ENERGY CONSTRAINTS AND CHOICES: A CASE STUDY OF NYATHUNA 'B' SUB-LOCATION, KIAMBU DISTRICT

BY

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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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ABSTRACT

This study addresses itself to rural energy constraints and choices in a high agricultural potential area which has a high 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. The scarcity of woodfuel is evidenced by its commercialization and the greater use of crop residues as woodfuel substitutes.

This study has, therefore, endeavoured first to establish the underlying causes of woodfuel depletion. Second, the choices of domestic energy that are available in the study area and the potential for new ones has been examined. Third, steps have also been taken to determine what methods can be used to conserve domestic energy in the study area.

In the study area mismanagement of the resources, due to farming practices and policies that encourage the clearing of trees to create land for cash crops has led to resource depletion. In addition rapid growth in the population has increased environmental stress because of fragmentation of the land (due to

land tenure practices), and clearing of trees for human settlement. As a result of the increasing distance to the supplies of fuelwood and charcoal, problems related to political economy have increased. Charcoal dealers (usually urban based) get charcoal from other parts of the country and transport it to the study area at high prices. A fourth cause of environmental deterioration has been changes in the climate leading to unpredictable rain patterns.

The study has established the possibility of increasing the production of energy through agro-forestry and biogas technologies. Besides increasing the energy choices these technologies help to preserve and improve the environment. In addition, solar energy is also a possible source of energy, but the high cost of solar equipment is a constraint.

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

Following the research findings, planning strategies have been prepared. These have been based on what the people stated were the major problems - lack of land and fuelwood. The three planning strategies are agroforestry systems, biogas technology and domestic energy conservation. Even though the land will not be increased, its productivity will be improved.

The policies thus adopted will encourage public participation in the planning and implementation of the strategies. Then, through reduced resource depletion, and increased availability of domestic energy, rural development will be enhanced. Human hardship and poverty will be reduced to a certain degree.

It is expected that the research methodology used in this study can be applied in similar high-agricultural potential areas with a high population density, and therefore help to alleviate the problem of resource depletion, evidenced as woodfuel scarcity.

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TABLE OF CONTENTS

Page

Page

Page

List of Figures

List of Figures Contd....

List of Tables

List of Tables Contd........

DEFINITIONS

Anaerobic Fermentation - A natural, biochemical process which occurs when organic matter decomposes in the absence of oxygen or fresh air.

Biogas - Combustible gas that is produced during anaerobic fermentation.

"Boma" - Semi-permanent or permanent zero-grazing unit. (Swahili)

Charcoal - The product of carbonization, or charring of wood when it is heated up to temperature of between 420^{o}C to 550^{o}C, while restricting air intake.

Fuelwood - Wood which is used directly as a fuel; firewood.

"Githeri" - A dish which is made from a mixture of beans and maize. (Kikuyu).

"Ibuti" - A stack of fuelwood with an approximate volume of 1.7M^3. (Kikuyu).

"Jiko" - Cookstove. (Swahili).

"Kuni-mbili Jiko" - A cookstove that uses two pieces of fuelwood to prepare a meal. (Swahili).

LPG - Liquid petroleum gas, sold commercially in cylinders.

Photovoltaics - The generation of electricity from sunlight using solar cells.

Woodfuel - Fuelwood and charcoal.

"Ugali" - A dish made from maize meal. (Swahili).

ACRONYMS AND ABBREVIATIONS

E/DI	-	Energy/Development International
GTZ	-	German Agency for Technical Assistance
HABITAT	-	United Nations Centre for Human Settlements
ICRAF	-	International Council for Research in Agroforestry
KENGO	-	Kenya Energy Non-Governmental Organisation
KIE	-	Kenya Industrial Estates
NAS	-	National Academy of Sciences (U.S.A.)
SEP	-	Special Energy Programme.

CHAPTER 1

INTRODUCTION

Preamble

Energy is an important aspect of the national development process of any country. Cipola (1962) has argued that to the extent that man can utilize successfully his own energy output to control and put to use other types of energy, to that extent can he acquire control over his environment and so achieve goals other than those related to animal existence.[1] He explains that this control is limited by the problem encountered in the utilization of non-muscular energy in transforming it to the required form at an affordable cost where and when it is needed. He also observes that per capita energy consumption rises as the level of national income increases.

Energy is expended in various types of land uses and activities, such as in agricultural operations and transportation, in industrial operations, in the construction and operation of infrastructural services and facilities, and in domestic activities. However, this study focuses on those energy issues that affect the domestic sector of the rural household and how they influence national development.

