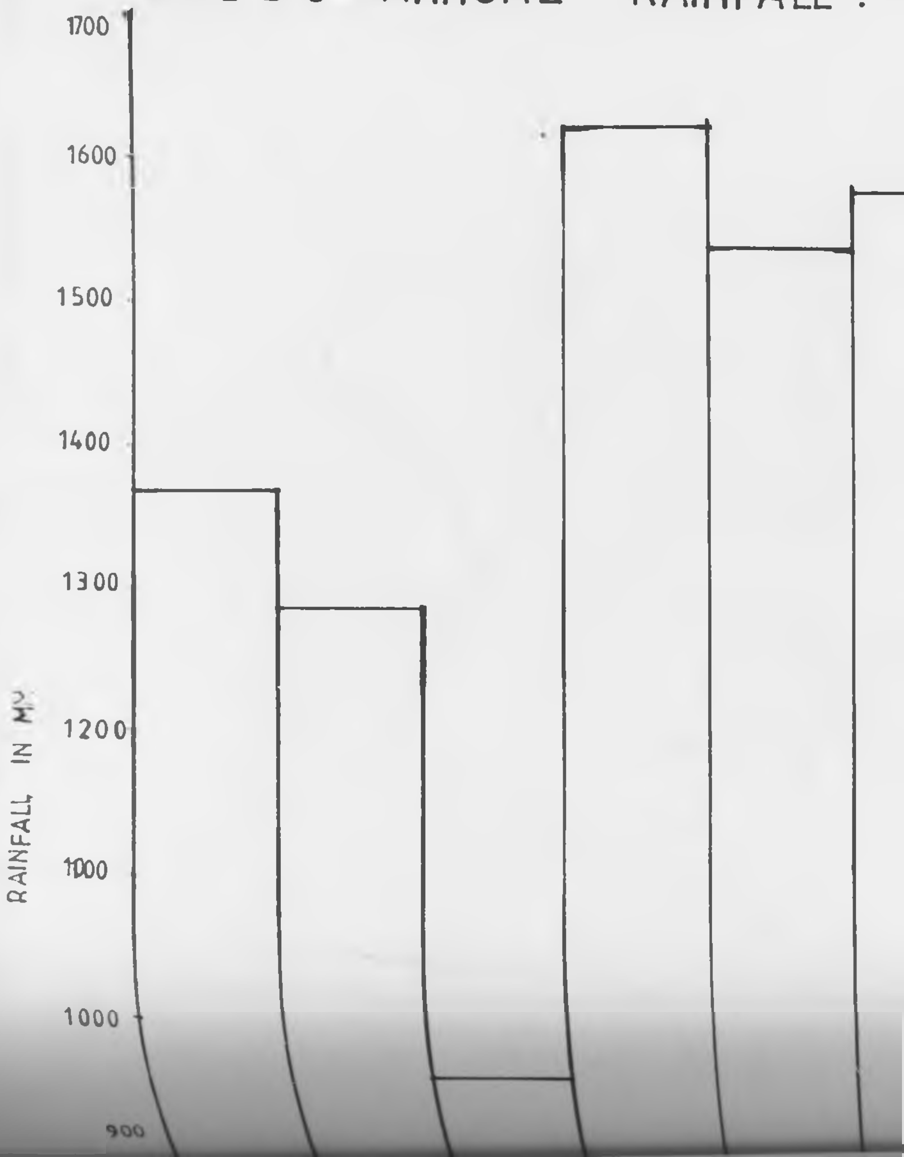


FIGURE 3.6 ANNUAL RAINFALL :



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TREND FOR TEN YEARS

FIGURE 3.7

MINIMUM MAXIMUM AND MEAN MONTHLY TEMPERATURE

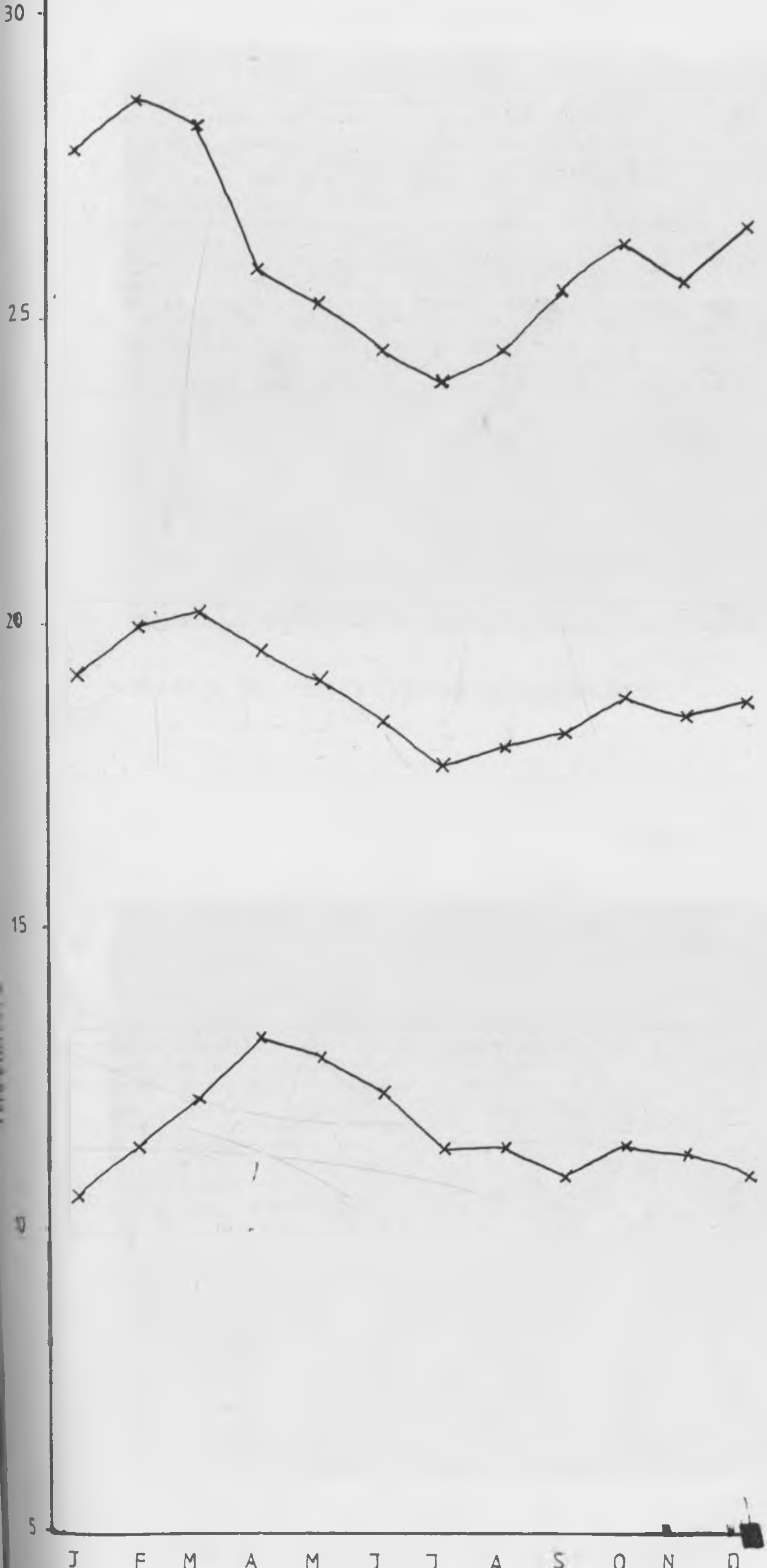

Plate 5: Eucalyptus plantation

Plate 6: A woodlot of cyprus trees

Plate 7: A woodlot of Pinus trees

Plate 8: A woodlot of Grevillea trees

3.6 SOCIAL ECONOMIC PROFILE POPULATION

As per the 1979 population census which was the first one in this area, the population of the whole division was as shown below.[6]

Table 3.1: Population

Area	Population [No.of People]	Density No./sq.Km
Naitiri/Kamukuywa [sub]	13,130	121
Kibisi/Kabuyefwe [sub]	14,522	167
Naitiri/Location	27,652	142
Ndalu/Kiminini [sub]	9,085	93
Tongaren/Soysambu	12,497	144
Tongaren T.C.	224	350
Ndalu Location	21,458	118

Source: Central Bureau of Statistics , 1979 Population census P. 87

Naitiri sublocation is one of the four sub-locations of Naitiri location, the other three being Kamukuywa, Kibisi and Kabuyefwe. During the 1979 census, the location had only two sublocations that is Naitiri/Kamukuywa with a population of 13,130 and Kibisi/Kabuyefwe with a population of 14,522 people. At the time of the survey, the two sublocations had been sub-divided into four which are mentioned above.

The total land area of the sublocation is 3634 ha all of which is arable. Agriculture is the mainstay of the area and non-agricultural employment is very scarce in this area. The majority of the people are engaged in small scale mixed farming growing both cash and food crops as well as keeping livestock. Maize is the main staple food though it is also a cash crop. The other cash crops grown include sunflower and coffee [recently introduced]. The livestock reared include cattle [both dairy and draught], goats, sheep and poultry. Milk from the dairy cattle is a major source of income.[7]

Population changes in any area have major influences on resource utilisation of the particular area. For example, the higher the population of an area, the faster the depletion of non-renewable resources. The type and level of employment on the other hand will determine peoples' ability to afford alternative forms of energy and will also influence their response to development issues.

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CHAPTER FOUR

RESEARCH FINDINGS AND DATA ANALYSIS

The study has come up with a wide range of information as regardsthe study problem. This includes information on the nature of community characteristics and how they are related to the study,what the people feel are the community problems and the implications of these problems on development programmes. Farming practices and the other local economic activities have been examined in the light of the study problem.

The level of woodfuel consumption has been established and the factors that affect it looked into too. Established also is the level of wood supply and the factors that affect it.

The causes of woodfuel scarcity were examined and possible remedies considered. This includes examination of the various alternative sources of energy as regards suitability, and affordability.

Considered too are the energy conservation measures practised in the area and the extension services provided for the people as regards tree planting.

4.1 Nature of Community Characteristics

Information from the household questionnaire indicate that out of the total number of respondents interviewed 20% of them were heads of households, 75% wives, 2.5% sons and 2.5% daughters. This distribution is so because most of the men are out of the homes during the day in search of income generating activities. It was established that 9.8% of the men were working and residing elsewhere and, 10.9% not there at all meaning that 10.9% of the households are headed by women. This was considered since first the gatherers and users of wood fuel are mainly women hence if the majority of the respondents were men, the information gathered would be less accurate; usually, men get involved in woodfuel matters when it concerns charcoal production and when it is wood for sale. Secondly, in Kenya, land belongs to men since it is them who inherit from their fathers therefore decisions concerning land utilisation is mainly a man's responsibility. When the men who are supposed to make these decisions are away most of the time, i.e. working and residing away from home development on the farm may lag behind. It is worse in areas where customs prohibit women from planting trees, because a wife will be forced to wait until when the husband comes home either on leave which may be once or more times in a year.

Considering the age of the respondents, most of them [70.9%] were between 36 and 60 years and 17.1% below 36 years, while 12.2% above 60 years. Those above 60 years of age tended to be rigid on customs and less flexible to the idea of women planting trees. Those below 36 years of age were very flexible and not bothered much with customs while those between 36 and 60 years of age seemed to be operating within the above two extremes Those who had gone to school had less adherance to customary laws as concerns tree planting while those who had not gone to school tended to have strongly held on the customary laws. It was found that 52% of the respondents had received primary level education, 16% secondary level and none had received high school education. The remaining 32% who happened to be the very old above 51 years had received no formal education. It was generally observed that those who have been to school at least to secondary level were very informed and could understand the woodfuel problem faster and also the same have good stand of wood on their farms. There could be other factors like income that were influencing these cbserved facts but still education seemed to have played a significatnt role. Cultural beliefs have been found to have a major influence on tree planting hence woodfuel production. This infleunce was sought by looking at the various tribes that occupy the study area and their beliefs as regards tree planting. The results of the survey indicated that the following three tribes are represented in the study area that is : Luhya [95.1%], Masai 1.2% and Luo [3.7%]. The Luhya tribe was further broken down to the different communities that it comprised of.Table 4.1 below showsthe details.

Table 4.1 Luhya Communities

Community type	Frequency %
Bukusu	56
Maragoli	11.0
Isukha	6.1
Tachoni	7.3
Tiriki	1.2
Kabras	4.9
Banyala	3.7
Kisa	1.2
Bunyore	2.4
Butsotso	1.2

Source: Field survey

It was observed that the belief prohibiting women not to plant trees was dominant among members of the Luhya communities that originated from Kakamega district. That is the Maragoli, Isukha, Tiriki, Kabras, Kisa, Bunyore and Batsotso , who form 29.2% of the Luhya in the study area. These groups still hold firmly on the said belief though they claim that it is not a handicap since they can use their sons or workmen to plant trees if there was need for such an activity. The Bukusu who form 65% of the Luhya community in this area, do not have this kind of belief except for a particular Ficus [Mugumo] tree species which cannot be planted by women because it is used for witchcraft. From these findings, it is clear that customs are not a hindrance to tree planting hence they are not a constraint to woodfuel production in the study areas.

As regards the observation made in Kakamega district by Kenya Woodfuel Development progamme [KWDP] that trees belong to the man and they are mainly for sale. The study area appeared to have a different arrangement where by women seem to have a fair say in tree issues. That is, a woman can harvest and sell trees or even use for fuelwood.

In chapter two, it is mentioned that the bigger the family size, the less the per capita consumption of woodfuel while the smaller the family size, the larger the per capita consumption. It is further indicated that land tenure is a constraint to tree planting. This came out very clearly in the study area whereby most of the plots are still in the names of the original owners that is land has not been subdivided among the sons so despite the fact that the number of housholds per plot have increased from one to an average of 2.5 the land still belongs to the parents. This has made it difficult for the sons to plant trees because some have been refused by the parents while others feel that after planting, when land is subdivided, their trees may be given to their brothers, yet the same people continue using the wood that is already there. These two factors together with population increase have contributed significantly to wood resources depletion in the study area.

From the survey, the average household size was found to be 7.3 people and the average number of households per plot is 2.5. In 1965 [time when the people were settled] only one household was settled on a plot but over time, sons have moved from their fathers households to form their own families and these accounts for the increase in the number of households per plot. From the 1979 census the household size was 8.18 people. This has gone down to 7.3 bringing the average number of people per plot to 18.2 [decrease in household size is mainly due to the new households who are in their early stage of having families], hence increasing the density by 122.5%. Given that the density in 1979 was 121 people pe sq km and 1988 it had increased by 122.5%, the density in 1988 is 269.2 people per sq.km.and since the area of the study area is not given, it has been worked from the land sizes as shown below and estimated to 36.34 sq.mk. given the above density, the 1988 population is estimated at 9,783 people, a 63% increase in ten years.

4.2 Land Sizes and Farming Practices

The land holdings, farming practices and income has major influences on the type and number of trees that any given individual can plant. These were also looked into and the following information was gathered. According to the survey, the land sizes in the study area are grouped in five categories, ie.

Table 4.2 Land size distribution

Ha	%	No of plots and area covered	
		Plots	[ha]
40	1.5	5	200
15	23.2	80	1200
11	31.7	110	1210
8	17.1	59	472
6	26.5	92	552
Total	100	346	3634

Source: Field survey

The total land area of the sublocation is 3634. All except 1.5% are small holdings of between 6 and 15 ha the other 1.5% are over 40 ha each and are under mixed farming but at a slightly large scale. The sizes of the remaining 98.5% are as in the table above.

The majority of the people are engaged in small scale mixed farming that is growing both cash and food crops as well as keeping livestock. Maize is the main staple food though it is also a cash crop. The other cash crops grown include sunflower beans and coffee [recently introduced]. The livestock reared include cattle [both dairy and draught],goats, sheep and poultry.

Maize cobs and stalks together with sunflower stalks are alternative sources of energy especially the maize cobs. Increased availability of these alternative source has two effects on the use and production of wood resources. First, it reduces pressure on the use of woodfuel and second it acts as a constraint to woodfuel production. Their net effect on wood resources would be zero if the two effects were equal but it is not easy to determine the magnitufe especially that of the constraint effect. The other effect can be measured and will be discussed later in this chapter by measuring the wood conserved by the use of crop residues.

As regards livestock, cattle were found to be a major component of the livestock kept. These are potential sources of the dung that can be used in biogs production Currently cowdung is used by the relatively poor people of the area, as farm manure, while the relatively well to do use commercial fertilizers for their farm inputs hence the dung produced on their farms is not used. It is these same well to do people who have more animals and fair incomes that can finance biogas units. On average 3.2 cattle are kept per household but considering only those who had cattle, it is an average of 3.5 cattle per household. The number of cattle and other livestock is relevant in that alternative sources of energy like biogas can only operate on a minimum quantity of dung from a minimum number of animals. 26.8% of the households were found to own more than 4 cattle hence qualify for biogas units on the grounds of raw material availability only. At the time of the survey, no zerograzing unit existed [it is recommended for effecient operation of biogas units]. Range grazing [where animals are released in grazing land to graze on their own with or without a herdsman] was the only observed form of feeding the livestock.

The sublocation average land size per household is 42 ha cut of this only 49.1% is cultivated but the remaining 50.9% is uncropped. The uncropped land is left either for grazing or just as bush. This fact rules out shortage of land for tree planting as a reason for lack of woodfuel for domestic use.

4.3 Employment and Income Levels

Agriculture is the mainstay of the study area. It has employed 65.9% of the men and 97.6% of the women

13.4% of the men and 2.4% of the women are in formal employment mainly as teachers. 8.5% of the men are engaged in business of mainly retail shops, hotels and bars.

The average household annual income of the study area ranged between Kshs.2,200/- and 45,900/- with an average of Ksh.14,880/- per household. This gives a per capita annual income of between Khs. 301/- and 6,288/- averaging to Ksh. 2,038/- while the monthly per capita income ranges from Kshs. 25/- to 524/- with an average of Ksh. 170/-.

As will be discussed later in this chapter, income has a major influence on consumption and supply of wood-fuel. That is, the higher the income, the higher the wood-fuel consumption and also the higher the income, the higher the supply.

The agricultural sector is known to have low and seasonal incomes. It was observed that the people who were in formal employment had relatively higher number of trees than those who did not have any family member in formal employment. This tends to bring out the fact that incomes from agriculture alone are not high. The incomes appear high because the people are paid for the produce once in a year but when distributed over the year, it is very little.

An enquiry into the adequacy of food supply revealed that 43.9% of households do not have enough food for the whole year round, and have to buy food for an average of four months every year. The reason given was that enough maize is produced by the majority of the families but because of the low incomes the maize is sold for cash income so as to pay fees for the children and other expenditures. The selling of maize occurs mainly in January/February when schools are opening. It is around the same time that the tree planting occurs. This was seen as a hinderance to tree planting since it costs some money to plant trees. As regards food, during the onset of short rains July -August when tree planting could also be done, there is a food shortage so any money available is likely to be used for buying food and not tree seedlings or seed.

4.4 Community Problems

It is mentioned in chapter two that peoples' priorities as regards their problems determines their response to development projects or projects designed to solve community problems. Peoples views on what they consider the most serious community problems were sought and the findings were as show in the table 4.3 below:-

Table 4.3: Community Problems in General

Problem	Priority [1] [Frequency] %	Priority [2] [Frequency] %
Water	31.7	11.0
Firewood	20.7	3.7
Nursery school	1.2	1.2
Hailstones	1.2	-
Poverty	4.9	8.5
Health facilities	7.4	1.2
Marketing of farm produce	12.2	3.7
Roads	6.1	17.1
Disunity	2.4	1.2
Roadgrazing	1.2	-
Lack of shopping centre	1.2	3.7
Herdsmen	1.2	4.8
Vegetables [dry season]	4.9	2.4
No problem	3.7	41.5
Total	100.	100

Source: Field Survey

In summary, the most serious problems affecting the people of this area are shown in table 4.4. below

4.4 Summary of Community problems

Problem	Priority 1	Problem	Priority 2
watrer	31.7%	Road	17.1%
Firewood	20.7%	water	11.0%
Marketing of Agri. productts	12.2%	Others	30.4%
Others	34.4%	No problem	41.5%
Total	100.		100.

Source: Field survey

A close look at this table reveals that the people have very many problems and different people had their own different problem priorities. This implies that any efforts to solve any particular problem would meet with a weak support since peoples' priorities are too diversified. Table 4.4 summarises these problems in an attempt to bring out the problems that are affecting the majority of the people and the order of the seriousness of these problems. In this table, water is leading as the most serious problem followed by fuelwood and marketing of agricultural products, all the other problems summed together form 34.4% of peoples' views as regards their seriousness. As second priority, roads come out as the most serious followed by water. Other problems summed together came to 30.4% while 41.5% of the people felt that they did not have a second priority problem.

A closer look into these problems and from peoples' comments, it was noted that the major cause of water shortage was low capacity of the pump. All the homes in this sublocation have had water taps since 1972 but there is no water in this taps. The laying of pipes for provision of water in this area was done by the government in 1971/72. The project provided water for only two years and since then only 6.1% of the homes receive tap water. The others get their water from various sources. 29.3% get water from the river 40.2% from wells and 24.4% have dug up borehols in their own homes.

Given that water has the highest attention as regards community problems suggest that development projects should try to solve the water problem of this area before embarking on other problems like woodfuel shortage and marketing of produce. However, if it becomes necessary to start with the second or even third priorities, in national interests or due to a major constraint in solving the first priority problems first an explanation to the community as to the reasons of the action taken can help in getting support and cooperation. Beside this, shortage of water greatly retards tree planting efforts. Considering that raising of tree seedlings in the nursery will require watering for a minimum of two months explains the importance of water in tree planting hence wood fuel production.

Considering the distance covered when going to fetch water, about 92.7% cover less than 1 km while the remaining 7.3 go for more than a km. Though the percentage of households that fetch water from far is small, it is still a significant problem when considering the many hours that are spent on fetching water which would otherwise be spent on other income generating activities like farming, which would in turn improve income hence woodfuel supply or the time would be spent directly on tree planting.

As regards the second most serious problem which was identified as fuelwood shortage the fact that the community has already identified this as a serious problem implies that efforts to solve the woodfuel shortage will receive a fair cooperation from the people. The third problem which is marketing of produce affects income levels hence wood production. Focusing on second priority problems poor roads came out as an outstanding problem. Repair of these roads will facilitate easy and faster transportation of farm produce and even transportation of the tree seedlings from the nurseries to the planting sites.

Another community characteristic that was looked at is religion. Churches are known to have influence on development projects. The influence may be positive or negative depending on the type of project, and also type of denomination. For example, in Kakamega, it was observed that the area dominated by the Anglican Church had more flexible attitudes as regards women planting trees as compared to another area dominated by the Friends Church.

Below is table 4.5 showing the findings of the nature of the church and distribution of people in the various denominations:-

Table 4.5 Types of Denominations

Type of church	Frequency %
Friends	29.2
Catholic	28.1
Salvation Army	15.8
P.A.G	14.6
Church of God	3.7
Anglican	3.7
S.D.A.[Seventh Day Adventist]	1.2
None	3.7
	100

Source: Field survey

In this area, members of some denominations feel they are more superior than the others. This has bred disunity in the community and it came out clear that except for a few members the majority are not ready to unite in community projects. Some churches would want to see the others falling apart and failing.

Finally, a community that works together displays a spirit of unity which can effect fast development. An examination into the level of unity among the people of the study area by looking into their involvement in social organisations other than church revealed that only 44% of the people were involved in two types of activities, that is money contributions and marketing of produce. The other 56% were not involved in these kind of activities. Most of them claimed that the low level unity was due to mistrust of one another. This is an attitude that developed in people after some group resources were mismanaged by the officials. This displays a weakness that can retard development efforts especially where communal efforts are required.

4.5 ENERGY CONSUMPTION

The survey established that there are various sources of domestic energy in the study area. These includes fuelwood, maize cobs, charcoal, maize stalks, sunflower stalks, tree barks, sisal leaves, liquid petroleum gas and kerosene. Some of these are shown in plates 9-14 below. All expect kerosene provide energy for cooking, heating water and warming houses. Kerosene mainly provides energy for lighting and only 1% of the households use it for cooking and heating water.

4.5.1 Fuelwood

The findings show that only 2% of the people use only firewood for cooking, heating and warming the whole year round. It was observed that the 2% who use fire-wood exclusively are the people who have eucalyptus plantations that were left by the white settlers. 97.5% of the people, however, use fuelwood in an average of 197 days in a year [about 54% of the time in a year] with

a daily per capita consumption of 2.2 kg. This gives an annual per capita woodfuel consumption of 433.4 kg. If woodfuel is to be used the whole year round at the given average rate of 2.2kg per capita per day, then the annual consumption would be 803 k.g per capita. The difference between what would be consumed in the absence of crop residues and what is currently being consumed gives an indication of the woodfuel deficit. It cannot, however, be equated to the domestic demand deficit because consumption has many variables as shown in chapter two but for the purpose of this study, consumption will be considered as a close estimate of demand and it is the consumption level which will be used in the projections. As a general pattern of consumption it was observed that woodfuel is used only when there is no maize cobs. This is the period starting from around mid-May to mid-October. The main reason for this pattern of consumption was that from November to April, there is alot of work that is maize harvesting, [November and December] land preparation, [January and February] planting [March and April] hence there
Weeding (May/April) top dressing (July Aug) Beans uproot (June/July) cutting Maize (Sep/Oct)
is no time to search for fuelwood and also that the maize cobs are readily available. This seems to agree with the suggestion in chapter two that consumption level of woodfuel depends on availability of free-labour to search for woodfuel and also on the availability of suitable substitutes.

Plate 9: Freshly cut and split wood for firewood

Plate 10: Fuelwood stored outside the house

Plate 11: Maize cobs and firewood left to dry in the sun

Plate 12: Maize cobs and sisal leaves drying in the sun

Plate 13: Children coming from collecting maize stalks for cooking

Plate 14: Tree bark drying in the sun

4.5.2 CROP RESIDUES

Maize stalks and sunflower stalks are some of the crop residues used but these are mainly used for lighting fires. Though there are some households that use them for cooking and heating, the level of consumption of these two crop residues is not significant - when compared to the other sources of energy. Maize cobs as a source of energy, however, is considered a major substitute of fuelwood and is used by 0.5% of the households the whole year round and 97.5% of the households for about 5.6 months or 168 days [46% of the time in a year]. The per capita daily consumption of maize cobs was found to be an average of 2.23 kg. This comes to an annual per capita consumption of 374.64 kg. of maize cobs. Looking at the per capita daily consumption of fuelwood [2.20kg] and maize cobs [2.23kg], one sees a value ratio of almost 1:1 suggesting that maize cobs are a suitable substitute to woodfuel. It was found that the amount of maize cobs available depends on the maize harvest of the particular year in question and that the more the maize cobs available, the less the fuelwood used on annual basis.

4.5.3 Other Sources of Energy for Cooking

Other sources of cooking energy are gas and kerosene but are used by only 1% of the households in both cases and used only on special occasions like during weddings, funerals or some other functions when extra cooking is required. Charcoal is also used at a rate of 0.36 of a bag [12.6 kg] per capita per year but it is mainly used for warming during the cold season and also for straightening [Ironing clothes].

4.5.4 Lighting

All the people of these area use kerosene for lighting at a rate of about 8.82 litres per capita per year. The kerosene is obtained from a distance ranging from 0.5 km to 50km. Table 4.6 below shows the distribution of households as regards the nearest source of kerosene.

Kerosene Table 4.6: Distance to Source of Kerosene for Households

Distance Range km	Frequencey %
< 5	18.3
> 5 ≤ 10	20.7
>10 ≤ 15	7.3
>15 ≤ 20	9.8
>20 ≤ 25	1.2
>25 ≤ 30	12.2
>30 ≤ 35	0.0
>35 ≤ 40	23.2
>40	7.3

Source: Field survey

kerosene is a potential substitute to woodfuel. From these findings, only about 18.3% of the people travel less than 5km to it . The rest travel more than 5km to get it and there is even 30.5% of the people who travel over 35km. to get kerosene. The long distance can be a disincentive to anybody wanting to use kerosene for other uses like cooking. Currently most of the users buy in 5 or 10 litre containers once in a month so they do not find it very costly but if they were to use more quantities of kerosene, it would be too expensive. Since they would have to buy it more than once a month.

4.6 FACTORS THAT AFFECT CONSUMPTION OF FUELWOOD

There are four major and two minor factors that affect domestic fuelwood consumption in the study area. The major ones include income, family size, supply and availability of suitable substitutes while the minor ones are ceremonies [e.g. funerals and weddings] and competition for labour. Table 4.7 below shows the per capita daily consumption [kg] and annual income, family size and wood supply relationships:-

Table 4.7: Village Consumption, income, family size and supply

Village	Per Capita[kg] Daily Consumption	Annual Per capita income Kshs	Family size	Supply No of trees
Lungai	2.01	1,747.00	21.6	463
Shihilila	2.55	2,557.00	13.5	560
Sirende	2.64	3,587.00	16.4	1169
Sango	1.78	775.00	32.5	120
Nanjala	2.37	1,457.00	15.3	308
Wabukhonyi	1.81	2,646.00	15.2	466
Makhanga A	2.56	3,364.00	11.0	452
Makhanga B	1.87	1,228.00	19.3	252

Source: Field survey

4.6.1 Income, Household Size, and Supply

Questions on income tend to be sensitive and though it was difficult to get the exact income earned, approximate income for the households was estimated from the peoples' formal employment and agricultural produce.

The per capita annual income was compared to the per capita woodfuel consumption to establish the type of relationship and the level of dependence of woodfuel consumption on the income of the people. Initially, scatter diagrams were drawn from all the three relationships to give the general tendency or type of relationships, that is whether directly or inversely related. For the first relationship, consumption was the dependent while income was the independent variable. In the second and even third relationships consumption still remains the dependent while household size and supply are the independent variables respectively. The scatter-grams are as shown in figure 4.1, 4.2 and 4.3.

From the scatter-grams the following relationships have emerged. Figure 4.1: shows that the higher the per capita income, the higher the per capita consumption of woodfuel. Figure 4.2 on the other hand shows that as the family size increases, the per capita consumption of woodfuel drops and figure 4.3 show that the higher the supply level the higher the per capita consumption. After establishing the type of relationships, it was found necessary to find out the level of dependence of woodfuel consumption on the three woodfuel consumption on the three given variables.

Using simple regression analysis, the level of the dependence of woodfuel consumption on the three independent variables was established. Using the regression formula of:-

FIGURE 4.1 INCOME : CONSUMPTION RELATIONSHIP

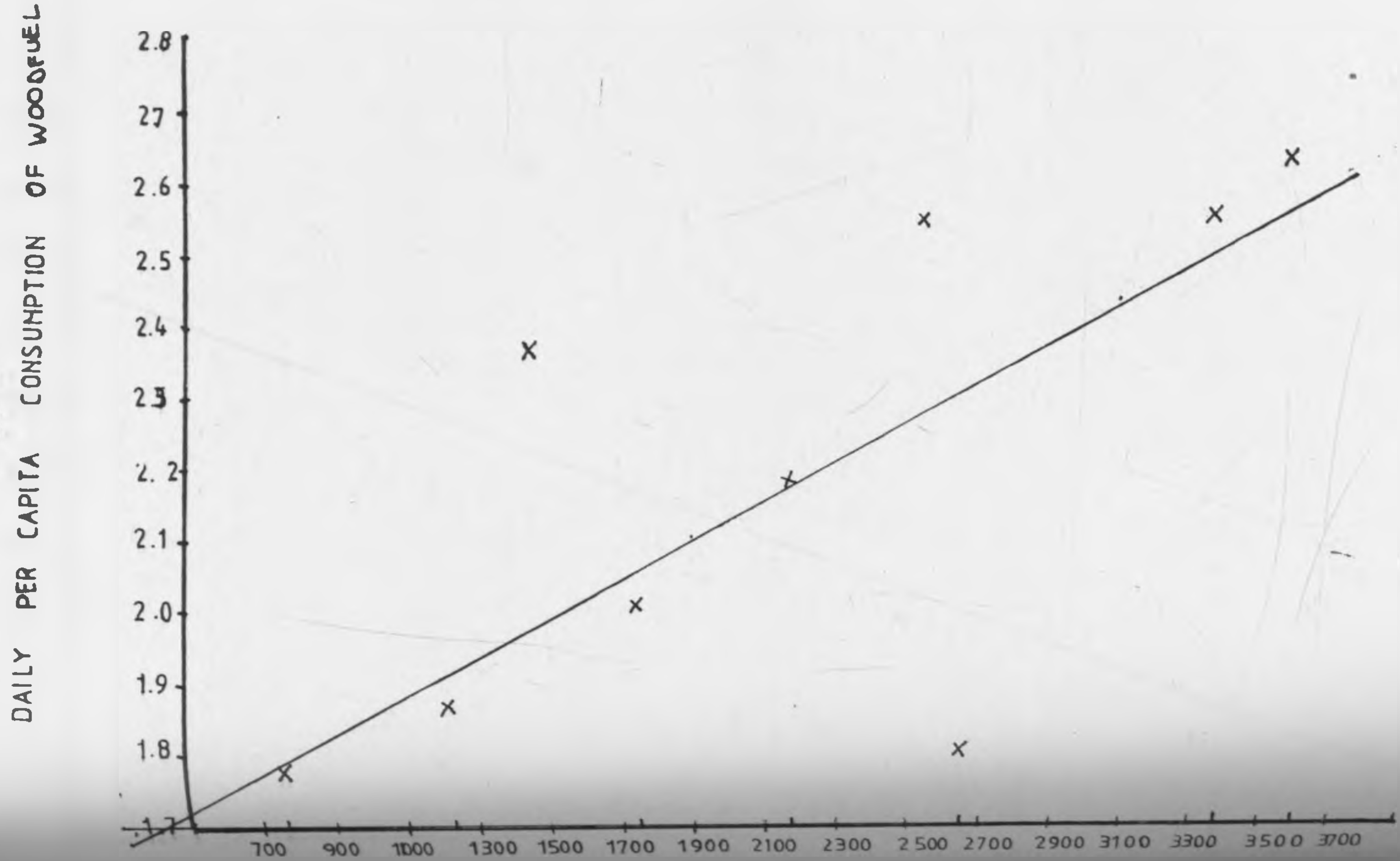


FIGURE 4.2 FAMILY SIZE: CONSUMPTION RELATIONSHIP

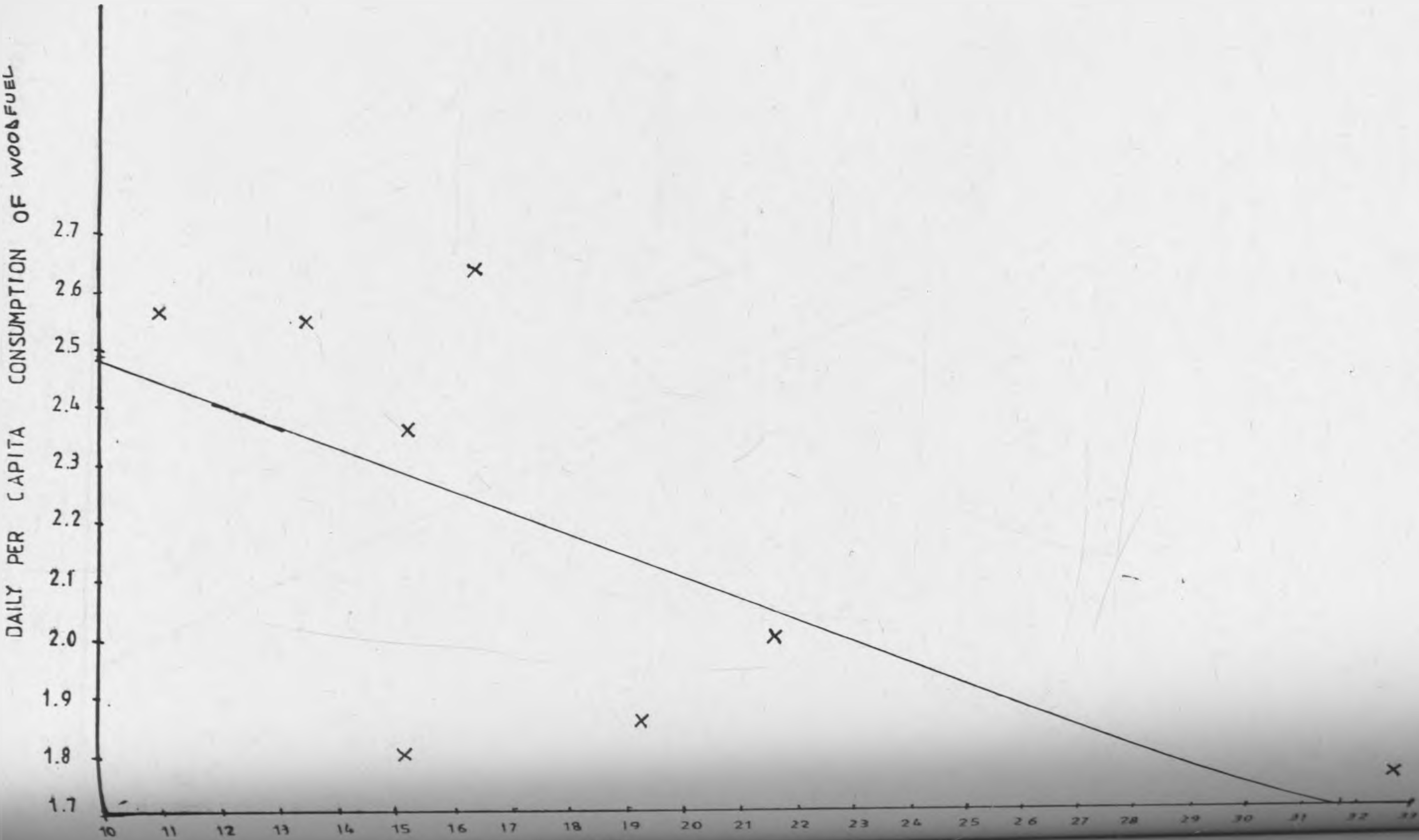
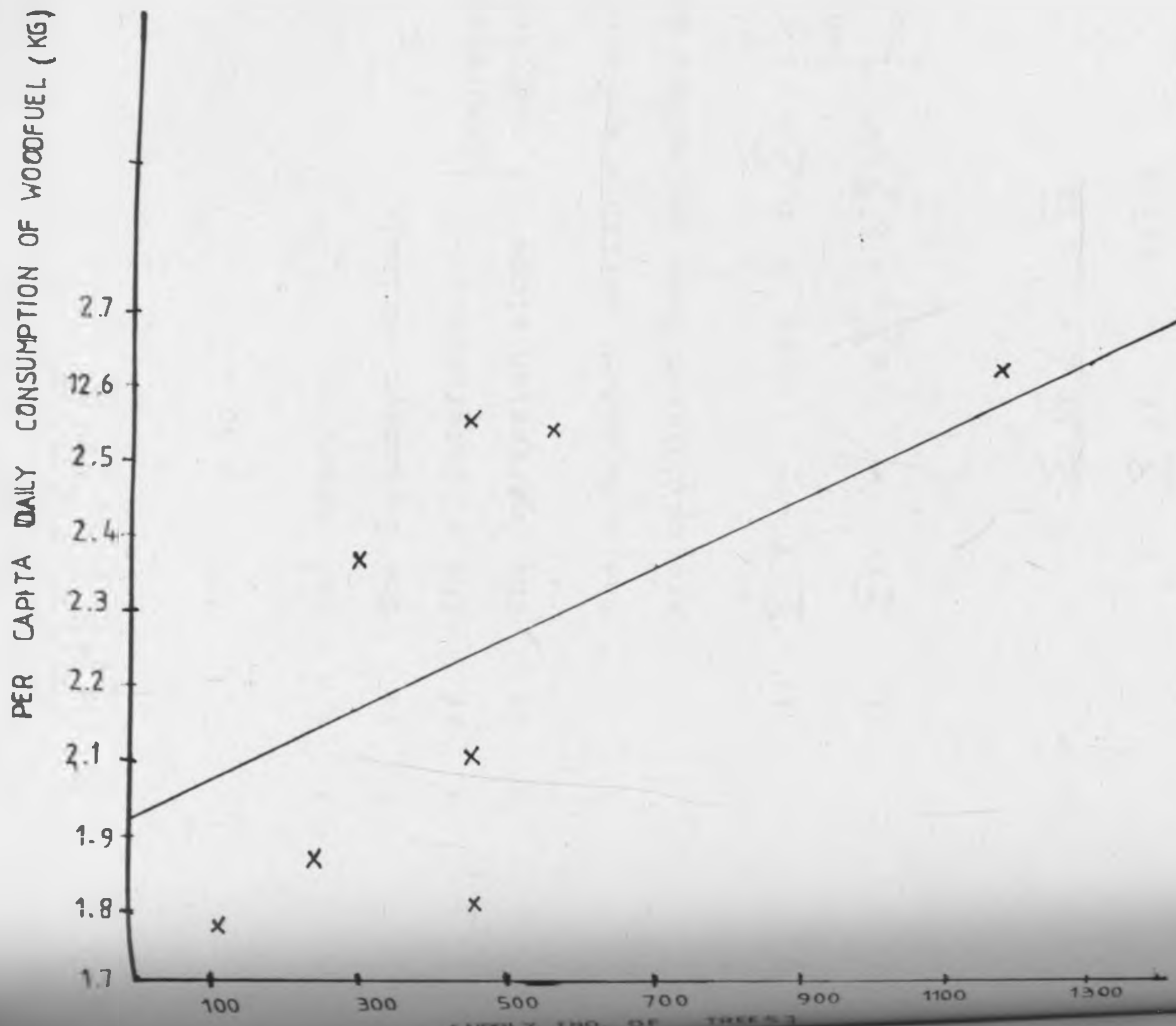


FIGURE 4.3 CONSUMPTION : SUPPLY RELATIONSHIP



$Y = a + bx^1$ where by

Y	is	The dependent variable	
a	is	The y intercept :	] Regression
b	is	The regression slope	] coefficients
x		The independent variable and a and b are calculated from two normal equations:-	

i] $\sum Y = na + b\sum x$] which works

ii] $\sum XY = a\sum x + b\sum x^2$] out to:-

$$b = \frac{\sum XY - n\overline{XY}}{\sum X^2 - n[\bar{X}]^2}$$

$a = \bar{Y} - b\bar{X}$

n = Number of observations

1. For the first variable income, the following was established from the above formulae and table 4.8

$Y = a + bx$

$Y = 1.65 + 0.00002532X.$

Table 4.8 : Calculations on consumption and income

Obs	X[Ksh.]	Y[kg]	X^2	Y^2	XY
1	1,747	2.01	3052009	4.0401	3511.47
2	2,557	2.55	6538249	6.5025	6520.35
3	3,587	2.64	12866569	6.9696	9469.68
4	775	1.78	600625	3.1684	1379.50
5	1,457	2.37	2122849	5.6169	3453.09
6	2,646	1.81	7001316	3.2761	4789.26
7	3,364	2.56	11316469	6.5536	8611.84
8	1,228	1.87	1507984	3.4969	2296.36
8	17,361	17.59	45,016,197	39.6241	40031.55

Source: Authors calculations

$\bar{X}$ = 2170.125

$\bar{Y}$ = 2.19875

b = 0.0002532

a = 1.65

Y = 1.65 + 0.0002532X

That is when X = 0, Y= 1.65 as relates to the relationship, this indicates that even without any income, there is a woodfuel consumption of 1.65kg per capita per day and that this consumption increases with every increase in income at the rate of 0.0002532 kg per capita per day for every increase of 1 kshs. in income.

Table 4.9 : Consumption/Family Size

Obs [n]	X[No]	Y[kg]	X^2	Y^2	XY
1	21.6	2.01	466.56	4.0401	43.416
2	13.5	2.55	182.25	6.5025	34.425
3	16.4	2.64	268.96	6.9696	43.396
4	32.5	1.78	1056.25	3.1684	57.850
5	15.3	2.37	234.09	5.6169	36.261
6	15.2	1.81	231.04	3.2761	27.512
7	11.0	2.56	121.00	6.5536	28.160
8	19.3	1.87	372.49	3.4969	36.091
8	144.8	17.59	2932.64	39.6241	307.011

$n = 8$

$\bar{X} = 18.1$

$\bar{Y} = 2.199$

$b = -0.3658$

$a = 2.86$

$Y = 2.86 - 0.03658X$

$$b = \frac{XY - n\bar{X}\bar{Y}}{X^2 - n\bar{X}^2} = - \frac{11.4042}{311.76}$$

$b = -0.03658$

$a = \bar{Y} - b\bar{X} \quad = 2.861098$

$\simeq 2.86$

$Y = 2.86 - 0.03658X$

Thus for every increase in family size by one person, there is a per capita decrease in daily consumption of fuelwood by 0.03658 kg. since there cannot be a family of zero people, the coefficient which in this case is equal to 2.86 does not have any meaning. The equation is operational from when X=1 i.e. where we have one person living and cooking alone Table 4.9 has the details.

Supply of fuelwood was considered in terms of the trees available per household. This was taken so since households that have alot of trees are unlikely to suffer fuelwood shortage as compared to those without. Even when trees are cut for other purposes, the branches and tips are still left for cooking. When used for fencing and house construction, they still end up in the kitchen since when fence posts get old and fall or when a house gets old and its demolished, in most cases the wood will be used for cooking. In chapter one, it has been indicated that only 2% of the total wood produced in Kenya is used as poles and posts, 4% in industry and 94% for cooking therefore 2% is insignificant when compared to 94%. As regards use of wood in industry the study established that only 1% of the households were using wood for firing bricks hence the quantities of wood or number of trees used in industry are also insignificant compared to that used for domestic purposes.

A comparison of level of supply and level of consumption revealed that the two variables have a directly proportional relationship whereby the higher the supply of wood, the higher the per capita consumption of the same as shown in figure 4.3 and table 4.10 below. This implies that for every increase in supply by one tree, the consumption increases by 0.00076 kg. per capita per day. And that even in the absence of any trees, where the household has none there still be a per capita consumption of 1.8kg per day as shown in the calculation below. This level of consumption could be from neighbours.

Table 4.10: Consumption/supply

obs	x[No]	Y[kg]	X^2	Y^2	XY
1	463	2.01	214369	4.0401	930.63
2	560	2.55	313600	6.5025	1428.00
3	1169	2.64	1366561	6.9696	3086.16
4	120	1.78	14400	3.1684	213.60
5	308	2.37	94864	5.6169	729.96
6	466	1.81	217156	3.2761	843.46
7	452	2.56	204304	6.5536	1157.12
8	252	1.87	63504	3.4969	471.24
8	3790	17.59	2488758	39.6241	8860.17

$n = 8$

$\bar{X} = 473.75$

$\bar{Y} = 2.19875$

$b = 0.0076$

$a = 1.84$

$Y = 1.84 + 0.00076X$

$$b = \frac{526.9076}{693245.6} = 0.00076$$

$$a = \bar{Y} - b\bar{x} = 1.8387 \simeq 1.84$$

4.6.2 Availability of suitable substitutes

Availability of other suitable substitutes of energy for cooking reduces the quantity of wood used for cooking and heating. For this particular area, the quantity of crop residues [mainly maize cobs] and tree barks reduces the use of fuelwood to a minimal level. And their absence increases the use of the same. Use of other substitutes like gas and eletricity would have the same effects and though they are superior sources of energy, their exorbitant prices minimises the use of these sources. From the survey, an increase in lkg of maize cobs reduces wood consumption by lkg. hence increasing maize cob supply will reduce woodfuel consumption by the same quantity.

4.6.3 MINOR FACTORS

Funerals, weddings and circumcision ceremonies were named as some of the events that add to the domestic consumption or demand of woodfuel. It was estimated that about 2000 kg. of wood is used for any given funeral-about 800kg. for a wedding and about 1500kg for circumsicion. In addition to this is the competitive for labour. Searching for fuelwood requires time, the length of time for any given household will depend on the level of availability of the wood. During the seasons when there are a lot of agricultural activities like planting weeding and harvesting, there is very little time available to look for fuelwood therefore, consumption is very minimal if any at all. But during the other seasons when there is less competition for labour, there is more time to search for fuelwood hence consumption also goes high due to the increased availability of wood.

4.7 SUPPLY OF FUELWOOD

As mentioned in chapter two the bulk of the domestic woodfuel supply in rural areas of Kenya is still obtained on a non-commercial basis. The study area displays the same observation. Information obtained shows that the majority [58.5%] obtain fuelwood from their own farms while 9.8% buy all their fuelwood. Of the remaining 31.7%, 12.2% get their wood both from their own farms and buying. 11% obtain from their farms and borrowing from neighbours while 7.3% buy and borrow from neighbours. In summary, those who buy at least some fuelwood are 29.3% and they buy at fifty cents per kg. while those who do not buy at all are 70.7%. Studies done earlier have estabilished that the higher the commercialisation of woodfuel, the higher the incentive for woodfuel production. But as long as wood can still be obtained on non-commercial basis many people will not be motivated to plant trees for woodfuel production. Those who have will not plant more because people in the community will just be collecting from his farm without cash payments and those who do not have may not be encouraged to plant because it does not cost them anything to obtain it.

The number of trees available per household were counted in an attempt to get the general level of supply of fuelwood in the study area. The height, Diameter at Breast Height [DBH] for exotic trees were measured, volume calculated and converted into kgs by using the formular $1m^3$ of [air dry] wood is equal to 714kg [Chavangi and Zimmerman 1987 pg. 45][2] For indigenous trees, a sample or whole trees [mature and young] were measured and the weights for each recorded.

4.7.1 Indigenous Trees

Out of the total number of trees counted, three quarters of the indigenous trees were found to be mature and weighed an average of [1500kg] while one quarter were found to be young to medium age and weighed an average of 300kg [0.3 tons[. The average number of trees per head were 13.6 which is equivalent to 10.2 mature [15.3 tons] and 3.4 young [1.02 tons] giving a total of 11.22 tons of standing wood per head. The main species in this category are Terminalia and Combretum. A technical report from the National Academy of Sciences [1980][3] has established that the annual growth or yield of Terminalia species per tree is 7.375 kg. Since annual growth of the Combretum species is not available and they have the same growth habits, the same figure 7.375 kg. per tree is taken as the estimate for the Combretum species. From the above figure of 13.6 indigenous trees per head the stock per head from indigenous trees is 11.22 tones [11220 kg] and annual supply [yields] per head is 100.3 kg.

4.7.2 EXOTIC TREES

The exotic trees in the study area are mainly Eucalyptus, and cyprus. The others include pinus and grevillea. These trees fell into three categories of Big medium and small using age as the criterion where small refers to trees between one and ten years, medium is from

11 to 20 years while big is from 21 yeas and above. After taking the total household count, 1/4 of the trees were placed in the category of small, 1/4 in large and ½ in medium. The area was found to have a total of 200.1 trees per household or 27.5 trees per head. Using the formular above, the corresponding weights were calculated from the measurements taken.

The distribution of the tree sizes per head are:-

Large	-	6.9	trees
Medium	-	13.7	trees
Small	-	6.9	trees

4.7.3 Exotic Wood Stock and Yields Per Head

i] The big tree were found to have an

average	height of	-	53.22	metres (h)
"	diameter of	-	0.9	metres (d)
"	radius of	-	0.45	metres (r)

Volume $= \frac{\pi}{2} r^2 h$

$= \frac{3.14}{2} \times 0.45 \times = 0.45 \times 53.22 \text{ M}^3$

$= 16.92 \text{ m}^3$

Weight $= 16.92 \times 714$ kg.

$= 12{,}080.88$

12,081 kg or 12.08 tons

ii] Medium trees had an average

Height of	13.5 metres
Diameter of	0.39 metres
Radius of	0.195 metres

Volume = $= \frac{3.14}{2} \times 0.195 \times 0.195 \times 13.5$

$= 0.8059398\ m^3$

Weight per tree = 0.8059398 x 714 kg.

= 575.44 kg.

iii] Small trees average:

Height	-	3.6 metres
Diameter	-	0.06 "
Radius	-	0.03 "

Volume = $= \frac{3.14 \times 0.03 \times 0.03 \times 3.6}{2}$

$= 0.0050868\ m^3$

Weight per tree = 0.0050868 x 714 kg.

= 3.63 kg.

∴ The total wood stock per head is

6.9 x 12,081 kg	=	83358.9 kg
13.7 x 575.44 kg.	=	7883.5 kg
6.9 x 3.63 kg	=	25.1 kg
		91267.5 kg
	≃	91.3 tons

using the annual yields of Eucalyptus grandis and saligna, the annual yields of the trees were also calculated. According to a technical report from National Academy of Sciences. The annual yields during the first 10 years is $0.0593333 m^3$ per tree. After ten years annual yields in volume decrease to $0.0019642\ m^3$ per tree.

The annual yield per head is: Each individual has 6.9 trees below 10 years and 20.6 trees above 10 years

6.9 x 0.0593333	= $0.4093997 m^3$
20.6 x 0.0019642	= $0.0404625 m^3$
Total	= $0.4498622 m^3$
Weight	= 0.4498622 x 714 kg
	= 321.2 kg.

The total annual yield of wood per head is:-

From indigenous trees	= 100.3 kg.
exotic trees	= 321.2 kg
Total	421.5 kg.

This is 421.5 kg. of air dry wood.

Earlier in this chapter it was established that currently the consumption is 433.4 kg. per capita per year and the supply is 421.5 kg. per capita per annum. Since the consumption is higher than sustainable supply, the difference of 11.9 kg. per capita per year is drawn from standing stock. In addition to this it can generally be said that there is a supply deficit of

369.6 kg per capita per annum. This is the wood that would be used for cooking if crop residues were not being used. In this case it is assumed that wood is a more preferred fuel for cooking than crop residues.

4.7.4 Supply of Alternative Sources of Energy

As indicated under consumption maize cobs are a major substitute of fuelwood as regards energy for cooking. The survey revealed that the quantity of maize cobs available per family or household depends on the size of land under the maize crop. The bigger the land size cropped the more the cobs. The families which plant few maize acreages end up with very little cobs and at times they tend to get maize cobs from neighbours.

An enquiry into the source of cobs for households cooking showed that 78% of the households obtain all the cobs they use from their own farms. Those who obtain from their own farms and borrow some from their neighbours were found to be 22%. For every 1 bag of shelled maize, there are two bags of maize cobs. The average quantity of shelled maize per household was found to be 50.45, 90kg bags which produced 100.9 bags of cobs. This gives an annual supply of 13.83 bags of maize cobs per capita. I bag of maize cobs is 25kg. hence the total quantity availabe per capita per annum is 345.8kg.

Since use of maize cobs is quite acceptable in the study area, an increase in maize acreage may be an indirect way of reducing pressure on the wood resources. This may prove a very profitable move since it will have a number of positive effects to the community. One, there will be an increase in maize production hence income and food and two, it will conserve the environment. The other effects though indirect would be an increase in tree planting due to the increased income and increased food since it was mentioned earlier in this chapter that this two have influence on wood production. Despite these good effects, the same could still act as a constraint to tree planting as it is mentioned earlier that increased availability of suitable substitutes can have negative effects on wood production for fuelwood. But the ash is left in the farm since it has minerals that are useful to plants.

The households were requested to comment on the current availability of fuelwood as compared to the time when they first came to the scheme. Three different answers were obtained 70.7% of the households felt that the current level was lower, 24.4% felt it is more and 4.9% felt there was no difference at all. A further follow up on these answers showed that the 70.7% who felt the quantity of fuelwood had decreased are those who initially had large forests of indigeneous trees on their farms, while the 24.4% who felt it was more are those

Plate 15: A traditional granary for storing maize and cobs .[after shelling]

Plate 16: Improved granary for storing maize and maize cobs [after shelling]

Plate 17: A three stone fireplace: Natural stone used.

Plate 18: Mud build three- stonefire place with firewood and maize cobs for cooking. The survey was done during a transition month, Sept/Oct. when both firewood and maize cobs are used for cooking.

who found very few or no trees at all on their farms so they were encouraged to plant some immediately and the 4.9% who felt there is no difference are those who have been using and planting trees steadily over the last 23 years since 1965!

Reasons for the fuelwood being less or same or [which are also factors affecting supply] more varied from household to household and below is a table showing this variations.

4.11: Reasons for Fuel Being Less

Reason	Frequency %
Farming	39.7
Discrete planting of trees	3.4
Domestic consumption	41.4
Lack of awareness	1.7
Increase in population	6.9
Presence of Ants [eat tree seedlings]	1.7
Brick burning	1.7
Lack of fences [planted tree destroyed by animals].	1.7
Laziness of individuals to plant more	1.7

As more forests and bushes are cut down to give way to farming without a matching replanting of the same, the supply diminishes. The use of fuelwood is continous, i.e.on daily basis while tree planting can only be done during the rainy season and a lot of the people do not even plant on seasonal or even annual basis. They plant after two, three , four or even more years. This discrete form of planting trees has negative effects on the quantity of wood supplied. Use of fuelwood for cooking is an obvious depletor of trees and bushes and the rate of consumption of woodfuel will determine the rate of depletion of the supply. Together with this is the population. Increase in population without a matching increase in supply will definately reduce the supply level and the other factors that affect the supply level in the area are, lack of awareness as regards the dangers of depleting wood resources, presence of ants which eat the tree seedlings that are planted, brick burning especially by non-farmers who have no land of their own to plant more and laziness by some people who do not want to take the trouble of raising or looking for tree seedlings to plant.

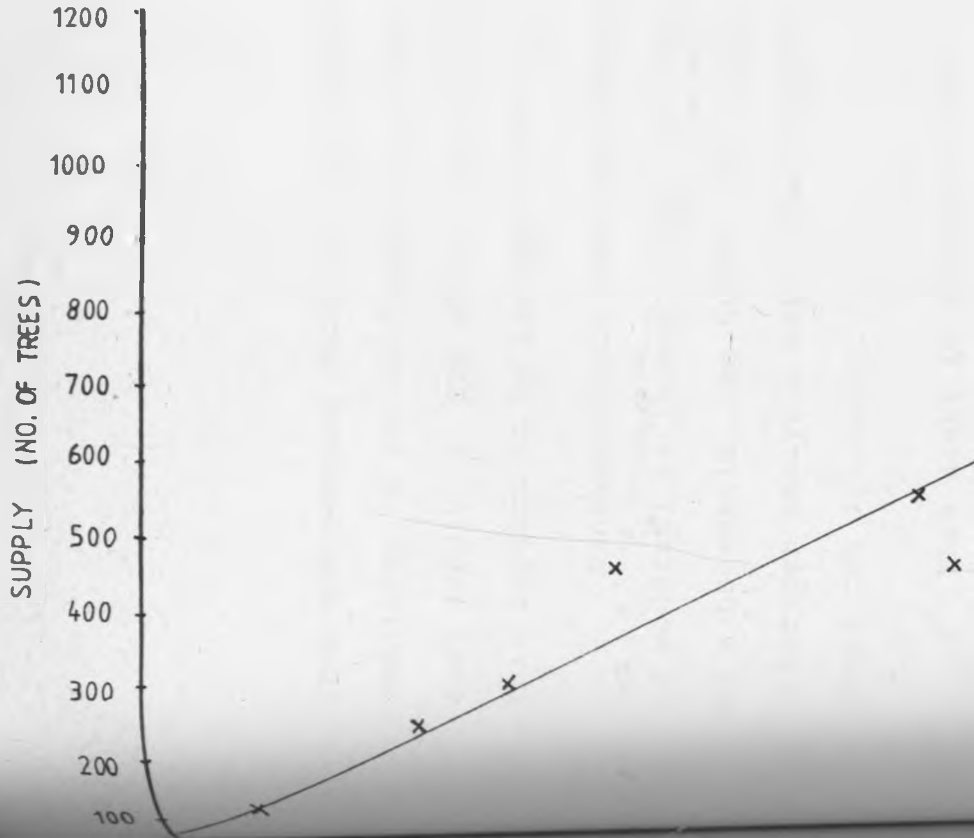
90% of the 24.4% of households who indicated that woodfuel has increased over time gave the reasons of this increase as adequate planting and replanting of trees and regeneration of cut trees for example Eucalyptus. And of the 4.9 % that felt there has been no change gave the reasons of indigenious forests regrowth and replanting being equal to cutting.

The 70.7% who felt the fuelwood level was diminishing were asked to suggest ways of rectifying the situation and below is a table of the answers.

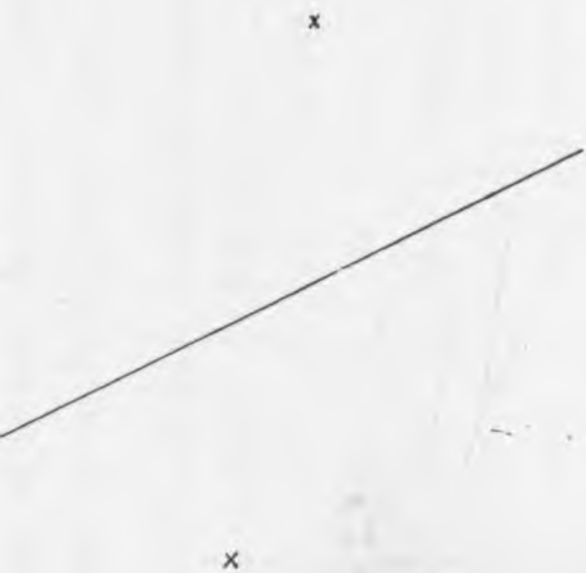
4.12: Proposed Means of Increasing Woodfuel Supply

	Remedy	Frequency %
1.	Seedlings should be availed	43.9
2	Land tenure [sons should be given their own land]	4.9
3	Family Planning [reduce family sizes hence -population]	1.2
4.	Kill ants [get a permanent solu tion to get rid of ants]	4.9
5	Create awareness [in tree planting]	6.1
6	Fence [people should fence their plots and guard animals]	3.6
7	Plant regenarating type of trees	1.2
8	Buy firewood from out [from those who have plenty]	1.2
9	Avail tree seeds	1.2
10	Do not know	31.8
	Total	100.00

FIGURE : 4.4 SUPPLY :



INCOME RELATIONSHIP



From the peoples point of view availability of tree seedlings is the most appropriate way of increasing woodfuel supply. The other mentioned problems exist but this appears to be the most serious.

Another factor that was found to affect the supply of woodfuel is income. That is, the higher the income of a household, the higher the supply of fuel wood and a further analysis using the simple regression analysis shows the following.

This seeks to determine how supply is affected by change in income. As shown in figure 4.4, these two variables are directly proportional.

Table 4.13: Supply/ Income calculations

obs.	X[shs.]	Y[No.]	X^2	Y^2	XY
1	1747	463	3053009	214369	808861
2	2557	560	6538249	313600	1431920
3	3587	1169	12866569	1366561	4193203
4	755	120	600625	14400	93000
5	1457	308	2122849	94864	448756
6	2646	466	7001316	217156	1233036
7	3364	452	11316496	204304	1520528
8	1228	252	1507984	63504	309456
8	17,361	3790	45,016,197	2488758	10,038,760

Source: Authors calculations.

$n = 8$

$\bar{X} = 2170.125$

$\bar{Y} = 473.75$

$b = 0.247115 \qquad 0.25$

$a = -\ 62.52$

$Y = -\ 62.52 + 0.247115X$

$$b = \frac{10{,}038760.0 - 8{,}224{,}773.6}{45{,}016{,}197.0 - 37{,}675{,}540.0}$$

$$= \frac{1813987}{7340657} = 0.247115$$

$a = 473.75 - 536.27 = -\ 62.52$

This means any increase in income of 1 ksh. increases the supply by 0.25 of a tree and that is when there is no income at all, there is a deficit of 62.52 trees this could mean the people are borrowing from neighbours.

The Seedlings Availability

Trees and shrubs are mainly planted from tree seedlings, seeds and cuttings may also be used. From the research findings 43.9% of the households felt that provision of tree seedlings will solve the problem of fuel-wood depletion The supply of tree seedlings for planting in the study area was looked into to determine its adequacy.

It was found that, there is only one locational chief's tree nursery which is located at the Chief's centre and is supposed to serve four sublocations with tree seedlings. The capacity of the nursery at the time of the survey was 100,000 tree seedlings. Beside this, there were other two private nurseries with capacities of 10,000 and 5,000 tree seedlings. The major type of tree seedlings raised in these nurseries was Eucalyptus Cypress, Grevillea, Jacaranda and a few indigenious species.

In order to establish the adequancy of supply, the demand and source of seedlings was also looked into and it was found that 78.1% of households do not get enough seedlings for planting while 20.7% get enough. 24% of the households raised their own seedlings, 68.1% buy from the nurseries and 6.1% raise some and buy some from the nurseries while 2.4% do not plant any trees hence are not bothered about tree seedlings.

The distance to the nearest tree nursery was looked into and it was found to vary between ½ km to 12km with an average of 6.2km and it was observed that, generally, the people who are closer to the tree nurseries have more planted trees than those far away. Asked whether ever visited by extension officers to advice on tree planting, 91.5% of the households said they have never been visited while 8.5 had been visited. This implies that tree nurseries in this area are too few and of very low capacity and also that the people do not receive adequate extension services.

Energy Conservation

Energy conservation is one way of reducing the first depletion of fuelwood by using efficiently what is available. A search into the level of energy conservation in the study area revealed that the use of improved cooking stoves had not reached this area. All the people were using the open three stone fire place: Plate 17 and 18. However, there were traditional methods of conserving fuelwood and these are: pulling firewood out of the fire place after cooking [26.8%] the households putting off the fire with water [39.0%], putting the burning firewood under ash [13.4%] and 20.7% just leave the wood to burn down to ashes. Beside this pre-cooking conservation measures are also observed by some of the people that is 25.6% of the household soak maize and beans before cooking while 74.4 boil them without soaking. When asked why they do no soak, they claimed that soaking gives the food [maize and beans] a bad taste.

When asked what bothers them most when cooking, 67.1% claimed that smoke is a big bother especially when using maize cobs for cooking, 20.7% had problems with both smoke, heat and wind, 1.2% were bothered by heat and 11% had no problem at all when cooking.

Those who use maize and sunflower stalks for cooking indicated that they are very much bothered by the feeding frequency since they have to keep adding the stalks to the fire.

The f i n d i n g s on none use of energy conserving cooking stoves exposes the fact that a large quantity of wood is wasted. Studies done on woodfuel conservation found that the efficiency of the three stones is 10-13% as compared to the improved woodstove which has an efficiency of 29 to 35%. Meaning 19 to 22% of wood could be saved if the improved wood stoves could be put into use. The findings on smoke as a bother suggests that wood is a more superior fuel and also that a maize cob smokeless stove should be designed. The issue of heat and wind being a bother when cooking reflects a problem in the designs of kitchens. Poor kitchen designs results in holding of smoke. This may make those cooking to stay outside the kitchen when cooking hence it will take longer to cook and use more fuelwood.

SUMMARY

In summary the research findings indicate that the major factors that affect woodfuel supply and demand in the study area are: the education level of the people land tenure, income level, water availability and unity.

In addition to the above the research findings indicate that currently there is about 50% energy involution in the study area whereby about ½ of the total domestic energy required is obtained from crop residues. It is further noted that there are about nine factors that affect woodfuel consumption and these are income, household size, supply level of woodfuel and availability of suitable substitutes, [which for this case is maize cobs], home industries like brickmaking and brewing and also cultural ceremonies which for this area are: circumcision, weddings and funerals. As concerns the first four factors indicated above which affect mainly the household daily consumption, the formular given below summaries their effects on consumption. This is:-

$$C_n = C_t + \frac{I[i]}{I_{[i]}} - \frac{F[f]}{F_{[f]}} + \frac{S[s]}{S_{[s]}} - SS$$

where C_n is annual per capita consumption in n years time from the base year t

C_t is annual per capita consumption in the base year t.

I is change in income while [i] is income coefficient.

F is change in family size while [f] is the family size coefficient.

S is change in supply while [s] supply coefficinet.

SS is change in suitable substitute measured in wood equivalent .

Note: Daily consumption ratio of maize cobs to wood is 1:1 for the study area.

As concerns woodfuel supply the study has found that the level of woodfuel commercialisation is still very low at 29.3% since 70.7% of the people obtain all the woodfuel they use without any cash payments. It has also come out clear that the current supply of woodfuel is less by 42% and that the major cause of depletion is land clearance for agriculture and population growth. The major factors that affect woodfuel supply is income and tree seedlings availability for planting.

Finally, the findings show that energy conservation efforts have not had any significant effect in the study area since no single household has the energy saving cooking stoves. Some people have heard about the cooking stoves but have not been able to obtain any mainly because the stoves are not available in the study area. The improved charcoal stoves which have spread mainly in th urban centres of Kenya are of minimal use in the study area since use of charcoal in this area is very limited.

References:

1. Lawrence L. Lapin: Statistics for modern business decisions: 46h edition 1987 pg.308 and 309.

2. Chavangi, A.H and Zimmermann, R: A Guide to Farm Forestry in Kenya, 1987, pg.45

3. National Academy of Sciences: Firewood Crops. Shrush and Tree species for Energy production, 1980. pp.84.

CHAPTER FIVE

5.0 FUTURE PROJECTIONS AND RECOMMENDATIONS

Energy is not only an essential input in the production process of the economy but also a direct requirement in peoples' daily lives. It is generated mainly from woodfuel, petroleum and electricity. In Kenya, the main source of energy particularly for household consumption, heating and cooking has been woodfuel. Since independence, however, the government has embarked on a rigorous rural electrification programme to supplement dwindling supplies of woodfuel and improve peoples' lives through opening up opportunities for commercial, industrial and social activities and also for lighting. The consumption of woodfuel in the past has resulted in the depletion of the vegetable cover leading to soil erosion and desertification, threatening to impoverish the people. Since eletricity is a relatively expensive source of energy for domestic use, efforts are being directed toward the development and exploitation of renewable sources of energy such as solar, wind, biogas, and afforestation and the employment of energy efficient kilns and cooking stoves.

The agencies that have been implimenting these programmes of increasing woodfuel production, finding alternatives and conserving what is there already, have not been very successful because of not knowing the magnitude of the problem they are addressing poor policy support from the government, and lack of accurate knowledge of the factors that determine woodfuel production, consumption and conservation.

The levels of woodfuel production and consumption in other countries and some parts of Kenya and the factors that affect both were looked at in detail and the information obtained used as a guide in establishing the situation in the study area. The study has established the woodfuel supply-demand balance in the study area and projected the likely future trend that it will take, the current shortcomings of the policy as regards woodfuel production and conservation and the community characteristics that affect the same. Policy recommendation to rectify the situation and requirements for effective implementation of policy have been made.

5.1 Problem identified

5.1.1 The woodfuel Demand and Supply balance in Naitiri Sublocation

As indicated on page 3 of Chapter ONe, the current national woodfuel demand deficit is 9.8 tonnes. This was considered too broad to be useful at a local level hence necessitated the study to establish the sub-locational deficit for the purpose of planning and implementation of woodfuel production, utilisation and conservation projects.

The study established that the current domestic woodfuel consumpiton in the study area is 433.4kg and the sustainable supply 421.5 kg. per capita. This leaves a supply decifit of 11.9 kgs per capita. Beside this there is also consumption by non-domestic activities which is considered later in this chapter. It was noted that in about 168 days of the year, maize cobs are used for cooking and heating. This is about 46% of the time in a year. Also, maize cobs have a consumption ration of 1:1 with woodfuel therefore, they have been considered suitable enough to be considered as an appropriate substitute to woodfuel. Therefore in calculating the woodfuel demand, this fact has been taken into consideration. It appears that as wood becomes more valuable, and maize cob production increases, cobs will be used more times in a year than what is indicated in the findings.

5.1.11. Projected woodfuel Demand for Naitiri Sublocation to the year 2008.

With the increase in population, there will be a definite increase in consumption of woodfuel. The per capita consumption of woodfuel may increase or decrease depending on the changes which will occur in the factors that affect consumption. These factors are income, family size, supply of wood and the availability of suitable substitutes.

5.1.1.2 Population

The population growth rate as calculated by Central Bureau of Statistics [CBS] for Bungoma district to the year 2000 is 3.98% p.a. This is the rate that has been adopted in projecting the population of the study area. Given that no other rate was available for projecting beyond the year 2000, the same rate has been used to project the population to the year 2008. Using this rate, the population of the study area will have increased from 9783 in 1988 to 11,891 [21.5%] by the year 1993. In 1998, it will have increased to 15,446 [47.7%]. Ten years from now that is 2003 the population will have increased to 17,559 [79.5%] and by the year 2008, the population will be more than double the current level, i.e. it will have increased to 21,331 [118.0%], [table 5.1]. This means that without even considering the current deficit, the woodfuel production will have to be tripled and if the deficit is included , the current production should increase by about 5 times by the year 2008 if supply and demand have to balance.

5.1.1.3 Income

According to the current development plan of 1988-1993, it is expected that the National per capita income will grow at 1.6% to the year 2000. Since the per capita income growth is not given for the district, the national per capita income growth rate has been used in the projection of the per capita income of the study area. At the time of the survey, the per capita annual income was Kshs.2,038, this is projected to increase to Kshs.2,206 in 1993, Kshs.2,389 in 1998, Ksh.2,586 in the year 2003 and Kshs. 2,799 in the year 2008 as indicated in table 5.1, and from calculations using the formular derived in Chapter Four, the consumption will increase by 15.5 kg., 32.4kg, 50.6kg and 70.3 kg. respectively. Therefore income will increase the per capita domestic consumption by 3.6%, 7.5% 11.7% and 16.2% respectively. This calls for increased efforts in wood production to avoid environmental degradation.

5.1.1.4 <u>Supply of Wood Resources</u>:

It is indicated in the 1988-1993 development plan that the forest sector is expected to grow at a rate of 8% p.a. Since the growth rate of the various sections of the forest sector are not given and the previous year's growth rate was 6.9% the growth rate of 8% is considered realistic and has been used in the projection of the supply of woodfuel. In Chapter four, supply was considered in terms of the number of trees that are available per person and the supply calculated from the annual yields. It had been established in Chapter Four that the more the number of trees hence supply, the higher the consumption. At the time of the survey, the number of trees per head were 27.5, using the given rate, this number is expected to grow to 40.4 in 1993, 59.4 in 1998, 87.2 in 2003 and 128.2 in the year 2008. Calculations using the formular developed in Chapter four shows that this expected increase in woodfuel supply will increase consumption by 3.6kg, 8.9kg 16.6kg and 27.93 respectively. This too, will require an increase in woodfuel production.

5.1.1.5 Suitable Substitute

In the study area, maize cobs are a suitable substitute for wood. The level of supply of this source of cooking and heating energy depends on the level of maize production. In the current, plan, the maize yields [production] is expectd to increase by 1.04%. For every bag of shelled maize harvested, the cob production will be twice,therefore, the cob availability will increase by 2.08% per annum. The cob utilisation at the time of study was 375 kg per capita p.a. The projected figures are 416 kg. in 1993, 461 kg. in 1998, 511 kg in 2003 and 566kg in the year 2008. Increase of suitable stubstitute will decrease woodfuel consumption by a similar amount i.e. cob use to wood use has a ratio of 1:1 in the study area. This will contribute in conserving woodfuel. The actual increase will be 41 kg., 86 kg, 136kg and 191 kg. respectively. [Tables 5.1 and 5.2].

5.1.1.6 Family Size

It is the government's wish that the family size may decrease with time. During the 1979 population census, the household size of the study area was found to be 8.18. Nine years later 1988, the average family size was found to have decreased from 8.18 to 7.3. This is a decrease of 1.3% p.a. Since the development plan has not given the expected change in family size, 1.3% has been used to project the future average family size in the study area to the year 2008. The family size is expected to decrease to 6.8 in1993, 6.4 in 1998, 5.9 in 2003 and 5.6 in the year 2008. As the family sizes decreases, the per capita consumption will increase this too will require efforts to increase the woodfuel production.

All the above given factors are summarised in section 5.1.1.7 to give the net effect on consumption by the year 2008 which is shown in table 5.3 and this will be, 4972.9 tonnes in 1998, 5788.5 in 1998, 6730.4 in 2003 and finally 7749.6 in 2008.

From the rates indicated above, below are the expected future changes in the various factors that affect consumption

Table 5.1 - Changes and factors affecting consumption

Year	Population	Income per capita p.a.	Family size no.	Supply No. of trees per head	Suitable substitute [cobs] kg.
1988	9,783	2,038	7.3	27.5	375
1993	11,891	2,206	6.8	40.4	416
1998	15,446	2,389	6.4	59.4	416
2003	17,559	2,586	5.9	87.2	511
2008	21,331	2,799	5.6	128.2	566

Source: Field survey and authors calculations.

Using the formular derived in chapter Four that is:-

$$C_n = C_t + \frac{I[i]}{I_{[i]}} - \frac{F[f]}{F_{[f]}} + \frac{S[s]}{S_{[s]}} - SS$$

Where C_n = Annual per capita consumption of woodfuel in n years time from base year t

C_t = Annual per capita consumption of woodfuel in the base year.

I = Change in income

[i] = Income coefficient, [on daily consumption]

F = Change in family size

[f] = Family size coefficient, [on daily consumption]

S = Change in supply

[s] = Supply coefficient, [on daily consumption]

SS = Change in suitable substitute measured in wood equivalent.

Note: Consumption ratio of cobs to wood is 1:1 for the study area.

THE PER CAPITA ANNUAL WOOD CONSUMPTION CHANGES ARE AS BELOW:

Table 5.2

	1993	1998	2003	2008
1] Change in income Kshs.	168	351	548	761
Consumption Change in kg.	15.5	32.4	50.6	80.3
2] Change in Family size	- 0.5	-0.9	-1.4	-1.7
Consumption change kg.	+6.7	+12.0	+18.7	+22.7
3] Change in tree supply [nos]	12.9	31.9	59.7	100.7
Consumption change [kg]	3.6	8.9	16.6	27.93
4] Change in Suitable Substitute [kg]	41	86	136	191
Change in Consumption[kg]	41	86	136	191

In the formular:

$$C_n = C_t \quad I_{[i]} - F_{[f]} + S_{[s]} - SS$$

[i] = 0.0002532 kg

[f] = 0.03658 kg

[s] = 0.00076 kg

5.1.1.7 <u>PROJECTED PER CAPITA DOMESTIC ANNUAL WOOD CONSUMPTION</u>

$$C_{1993} = 433.4 + 15.5 + 6.7 + 3.6 - 41\text{kg.}$$
$$= 418.2 \text{ kg.}$$

$$C_{1998} = 433.4 + 32.4 + 12.0 + 8.9 - 86 \text{ kg.}$$
$$= 400.7 \text{ kg}$$

$$C_{2003} = 433.4 + 50.6 + 18.7 + 16.6 - 136 \text{ kg}$$
$$= 383.3 \text{ kg.}$$

$$C_{2008} = 433.4 + 70.3 + 22.7 + 27.93 - 191 \text{ kg}$$
$$= 363.3 \text{ kg.}$$

Projected Domestic Consumption of Woodfuel to the 2008:
Table 5.3

Year	Projected Population No.	Projected per capita consumption kg	Total Consumption tonnes
1988	9,783	433.4	4239.9
1993	11,891	418.2	4972.8
1998	14,446	400.7	5788.5
2003	17,559	388.3	6730.4
2008	21,331	363.3	7749.6

Source: Authors calculations

The per capita consumption in 20 years time will have dropped by 16.2% due to the changes in the factors that affect consumption. While the total consumption will increase by 82.8%. This increase is due to the change in population which will have increased by 118%.

Beside domestic consumption, there were other activities like circumcision ceremonies, weddings, funerals, brick-making and brewing which add to consumption.

5.1.1.9 Circumcision

Boys are taken for circumcision at the age of between 10 -14 years. Using the district statistics, it was found that 36,295 of the total population belongs to this age in Bungoma district. This forms a proportion of 7.2% of the total population. For purposes of calculation, it is assumed that the circumcision is done at the age of 12½ years. The proportion of 7.2% is for an interval of 5 years therefore on annual basis, 1.44% of the population undergo this ceremony. It is possible that with time, the proportion of this age group to the total population will increase but also given that the family sizes are decreasing by 1.3%, there is a possibility of the two effects cancelling out hence the proportion of this age group to the overall population is not expected to change much. Using the projected population of the study area, the number of those undergoing this ceremony every year was calculated. Using the per capita consumption of 1500 kg. [from the survey] the demand for woodfuel for this purpose was calculated and given as shown in table 5.4. That is 211.5 tonnes in 1988, which is projected to 256.5t in 1993, 312.0t in 1998, 379.5t in 2003 and 460.5t in 2008.

5.1.1.9 Weddings

From the survey, it was found that about 8 weddings are carried out in the study area per year and each wedding uses about 800 kg. The increase in the number of weddings is also projected using the population growth rate which is about 4%. Projections for woodfuel demand for this purpose are as shown in table 5.6

5.1.1.10 Funerals:

The study found that funerals consume about 2000kg of wood per capita. Information on the death rate of the people in the area and even the district was not available, therefore, the national death rate was used to calculate the percentage of people who die every year and the future projections. In 1948, the deaths per every population of 1,000 people was 25 persons, this decreased to 20 persons in 1962, 17 persons in 1969 and 14 persons in 1979. The decrease in death rate between 1948 and 1962 was 1.4%. Between 1962 and 1969 it was 2.1% p.a. and between 1969 and 1979 it was 1.8% p.a. The average of these three rates, that is 1.8% has been used in projecting the current and future death rate in the study area. In 1988, the crude death is estimated at 12 persons per every 1,000 people. Therefore, the number of deaths in 1988 to 2008 in the study area is as below in table 5.4

Table 5.4: Future woodfuel Demand for Funerals

Year	Population	Proportions per every 1000	Actual numbers	Wood consumption [tonnes]
1988	9783	12	117.4	234.8
1993	11,891	11	130.8	261.6
1998	14,446	10	144.5	189.0
2003	17,559	9	158.0	316.0
2008	21,331	8	170.7	341.4

5.1.1.11 Brick Making

During the survey, it was found that about 135 households had permanent houses out of this, about 13 of them were build using blocks. This leaves about 108 brick houses. Given that these houses have been construced in 27 years that is since 1965, it can be assumed that the construction has been done at the rate of 4.7 houses in one year. It was also noted that the houses took between 15,000 bricks and 22,000 bricks per unit with an average of 19,000 bricks per unit. This implies that the annual brick consumption is 89,300. From a study done in Tanzania by Nkonoki it was found that to fire 25,000 bricks, it takes 35 cubic metres of wood. This is equivalent to 25 tonnes. The number of households had increased by 150% between 1965 and 1988. This gives an annual household increase of 6.5%. Since information on the future increase of households in the study area is not available, it was assumed that it will increase at the rate of 6.5% p.a. and that the proportion of households building brick houses will increase in proportion to the increase in household numbers, i.e. since the annual construction in 1988 was estimated at 4.7 houses by 1989, the annual construction will have increased by 6.5%.

Table 5.5: Projections for wood requirements for brick firing

Year	No of households	Annual brick house construction	Brick requirement	Wood requirement [tonnes]
1988	865	4.7	89,300	89.3
1993	1185	6.1	115,900	115.9
1998	1624	8.8	167,200	167.2
2003	2225	12.1	229,000	229.9
2008	3048	16.6	315,400	315.4

Source: Field survey and authors calculations

Note: 25,000 bricks use 25 tonnes of wood.

5.1.1.12 <u>Brewing</u>

Brewing of alcohol from maize flour has been identified as a heavy consumer of wood fuel elsewhere in the world. In Kenya, local brews are illegal so it was not possible to get information of how much alcohol is brewed and how much wood is consumed in the process. Since asking for such information would have hindered obtaining of the rest of the information for the study, it was deliberately avoided, but an attempt has been made to estimate the amont of woodfuel used on brewing.

From the survey, it was found that 18.1% of the population are Catholics. The Catholic Church does not prohibit drinking of alcohol hence most of the Catholics take this brew. It was also found that 3.7% of the population do not belong to any church and it is likely that most of this 3.7% also take this local brew. There are other people who go to the other churches yet they drink, therefore the percentage of Catholics who do not take the brew can be covered with this 3.7% and the others from the other churches. It was therefore assumed that 28% of the population take the local brew at a rate of 4 litres per day for two days in a week. It was also noted in an earlier study by Nkonoki in Tanzania that 1 cubic metre of wood is used in brewing 400 litres of the local brew and it is known from a formular given earlier that 1 cubic metre of wood is equal to 714 kg. of air dry wood. It is also assumed that local brew consumption will increase with the population therefore, consumption increase rate used is that of the population also estimated at 4%.

Projections of these are shown in table 5.6 below:-

Table 5.6: Non-Domestic Woodfuel consumption Projection [tonnes]

Year	Circum-sicion	Weddings	Funerals	Brick making	Alco-hol	Total consump-tion
1988	211.5	6.4	234.8	89.3	2034.1	2566.1
1993	256.5	7.98	261.6	115.9	2474.8	3116.8
1998	312.0	9.9	289.0	167.2	3010.7	3788.8
2003	379.5	12.4	316.0	229.9	3662.6	4600.4
2008	460.5	15.4	341.4	315.4	4456.0	5588.7

Source: Field survey and authors calculations

The information in this table together with that of the domestic consumption give an estimate of the wood-fuel demand and how it is expected to change with time.

5.11.13 WOODFUEL SUPPLY

From the survey it was observed that trees are planted after between 2 and 6 years with an average of 5 years. The numbers planted range between 50 and 400 trees with an average of 120 trees [mainly exotic trees] per plot. There are 346 plots in the sublocation. This means that a total of 8304 trees are planted every year. Table 5.5 below shows the changes in wood supply to the years 2008.

Table 5.7 Woodfuel Supply Projections

Year	No of trees	Wt in tons.	Tons.	+ve Current Supply
1993	41520 [5yrs]	1759.0	1759.0	5882.5
1998	83040 [<10yrs]	3518	3518.0	7641.5
2003	83040 [>10yrs]	116.5]	1875.5	5999.0
	41520 [5yrs]	17590.0]		
2008	83040 [>15yrs]	116.5]	3634.5	7758
	83040 [5yrs]	3518.0]		

Source: Field survey and authors calculations

Table 5.8

Projected Woodfuel Supply and Demand to the year 2008 [Tonnes]

Year	1988	1993	1998	2003	2008
Demand	6806.1	8089.6	9576.5	11330.7	13338.8
Supply [Annual Yield]	4223.5	5882.5	7841.5	5999.0	7758.0
Supply Shortfall	2582.6	2207.1	1735	5331.8	5580.8

There is a supply shortfall decrease of 21.2% to the year 1998. From 1998, the supply will decrease and deficit increase mainly because tree growth decreases by

97% when a tree reaches 10 years its growth decreases from 0.0593333 m³ per year to 0.0019642 m³ per year. By the year 2008, the deficit will be 42% of the total demand if nothing is done to alter the situation.

5.1.2 Policy Shortcomings:

As it can be seen in the table below, woodfuel provides 93.4% of the total energy required in Kenya and by 1993 it is projected that 93.9% of the energy demand in Kenya will be obtained from wood resources. This shows the increasing importance of woodfuel in this country.

Table 5.9 Projected National Energy Demand by Fuel Type to the Year 1993 [Million Tonnes of Oil Equivalent]

Energy Source	1988	1990	1993
Woodfuel	27.80	30.30	35.30
Petroleum Fuels	1.70	1.81	1.90
Electricity	0.20	0.23	0.28
Coal	0.08	0.09	0.10
Total	29.78	32.43	37.58

Source: 1988-1993 Development Plan

In the 1984-1988 development plan which addressed the woodfuel problem more seriously when compared to the previous development plans, the policy statements made as regards woodfule are too broad and vague to effect fast implementation of woodfuel programmes.

In the current development plan 1988-1993, woodfuel is still acknowledged as the main source of energy in Kenya for the next five years. It states that " The overall objective for wood energy is to ensure adequate supplies through sustained yields while at the same time protecting the environemnt. To achieve this objective the government will promote the wide spread use of fuel efficient jikos and cookstoves by providing information advice through extension-services and demonstrations to appropriate target groups".

Looking at the 1984-88 development plan and sessional paper number one of 1986, five ministries that is Energy, Agriculture, Regional Development,Livestock and Environment are given the responsibility of implementing the tree planting and wood conservation programmes, the Ministry of Energy is supposed to take the lead in liaising with the extensionstaff of the other ministries. There are two major problems with this strategy.

i] The Ministry of Energy does not have enough staff to implement the proposed agroforestry programme. At the time of the study there was only one senior officer for every four to five districts. This is too wide an area for an individual to cover given the detailed nature of tree planting activities.

ii] The other ministries which are supposed to assist in the agroforestry extension work have their own programmes which they give priority hence agroforestry suffers. The staff of the other ministries do not have a direct commitment or direct responsibilities to the agroforestry programme since at the end of the day they will not be asked to account for the progress of the programme. Beside this, these particular staff have not had formal education in agroforestry and even energy conservation hence do not feel confident to handle the programme.

New and replanted forests refer to government or community land. In Kenya most of the land is free-hold hence there is no community land where new forests can be planted. This statement excludes the farmers and yet they are the owners of land.

To provide woodfuel and conserve the environment, the policy should aim at producing above the level of demand other wise the depletion will continue and there will be no environmental protection.

The extension staff especialy in the Ministry of Energy, Environment, and Regional development are too few to provide the required information and advice to the appropriate target groups in the rural areas. The plan does not say clearly who should do what in the programme and this could be the reasons for the slow take off that is being experienced in implementing this programme. As regards energy conservation, it was mentioned that no single energy saving cooking stove was found in the study area, some people have seen it elsewhere and others have heard of it through the mass media but they are not yet in use in the study area mainly because of lack of extension and technical staff like [jiko artisans].

5.1.3 The Factors that Accelarate Woodfuel Depletion

The woodfuel consumption and production pattern in the study area has been identified as indicated in chapter four and earlier in this chapter. The scarcity is displayed in the fact that people use maize cobs about half of the time in a year and even other crop residues like maize stalks, sunflower stalks, tree bark and sisal leaves - [this can be seen in the plates in Chapter four] are used for cooking.

The cause of the woodfuel scarcity was identified as mainly the fact that demand exceeds production by 38% and the reason for the low production identified as lack of tree seed and seedlings for planting. As regards the magnitude of this shortage, it was found that 78.1% of the households do not get enough seedlings for planting. Only 20.7% get enough and that 30.5% of the households raise their own seedlings. It was also found that the distance to the chief's nursery which is the only one, is long for the majority of the people.

As regards community priorities, it was established that in the study area water is the problem priority number one, followed by woodfuel and marketing of agricultural produce. In response to the water problem, 24.4% of people have drilled their own boreholes; and as regards woodfuel scarcity, 30.5% of the household have raised their own seedlings and 44% of the people have formed groups to market agricultural produce and procure agricultural inputs for the members.

Efforts to raise seedlings by individuals meet with one major constraint which is availabiblity of the appropriate tree seeds. The seeds that can be obtained in the area are Eucalyptus, Cypress, Combretum and Terminalia species all of which except Terminalia are not agroforestry species. Even Terminalia which is a moderate agroforestry tree is fairly a slow grower when compared to other agroforestry tree species.

The alternative energy source for this area were also considered and Biogas appears a viable alternative for the longrun in the study area and given that the raw materials are readily available and even the bricks which are required for the construction are available at 40 cents each. Earlier in chapter four, it was reported that only 26.1% of the people qualify for biogas units. [according to earlier recommendations that the minimum number of animals required to run unit is 4 cows]. However, observation from Jamhuri Energy Centre shows that two cows are adequate to supply dung to a biogas unit for a household of between 6 and 8 people. In this centre, there are two biogas units being served by 4 cows and the dung is enough and sometimes excess. Therefore, all the people of the study area qualify for biogas units since the sublocation average of cows per household was 3.2. The constraint in this case will be the trained manpower to do the construction of the biogas units and finance.

In summary, information on woodfuel demand and supply in the study area is now available at the lowest administrative level that is a sublocation and even though the survey showed that there are consumption and production differences from village to village and even among individual households. The variations are not too wide. The information gathered is fair enough for planning purposes in the study area and the surroundings.

5.2. Policy Recommendations:

In the foregoing discussion, the deficit has been identified, the policy shortcomings pointed out and the other general but relevant information in the study area noted. This section proposes the courses of action that should be taken to, reduce if not to balance out the deficit, effect fast implentation of programmes through reorganization of the institutions and involving the people in solving the problems of the area given the community characteristics and the resources available-

5.2.1 Balancing Out the Deficit

To balance out the deficit, various programmes to increase wood production will have to be embarked on. In addition, ways of efficient woodfuel utilisation, alternatives and substitutes will have to be sought.

5.2.1.1 Programmes:

The following programmes should be emphasized:-

i) Tree planting through Agroforestry

ii) Tree planting in wood lots

iii) Availability of tree seedlings by

a) Increasing tree seedling nurseries

b) Encouraging farmers to make their own nurseries and collect their own seeds

c) Encouraging direct seeding of tree seeds where possible.

5.2.1.1.1 Tree Planting through Agroforestry

In this chapter, "Agroforestry" is used restrictively to denote the systematic intercropping of woody perenials [trees and shrub] with non-woody food and cash crops [as in plate 19 and 20]. Some people refer to any crop tree mix as agroforestry however random it may be. There are agroforestry systems in which trees are added to woody perenial crops, such as shade trees in the case of coffee or fodder trees in silvo-pastoral systems.

Intercropping of woody perenials [trees and shrubs] into farming and pastoral systems brings about some ecological and economic advantages despite the risk of some detrimental effects on food and other crops. The two main advantages can be summarised as:-

i] Because trees and some shrubs grow at a different level than annual crops, the same piece of land can be made to yield tree products in addition to food and other non-tree commodities. This is particularly important as land becomes scarcer and as less and less land can be devoted to forestry. It has been estimated that in Kenya if the growing deficit of fuelwood has to be reversed, 2-3 millin ha of high-potential agricultural land must be brought under "intensive agroforestry" by the year 2000.

Plate 19: An intercrop of 1 year old Sesbania and Maize

Plate 20: 9 months old Calliandra intercropped with maize

ii] Trees can improve the agricultural and human environment by controlling erosion, moderating winds, pumping nutrients from the subsoil, adding humus [and thus increasing permeability and cation-exchange capacity] and green manure, fixing nitrogen providing shade, and occasionally by hosting useful predators.

When trees especially large ones are mixed in discriminately with annual or other crops, the latter are likely to suffer a decline in yield and quality if not worse. This decline can occur because of:-

i] Root competition of water

ii] Excessive shade [photosynthetic competition]

iii] Chemical antogonism between plants [allelopathy]

iv] Physical displacement [crowding out]

v] Hosting of harmful organisms [e.g. nematodes in tree roots].

To avoid the above negative effects in agroforestry farming systems, the right agroforestry tree species for the area in quesition should be selected. The main characteristics of ideal agroforestry trees are:-

i] Deep, narrow rooting: the bulk of the roots are in deeper soil layers not reached by crop roots.

ii] Light shade [unless the particular crop needs deep shade]

iii] Nitrogen fixation

iv] Nutrient rich leaf litter

v] No chemically antagonistic [allelopathic effects

vi] Soil binding roots

vii] Easy to manage [e.g no thorns]

viii] Multipurpose

ix] Reasonably fast growing.

The specific desirable traits of the trees will depend on the needs and objectives of the individual farmer.

As mentioned in chapter four,the number of households have increased since 1965 from one to two and a half in 1988. Population has also increased. This leads to a decrease in the land sizes. Subdivisions have already commenced and will increase rapidly in the next five years. Due to this increase in land subdivisions hence decrease in land sizes, agroforestry is the most appropriate farming system that should be adopted. From the type of vegetation, climate and soils of the study area indicated in chapter three, the following Agroforestry tree species stand a high chance of doing well.

i] Sesbania Sesban

ii] Grevillea robusta

iii] Calliandra callothyrsus

iv] Mimosa scabrella

v] Terminalia brownii

All except Mimosa are already growing in the area though not in deliberate intercrops where crops and trees are in the same plot at the sametime, there are other forms like boundary or line planting where one or two rows of trees are planted around a plot of crops though more easily acceptable to farmers that the direct intercrops, this form of arrangement is known to yield lesser wood. A third form of arrangement is rotation. [Though this is more applicable where there is a lot of land]. In rotation, an agroforestry tree species can be left in a field for two or three years and when it is harvested, crops are grown in the subsequent season.

5.2.1.1.2 TREES PLANTING IN WOODLOTS

Beside agroforestry, trees can also be planted as woodlots especially where land is available. As mentioned in chapter 4, only half of the land in the study area is being farmed, therefore, with enough awareness created and seedlings availed, trees can be planted as woodlots. This would be mainly trees that do not do well with food and other crops, e.g. Eucalyptus, Cyprus, Pinus and Black wattle trees. These are tree species which are already being planted hence there will not be any effort required in convincing the people about this particular species.

In Kenya, trials conducted at Muguga in the 1950s found that of the Eucalyputs spp. Eucalyputs Saligna [which is the dominant tree in the study area,] was the highest yielding species with yields of 24 m^3/ha/yr/ [17 tonnes] at 8 years rotations. Other species yielded less than 15m^3/ha/yr. [Jacobs, 1981]. Optimum spacing for Eucalyptus saligna to obtain these yields is 2.74 x 2.74 metres [1,329 stems/ha]. High yields tend to be confined to stick-sized wood grown on very short rotations. In Indonesia, Calliandra has yielded 40m^3/ ha/yr over rotations of two years. In an Indian experiment, Sesbania sesban has yielded 74 tonnes air dry in one year [96m^3/ha/yr] [Evans 1982] these species already exist and do very well in the study area as shown in the plates in chapter three hence what is required now is technical advice to the farmers on the kind of trees and arrangement in order to maximise on the available land. It is shown here that sesbania has yielded 96m^3 per ha in a year in India, this species can be considered for annual production of woodfuel [that is planted and harversted as an annual crop]. Plate 21 and 22 shows a 3 month and one year old Sesbania at Kabete campus field station and plate 23 shows a one year old Sesbania in the study area.

Plate 21: 3 months old Sesbania at Kabete Campus field station

Plate 22: I year old Sesbania at Kabete Field Station

Plate 23: 1 year old Sesbania in the study area

5.2.1.1.3 AVAILABILITY OF TREE SEEDLINGS BY

i] Increasing tree seedling nurseries and tree seed availability

From the survey, 43.9% of the people claimed that non-availability of tree seedlings was a major cause of the low rate of afforestation in the area.

Until recently, farmers seem to have been made to believe that they have to get tree seedlings for planting from the forest department or from the government. Given that some seeds are very difficult to raise, and also for the purpose of raising healthy seedlings and for training others on nursery techniques, a reasonable number of government nurseries should be established with the above purposes and after sometime when the farmers have picked up the techniques, the whole process can be left to the farmers themselves. In Naitiri sublocation five areas were identified as suitable for tree nursery establishment and even the owners are willing to set aside some land for that purpose. These are in Sango along sirende river, shihilila near kiminini river, Wabukhonyi, near river Kabuyefwe, Makhanga B near Makhanga shopping centre along the kabuyefwe river. Since some of the tree species being proposed like Calliandra are new in the country and study area the government should take the responsibility of availing the 1st and 2nd batches of seed but teach the farmer how to obtain seed from the already provided seed batches for future seed supply.

5.2.1.1.3 On-farm Nurseries:

The capacity of the one Chief's and two private nurseries at the time of study was 115,000 tree seedlings in total, the Chief's nursery services three other sub-locations. Only 20.7% of the households reported to be getting enough seedlings. The remaining 78.1% reported inadequate supply. Given that population has increased rapidly and the government can no longer supply enough for everyone that wants to plant trees and also that to meet the deficit, 0.44 million seedlings will be required annually for the study area, it is necessary that the farmers be encouraged to raise their own tree seedlings either by getting seed from the existing trees within the sublocation, from outside the sublocation or from any of the government institutions that deal with tree planting, every farmer should be encouraged to raise and plant about 500 tree seedlings every year. This can be raised from a small tree nursery of 1 x 1 metres.

From the survey, 30.5% of the households were faoundto raise their own tree seedlings for planting. This should be encouraged for effective cost sharing and public or community participation. The average distance to the nearest tree nursery was found to range between 0.5 to 12 km with an average of 6.2km. This is a fact that should be used in encouraging on-farm nurseries since it will decrease the transportation costs and increase a farmers choice of tree seedlings because he may plant what he wants.

iii] Encouraging direct seeding of tree seeds where possible.

Some tree seed like for <u>Sesbania</u> <u>Sesban</u> germinate very easily such seed can be direct seeded directly in the plot it is to be planted. Other seeds like for Eucalyptus can be direct seeded but the seeds are too small to be handled individually therefore, they have to be raised in nurseries first, before finally being planted in the field.

5.2.1.2 INCREASE EFFICIENCY IN WOODFUEL UTILISATION

Principally, firewood is used in rural areas and is collected by women and children. Most rural areas of Kenya still use the three stone fire as is the case in the study area, all the households surveyed use the three stone fire. Although the three stone fire has an efficiency as low as 10%, burning wood directly saves more energy than first converting it to charcoal because about 75% of wood energy is lost in the conversion process [E.D.I, 1986].

A search into energy conservation in the study area revealed that no single household was using improved cooking stoves [both the wood and charcoal stoves]. However, there were traditional methods of conserving energy this included, pulling firewood out of the fireplace after cooking. Putting off the fire with water, putting the burning wood under ash and soaking of some foods like maize and beans before cooking. First, these methods of conservation should be strengthened by providing additional information and advice through extension services and demonstration to appropriate target groups. [For this particular area, the women since they are the ones who do the cooking], second, the improved wood stoves should be introduced as soon as possible because they will save on wood energy, they are cheap enough for the people to afford and they conserve energy by 30%.

5.2.1.3 Encourage Domestic Fuel Substitution where possible.

The above strategy can very easily be applied in urban centres where there are more alternatives to choose from,for example, there is electricity, bottled gas, kerosene, charcoal and most recently some homes and institutions use solar.

The rural areas however, have very few choices or none at all. At the present level of income and technology, the rural areas of Kenya and the people of Naitiri sublocation in particular cannot afford most of the alternatives that may be offered in the place of fire-wood in fact as it stands now, instead of moving forward to better energies like bottled gas or kerosene, they are moving backwards to crop residues.

As the woodfuel scarcity increases, crop residues particularly maize cobs are fitting in as a possible substitute such that increase in th level of maize production hence maize cobs will reduce the demand of wood-fuel. Though the cobs are not liked as much as wood, their use as a source of cooking energy fetches a ratio of 1:1 with wood.

Another close alternative that can be used as a substitute to wood is kerosene. Because of the size of kerosene stoves and the big size of rural families, use of kerosene for cooking cannot easily substitute for firewood though it is a suitable substitute for charcoal especially in urban centres among the low income earners. Despite this fact use of kerosene even in rural areas can be encouraged by

i] Increasing the cost of wood

ii] Reducing prices of kerosene

iii] Reducing distances to buying centres.

In the study area, only 1% of the households are using kerosene for cooking. This is mainly because wood is cheaper for the majority, the price of kerosene is relatively high and it is obtained from fairly far buying centres [an average of about 30 km].

As regards the prices of kerosene, the Government in the current development plan, as a short term measure will provide a woodfuel conservation subsidy scheme based on reducing the effective price of paraffin to encourage its use as an alternative to charcoal and wood.

By comparison with other countries in the world, the price -royalties charged for the use of wood in Kenya are too low considering the opportunity cost of the use of these resources in environmental and economic terms.

The government therefore has planned to review the pricing structure for wood resources used in industry with a view to bringing prices to levels that reflect this opportunity cost. This will in turn increase the prices of firewood hence encourage more people to change to substitutes. At the same time it may act as an incentive for farmers to grow more wood for commercial purposes.

Increase in production of maize in the study area beside providing cobs for cooking, it will increase income and food availability, factors which boost wood production.

5.2.1.4 Introduction of Alternative Energy Sources to Broaden the Energy Mix

As mentioned earlier in this chapter eletricity is a relatively expensive source of energy for domestic use. Therefore efforts are being directed toward the development and exploitation of renewable sources of energy such as solar, wind and biogas.

5.2.1.4.1 SOLAR

Studies which have been done on solar applications for Kenya in the national power development plan are very pessimistic, whether in form of photo-voltaic cells or heat engines, costs under current technologies

Plate 24: Solar Unit

Plate 25: Solar bulb

were assessed as prohibitive. However, some direct [non-electrical] applications of solar power are potentially significant including applications for water heating and crop drying. The later is already being utilised directly whereby crops that require drying are sun dried directly and stored or marketed. In urban centre heaters are used for heating water especially in the residential areas. Solar cells or heat engines do not appear to be viable in the study area due to the exorbitant prices e.g. A solar unit for lighting four bulbs cost about Kshs. 18,000 compared to a lantern lamp costing Khs.100/- and using kerosene of about Kshs.240/- per year per household. Given the life of the solar unit of 25 years the cost comes to about 720/- per year without the maintenance cost. This is three times the cost of using kerosene hence though solar light may be brigher hence convenient [Plate 24 and 25], it is not economically feasible in the study area.

5.2.1.4.2 WIND POWER

Windmills have long played a role in satisfying the dispersed low power demands of rural development Installed in favourable sites, they serve end-uses from grinding and pumping to electric generation. In Kenya, windmills have been used for unattended water supply pumping for over 70 years.

The economic feasibility of wind mills is contingent on a number of factors.

i] Available wind: In general, sites are considered poor for windmill installation unless their average windspeed is 5m/s. Kenya's equatorial location does not fall within macro wind patterns, so her wind distribution is entirely the product of local land features. Information presently available suggests that average windspeed of 5m/s may be found in the Northern Rift Valley, North-eastern and Central Province and on the northern coast. Marginal winds of 3m/s may be found in the Lake Basin. From this information, it is clear that the study area is not among the areas mentioned therefore, its wind speed [though the exact figure is not given] is likely to be below the required minimum. Since the most important factor has disqualified the study area as regards use of windmills, the other factors will just be mentioned and not discussed. These are:-

i] Load matching [usually very expensive]

ii] Reliability [reliable machines are also very expensive]

iii] Service availability [very scarce in Kenya]

iv] Dedication [windmill can only be used for one purpose,many situations would require a multipurpose engine, e.g. small tractor] v] Capital market [reliable ones cost more than alternative diesel engines]

Windmill applications currently feasible are restricted to drinking and stock water pumping in windy sites where maintenance skills and capital are available. Development of inexpensive but reliable machines would extend the range of this application to the lake basin and coastal regions and might make use of windmills for crop irrigation marginally feasible in these areas.

5.2.1.4.3 <u>Biogas:</u>

Biogas is a medium energy [24mj/m^3] combustible gas derived from organic materials and composed of approximately 60% Methane and 40 percent. Carbon-dioxide. Biogas can be burnt for light, heat for cooking or used to fuel internal combustion engines.

Biogas is generated by a biological process anaerobic bacterial decomposition of its organic feedstock. The rate limitations of this biological process seriously constraints its application. Production of useful quantities of biogas requires a large volume permanent culture. Such systems produce continuously and are not easily regulated. Thus, biogas cannot be produced on as needed/where needed basis, but must be produced at fixed generation sites and stored. Since it is not generally

PLATE 26.

Plate 27: Biogas burner

Plate 28: Zero grazing unit

Plate 29: Digester and gas holder

economical to compress the medium energy gases, gas must be stored in large volume leak-proof containers and distributed through fixed piping. These considerations preclude mobile application and impose heavy costs on high demand, intermittent uses.

Nevertheless, biogas has one overwhelmingly attractive feature. Its imput material are comparatively cheap if water is freely available. The most common feedstock for biogas digesters are wet manure and crop residue. The fertilizing value of these materials is not reduced but enhanced by their passage through the digester. At the sametime, the action of the methanogenetic bacteria destroys many pathogens and serves as an effective sewage treatment. This ability to generate a valuable gas while treating and improving the quality of manure has prompted interest in biogas throughout the world. A simple technology has evolved and more than 800,000 biogas digesters have been installed, mostly in China, Korea, and India. Although there is considerable enthusiasm for Biogas in Kenya, fewer than 300 digesters have been installed. Most of these are a locally made version of the design described below. This system generally known as the Indian design, consists of a digester tank equipped with a floating metal cover constructed to collect and store evolved gas. The storage chamber is connected by a pipe to mantle lamps or other appliance. In use, a mixture of fresh manure or other material and water, is fed through a sub-emerged funnel into one end of the digester tank. The addition of this fresh stock displaces digested slurry through an outlet at the other end. Passage from input to output takes several weeks.

A typical family scale digester might have a volume of 1.5 cubic metres [plate 26]. A local digester would cost about Ksh.3,000. Under good conditions, this digester would convert the manure of two cows into $0.75m^3$ of gas daily. This amount of gas is sufficient to provide five hours of lighting. One hour of cooking [six inch burner] [Plate 27], or to fuel a one-horsepower stationary engine for half an hour. Storage capacity is limited to less than two days production. Even when a system of this size is functioning well, its usefulness will be quite limited mainly because rural homes cook for between 4-8 hours in a day, hence household systems are not likely to function well consistently.

Biogas generation is not as easy as the simplicity of its equipment might suggest. The temperature and chemical sensitivity of the methonogentic bacteria require careful management. Digesters must be fed daily with material of the proper liquidity, pH, and carbon/nitrogen ratio. A change in feedstock or some other biological shock may halt gas production for weeks.

Gas production rates are strongly dependent upon temperature virtually ceasing at temperatures below 50°C. Mechanical problems such as sludge and scum build-up and corrosion-induced gas leaks plague digesters. Two recent surveys in Kenya found that as a result of these problems very few [<25%] of the installed systems were actually producing useable gas.

While family systems can be economically under optimal conditions, capital, labour input, and management costs will severely limit their use. In India, where conditions are far more favourable, the state supported biogas programme has been heavily criticized for subsidizing a technology too costly and labour intensive for the wealthiest farmers. While this problem could in principle be avoided by development of larger, village scale biogas plants, taking advantage of the considerable economies of scale, dispersed Kenyan settlement patterns cannot support such plants. Even the Chinese acknowledge that their biogas systems are built primarily for sanitary reasons, with gas production as a side benefit.

In the Kenyan context, biogas may prove valuable in ideal sites such as large farms, coffee plantations, and institutions such as rural schools. However, for the foreseeable future Kenyan households will not likely find biogas plants worthwhile and biogas can be expectd to contribute little to the overall energy supply.

Considering the type of materials required for biogas production all of the households were found to own at least two cattle which is the minimum number of animals required for dung production, required also is a zero-grazing unit [though not a must] which will facilitate easy feeding of the digester and also help in the carbon/nitrogen balance: since there is a lot of nitrogen from the urine. Unfortunately for the study area, by the time of the survey no single zero-grazing unit existed in the study area. Another factor that would affect biogas units is availability of water. From the survey, the community expressed their number one problem as water inavailability therefore, biogas production would be greatly hampered by this defficiency.

Beside the raw materials for producing the gas, there is also the cost of constructing both the zero-grazing unit [plate 27] about Kshs. 12,000/- and the digester/gas holder [plate 29] costing about another Kshs.14,300/- [1982 prices]. If one did not have the animals, that would cost over Kshs.8,000/-. Any farmer who can afford this kind of money can as well go in for electricity. Given that electricity is still very far from the study area, [30 km], investing in tree planting and or changing to kerosene or bottled gas would be appropriate in the short-run; but for the long term planning, consideration should be given to biogas for the study area. Since woodfuel is becoming more scarce hence its commercialisation will also increase and it has been found that biogas becomes more viable in an area where all or most of the energy requirements are obtained on commercial basis. Appendix 2 has the detailed cost of constructing a biogas unit.

5.2.2 Institutional and Implimentation Requirements

It was mentioned earlier in this chapter that the Ministry of Energy who are the sole implementors of woodfuel programmes are deficient in both research and extension manpower. If the woodfuel programmes are to be successful:-

i] The Ministry should consider having their own extension staff who know and can emphasize the need for wood for energy purposes. This is because, the Ministry of Livestock staff will emphasize on fooder for their animals, Agriculture on food crops and other cash crops hence they will not emphasize the need for wood for energy.

ii] These extension officers should be positioned at the district headquarters to work together with the DDC instead of the current regional base.

iii] Information on energy situation in every district should be availed so that every district is given quantitative targets to meet on annually basis, this will make it easy to monitor and evaluate the performance of the programmes.

iv] In implementing of programmes, selective concentration should be excercised using the deficit level as the criteria for selection that is, the area with the highest deficit should be given priority hence efforts should be concentrated in it either on annual or project basis.

v] If it becomes necessary to use the extension services of other ministries, then the particular staff should be seconded to the Minstry of Energy as full time wood production and efficient wood utilisation promoters.

vi] Given the importance of trees to the environment, it may become necessary for the government to set a minimum size of land under trees or number of trees that every farmer should have at any one time. This will vary from district to district depending on consumption habits.

vii] As concerns the study area, given the information that culture, socio-economic and land sizes are not a hindrance to tree planting and that water shortage is a hindrance and it is recognized by the people as their priority number one problem, also given that there are pipes laid for water and every home has a tap, the government should revive the water project and see to it that every home receives water if the tree programmes have to succeed. Emphasis should also be put on the fact that a small nursery of about $1m^2$ will not take more than 20 litres of water in a day. A nursery may last for a maximum of only two months when dealing with the fast growing tree species like Sesbania, Eucalyptus, Calliandra, etc. that have been proposed hence the people can be convinced out of the feeling that there is no water for raising tree seedlings.

vii] Another major factor that can affect tree planting is lack of unity in the study area. Given that these people are newly settled in this area from different parts of the country, and it is even proved from the survey that there is lack of unity if tree planting programmes have to succeed, individual approach should be used instead of group approach. For example, in establishing tree nurseries, it will be better to deal with individual households than groups unless a particular group has initiated the project themselves.

ix] To improve on peoples' perception of tree planting programmes in the study area, awareness should be created for them to know why they are using crop residues for cooking since some of them just take it as the order of the day, they do not seem to have thought about it and this is reflected in some of the questions that they were asking during the survey, for example, one person asked that "what has the government to do with firewood?" Another one commented that "of all things, firewood, don't these people have other things to do"?.

The others were just too amused that anybody would be interested in woodfuel and yet all of them are using crop residues for cooking for about half of the time in a year. Mass media like radio, and films and also local Chiefs and sub-Chiefs' meetings should be used to emphasize the importance of woodfuel and the likely consequences if it gets depleted.

x] The family planning programme should be strengthened to help in reducing the population growth since it is one of the factors that deplete woodfuel.

xi] Finally, children in schools should be encouraged to work hard so that in future, they will have good jobs and high incomes; the government should work together with the parents and teachers so that every student gets a fair chance to go through their education up to the highest level possible by providing the necessary school facilities. This is suggested because very few people in the study area had attained higher education and higher education was found to affect woodfuel production positively.

<u>Summary</u>

In summary, three problems have been identified that is the deficit, policy shortcomings and the negative effects of some of the community characteristics as regards woodfuel production.

The courses of action for solving these problems have been identified and these include increasing wood-production and its efficient utilisation, looking for alternative energy sources and substitutes for woodfuel. The possible alternatives that is solar, wind and biogas have been considered and found not feasible for the short run but can be considered for the long term purposes. Eleven different policy considerations have been suggested for effective implementation of woodfuel programmes and the approach that should be used considered in the last section of the chapter.

CHAPTERE SIX: CONCLUSIONS

Woodfuel is an important source of energy for majority of Kenyans especially those residing in the rural areas. In the late 1970s it was noticed that this resource was getting depleted at a high rate. Tree planting and wood conservation progarammes were designed to try and contain the situation. Ten years later, much had not been achieved. From studies done earlier it appeared that the woodfuel programmes were failing because of lack of knowledge of the magnitude of the problem, weak government policy and other information that affect woodfuel consumption and production. It was also noted that the problem was more critical in the high agricultural potential and medium agricultural potential areas, and already some studies had been done up to sublocational level in some of the high potential districts of Kenya.

For the above given reasons, the study set to assess woodfuel demand and supply levels and the factors that affect both in a medium agricultural potential area. It also set to examine the causes of woodfuel shortage which is evidenced by the use of crop residues in the area and from the findings of the above, the study was to suggest the remedies to the identified problems.

The work that had been done before by other people in other areas gave guidelines on what parameters and characteristics should be sought. The relevant data was collected and analysed and from this, various conclusions can be made:-

i] It can be concluded from the supply and demand balance that there is a woodfuel deficit in the study area and it will grow with time.

ii] The major factors, that affect supply and demand of woodfuel in the area are income, family size, availability of suitable energy substitutes to woodfuel, cultural ceremonies, and home industries.

iii] The major causes of woodfuel depletion are non-availability of tree seedlings and that if seedlings are provided, the woodfuel problem will be rectified.

iv] If the policy recommendations can be effected, then the woodfuel and even energy problems in the study area will cease to exist.

It was noted that there are some other factors that affect woodfuel supply and consumption in the study area but information was not available on either how they affect or to what magnitude or both. Therefore, it is recommended that:-

i] Further research should be done to find out the reason for low level utilisation of land and low yields of crops in the study area.

ii] Research should be done to find out ways of improving the marketing of agricultural produce to avoid exploitation of the farmers by middle men.

iii] Further studies should be done to find out how the people of the area can be made to unite since lack of unity affects development especially when it comes to community facilities like schools.

iv] For national interest similar studies should be carried out in other areas of the country.

SUMMARY

It has been noted that the two basic problems in the study area are lack of water and scarcity of woodfuel. Plans have been proposed to address these specific problems and as they are implemented, some of the other minor problems in the area will be solved.

The study methodology can be applied to other areas of medium potential, medium population density, especially maize growing areas of the country.

While the strategies proposed for increasing the supply of woodfuel in the rural areas can be applied to other similar areas in the country, social cultural differences are important and should not be ignored.

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Appendix 1

HOUSEHOLD QUESTIONNAIRE

DEPARTMENT OF URBAN & REGIONAL PLANNING

UNIVERSITY OF NAIROBI

Name of Interviewer:

Date:

Beginning of Interview:

End of Interview:

1. Name of respondent

2. Age of respondent

3. Education of respondent

4. What positon does he/she hold in the household: tick

   i] Head of household

   ii] Wife

   iii] Son

   iv] Daughter

   v] Relative

5. Ethnic group [clan]

   i] Luhya ....

   ii] Kikuyu ....

   iii] Kalenjin ....

   iv] Luo ....

   v] Others [specify] ....

6. How many people live in the homestead?

   i] Adults [over 15 years] ....

   ii] Children [5-14 years] ....

   iii] Infants [below 5 years] ....

7. How many members of the family eat here every night? ....

8. Does the head of the household live there all the time?

   i] Yes

   ii] No

<u>Eonomic factors</u>

9. What are the main occupations of the head of the household?

   i] Farmer...................

   ii] Shopkeeper ....

   iii] Employee [where]...........................

   iv] Others, specify ....

   v] Remarks......................................

10. Does the head of the household manage any business?

   i] Yes...........................

   ii] No ....

11. If there are grown up children, do they contribute money to the family budget?

   i] Yes ....

   ii] No ....

   iii] If yes, how often ....and approximately how much?..............

FARM BACKGROUND

12. How much land does the family own [in acres].......

13. How many acres does the family cultivate?..........

14. What are the main crops grown and the acreage?

i] ....

ii] ....

iii] ....

iv] ....

15. Approximately how much of each of the crop is harvested annually?

i] ....

ii] ....

iii] ....

iv] ....

16. Does the family harvest enough food crops for the whole year round?..................................

If No, how much and when is extra food bought for the family?......................................

....

....

17. Do you keep animals? [i] Yes [ii] No

If Yes:

	Type	No of Animals	Number sold annually and how much
i]			
ii]			
iii]			
iv]			
v]			

18 Do you sell animal products?

i] Yes............................

ii] No ....

19

	Kind of animal type of products and how much	Frequency of selling	Price per unit
i]			
ii]			
iii]			
iv]			
v]			

ENERGY DEMAND

What do you use for cooking, warming lighting?

Firewood ....

Charcoal ....

Paraffin ....

Electricity ....

Agricultural waste ....[eg. stalks, etc]

2a How much of the above do you use daily, monthly or annually?

Firewood [kg] ....cost ....Kshs. per unit.

Charcoal [debes, bags etc.] ....cost.... ..Kshs.

Paraffin [treetop, bottles] cooking...cost.....Kshs.

Gas [cylinders] ....cost............. Kshs.

Agricultural [bags of maize cobs or
acres of sunflower or
maize stalks ....

Electricity [monthly payments ....Kshs

3a Do you buy any or all of the firewood and charcoal that you use? Yes [ ] No [ ]

b If yes, how much of the firewood to you buy?

i] Daily ....kg

ii] Monthly ....or kg

iii] Annually ....kg

Have you every cut a whole tree just for firewood or charcoal? Yes [ ] No [ ]

6. How long did the wood charcoal last ....

7. List the various sources of energy in order of availability [firewood, charcoal, eletricity, paraffin, agricultural wastes, gas, other, specify.

i] ....

ii] ....

iii] ....

iv] ....

8. Do you get all the energy that you need for:

Cooking ....

Lighting ....

Warming ....When you need it and enough for the purpose?

Yes [ ] No [ ]

9. Where do you store your firewood and charcoal?......

....

....

REMARKS

ENERGY SUPPLY

1. Where do you get the energy that you use for cooking/ warming/ lighting?

Firewood ....

Charcoal ....

Agric. wastes ....

Paraffin ....

Gas ....

Electricity ....

2. How far from your farm are the source of the above?

....

3. Do you experience any shortage of the above ....

4. Approximately how many trees do you have on your farm?

   i] indigeneous [natural] ....

   indicate species ....

   ....

   ....

   ....

   ii] Planted ....

   indicate species ....

   ....

5. Of these trees approximately how many are specifically for:

   i] Charcoal ....

   ii] Firewood ....

6a. What do you use the remaining for? Sale, poles, construction, etc.

b. If for sale, what is the price per tree?........Kshs

7. How much of the following do you harvest annually?

   Maize cobs [bags] ....

   Maize stalks [acres]............................

   Sunflower stalks [acres].........................

   Any other [specify] ....

8. Is there any of the above energy sources that is available in excess on annual basis? Yes [ ] No[ ]

9. If yes, which one/s and approximately how much of each?

	Type	Quantity
i]		
ii]		
iii]		
iv]		
v]		

10. How do you store you agricultural waste?

i]

ii]

iii]

11. What is your general view of fuelwood availability these days as compared to old days?

i] No difference ....

ii] More fuelwood ....

iii] Less fuelwood ....

iv] No idea ....

12 What do you think is the reason for the answer above?

....

....

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

....

....

....

TREE SEEDLINGS DEMAND

1. i] Approximately how many trees do you plant every year? ....

ii] Where do you get them from? On farm [ ]
Off farm [ ]

2. Which species do you plant?

i] ....

ii] ....

iii] ....

iv] ....

3. Which of these species do you prefer?

i] ....

ii] ....

iii] ....

iv] ....

4. What do you like about these particular species?

....

....

5a. What do you plant these trees for? [order of importance]

i] ....

ii] ....

iii] ....

iv] ....

v] ....

b] Do you usually get enough seelings when you want to plant? Yes [ ] No [ ]

If No, why?......................................

6. Have you ever been visited by an extension officer [E.O] advising you on tree planting? Yes [ ]
   No [ ]

7. If yes, which kind of advice did you get?
   ....
   ....
   ....
   ....

8. How have you utilized the advice given by the E.O.?
   ....

9. How far [in km] is the nearest tree nursery from your farm? ....

10.i] Are there any problems or traditions which hinder people here from planting trees?
   If yes, which ones ....
   ....

ii] What do you do about them?........................
   ....

11. What according to you is the best way to make people plant trees? ....
   ....
   ....

REMARKS

TREE SEEDLINGS SUPPLY

1. Do you have a tree seedling nursery?

   Yes [ ]   No [ ]

2. If No, why? ....

3. If Yes, how many seedlings do you raise annually?

   ....

4. Which species do you plant?

   i] ....

   ii] ....

   iii] ....

5. Do you sell the seedlings or not   Yes [ ]   No [ ]

6. If sold: what is the price per seedlings?.......Kshs

7. What problems do you get as regards the raising of the seedlings?

   i] ....

   ii] ....

   iii] ....

8. What have you done about the problem?................

   ....

9. Where do you get the tree seed for planting?.........

   ....

ENERGY CONSERVATION

1. Have you experienced a drop in your crop yields over the years? ....

   ....

2. Do you take any measures in preparing to cook e.g. 'githeri'...

3. Do you often cook more than one dish at the same time? Yes [ ] No [ ]

4. What do you do with left-over charcoal still glowing and firewood after the cooking is finished?

   i] Put the firewood off with water

   ii] Pull the firewood out

   iii] Cover with ash

   iv] Just leave it there to burn down

5. Do you have any problem with your stone?

   If yes ,what problems?.................................

   ....

6. What bothers you most in your kitchen while cooking?

   i] Heat ....

   ii] Smoke ....

   iii] Attending fire....................

   iv] No safety ....

   v] Others [specify]..................

7. i] Have you already seen one of the improved wood stoves and/or improved charcoal jikos? ....

   ....

   ii] What have you heard about them?..............

   ....

   iii] Who told you about them?....................

   iv] Have you heard of any problems with the new stoves?...................................

   ....

8. Why haven't you got one?............................

....

9. If you could buy a transportable metal cladding woodstove which does not need repairs, costing about Ksh.100/- or learn how to build a stationary clay sand stove needing occasional repairs and smearing [if there are cracks] costing Ksh.20-30, which one would you choose? ....

....

10 WATER

Where do you get you water from?

a] Pipe [ ]

b] Well [ ]

c] River [ ]

d] Others [specify]

11. Is there enough water in the dry season? ....

....

12. How far is it from your farm/[km. or time hrs]........

13. Do you have a water storage tank? ....

14. Observe the housing conditions and note or:

Roofing material........ i] Type....................

Walling mat ii] Condition ....

Waling material......... i] Type ....

ii] Condition ....

Flooring material i] Type ....

of the main house ii] Condition ....

If brick made, quantity of

of bricks used i] ....

GENERAL

6. Do you belong to any social organization?..........

....

7. Which is your religion? ....

8. What are the most serious problems:

i] In your village

ii] In your family [list in order of seriousness]

i] ....

ii] ....

iii] ....

Appendix 2

BIOGAS MATERIALS

Material required for the construction of an average family's biogas digester, 9.4M³

CONSTRUCTION MATERIALS

No	Item	Quantity
1.	Stones	550' x 4" x 9" or 550' x 6" x 9"
	of Bricks for bricks digester	[2200] 3 x 5 x 9
2.	Cement [for bricks digester	13 Bags 15 to 18 bags]
3.	Sand	4 tons
4.	Ballast	1 tone
5.	PVC pipe	6in. x 6m.
6.	Polythene sheet [gauge 750 or 1,000]	6m. or 1/2 kg.
7.	Ring wire, reinforced bar [2 for floor, 1 for collar]	3 x 3/8in. x 12m

FITTINGS

The quantity of fittings required varies from site to site. The digester builder will advise you accordingly. The list below is intended to give you an indication of what is required.

8.	Polythene or polypropene tube	1" diameter
9.	GI-pipe - BSP Class B	1/2" diameter
10.	Thread seals	

11.	Digester connection:	2 x 1" diameter
a.	GI double nippe	1
b.	Gate/ball valve	
12.	Underground gas pipeline:	1 x 1" PE to 1"
a.	Adaptor	1 x 1" to 1/2"
b.	GI reducer socket	
13.	House installation:	1/2" diameter
a.	GI tee	1/2" diameter
b.	GI elbow	1/2" diameter
c.	GI socket	1/2" diameter
d.	GI nipple	1/2" diameter
e.	House connectors	1/2" diameter
f.	Ball valves for cooker	1/2" diameter
g.	Clamps [if necessary]	1/2" diameter
h.	Clips [if necessary]	1/2" diameter
i.	Water trap[s]	1/2" diameter

14. Gas storage

a. Gas holder made from M.S. sheets 1/8" thick

b. Guide frame

c. Water trap[s]

[all from a qualified metal workshop]

15. Appliances:

a. cooker[s]

b. Lamp[s]

MS = mild steel

ND = Nominal Diameter

BSP = British Standard Pipe

PE = Polyethylene or polypropene

Source: Ministry of Energy

[List that is given to builders]

Appendix 2 Breakdown of the Investiment Costs of a Biogas Plant

	Kshs.
Digester	
a] Construction material	
- quarried stone: 550 pieces at Ksh.1.5 each	825.-
- sand, ballast, transport	750.-
- 12 bags of cement, waterproofing additive, transport	1,125.-
- inlet and outlet pipe, gas piping, etc.	1,400.-
b] Labour	
- excavation work	
- 30 days at Kshs.40 each- masonry	1,200.-
15 days of Kshs. 80 each	1,200.-
	6,500.-
Gasholder]including central guide frame]	6,500.-
Appliances	
- cooker	500.-
- lamp	800.-
	1,300.-
Grand Total	14,300.-

The total annual costs involved in the utilizatin of a biogas plant can be determined by transforming the investment costs into annual capital costs and then adding on the annual running costs [operation, maintenance and repair].

An owner of a biogas plant will incur total annual costs of approx. Kshs.2,500.-, and biogas will be substituted for fuelwood and charcoal in cooking applications, and for kerosene in lighting. The crucial question is, of course, whether the annual savings can be expected to offset the annual costs.