Nature of the Problem

Third World Energy Situation

The predominant source of rural domestic energy in developing countries is woodfuel and non-commercial fuels.[2] Goodman (1985) has written that 1.5 to 2.0 billion people rely on these fuels for cooking, space heating, and to some extent lighting.[3] He adds that as a general rule annual consumption of wood is about $1M^3$ per person per year, and that while the sources of these fuels are diminishing there seems to be no alternative to wood in most developing countries. As explained further on, Kenya is in a similar situation and is experiencing the same types of energy problems.

Approximations of the degree to which traditional and non-commercial fuels are consumed in different countries has been given.[4a] (Table 1-1).

Bhagavan (1985) reports that the governments that form the Southern Africa Development Coordination Conference (SADCC) have come to the conclusion that woodfuel will continue to be the primary source of energy for all rural households.[5] The SADCC countries are Angola, Botswana, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia and Zimbabwe. This view is supported by Mwandosya and Luhanga (1985) who

Table 1-1: Percentage of Traditional Energy Consumption

Country	Percentage of Traditional Energy to Total Domestic Energy Consumption	
	Year	Percentage
Ethiopia	1982	88
Malawi	1980	92
Uganda	1980	93
Ruanda	1979	93
Niger	1981	82
Sudan	1981	87
Morocco	1981	33
Zimbabwe	1981	32
Nepal	1981	93
Sri Lanka	1980	54
Papua New Guinea	1980	38
Haiti	1979	79
Bolivia	1981	35
Peru	1981	26
Costa Rica	1981	39

Source: G. Oelert, et al (1987)[4b]

report that in Tanzania biomass, in the form of fuelwood and charcoal, is the main source of energy for rural households.[6]

Studies carried out by the United Nations Centre for Human Settlements (Habitat, 1984) in India show that when the domestic energy needs are analysed it is found that the bulk of the energy is used for cooking.[7] A much smaller quantity is used for water and space heating. The same study revealed that in the domestic sector of rural northern India, in 1975 and 1976, 96.4% of the energy was obtained from non-commercial sources while 3.4% was commercial. The commercial component was used for lighting. Of the 3.4% paraffin contributed 92% and electricity 8%.

Sources of woodfuel have progressively been depleted leading to human hardship. For instance, Mwandosya and Luhanga (1985) report that in Tanzania the collection of wood for fuel accounts for about 400 person-days per family per year.[8] Shanahan (1986) writes that those that are affected the most by this scarcity are the poor and landless families, and families headed by women in that they have to walk long distances in search of cooking fuel. The Independent Commission on International Humanitarian Issues reports that women make up 95% of the work-force in the agricultural sector and for this reason a reduction of female productive activities affects development as a whole.[10] The Commission adds that the time and effort spent by women in search of wood undermines their health and the economic well-being of the family.

The Commission also reports that woodfuel scarcity has adversely affected the nutritional patterns in the developing countries.[11] This report explains that more effort goes into producing less food and that many families have only one cooked meal a day. It adds that traditional staples which require more fuel to cook have been replaced by fast cooking but less nutritious foods, leading to malnutrition and increased vulnerability of the people to diseases and reduction in their productive capacity.

Barnard (1985) explains that in response to woodfuel scarcity people are turning to crop residues and livestock dung cakes for energy.[12] He argues that animal dung provides fertilizer and that when it is burned as fuel the soil is deprived of additional nutrients. He adds that while some crop residues are incorporated into the soil during cultivation while others are fed to livestock a substantial quantity remains which can be used as fuel. He also points out that there is not sufficient data to show to what degree, if any, the use of crop residues can deplete soil fertility. However, the use of crop residues is a sign of woodfuel scarcity.

This problem is also evidenced in the commercialization of woodfuel and the increasing attention it is getting from men, as noted by Foley.[13]

Rural Domestic Energy Constraints in Kenya

Studies carried out by O'Keefe and Raskin (1985) in Kenya show that three-quarters of Kenya's primary energy needs are met by fuelwood and agricultural residues.[15] They explain that 85% of the total population is rural, and that 72% of fuelwood is consumed in the rural household sector, and that they also consume 37% of the charcoal and agricultural wastes, (which constitutes 3% of the total national energy consumption). They add that of the total energy used in the domestic sector in rural areas cooking and space heating account for 98% and lighting accounts for the 2%. They conclude that the wood thus consumed is obtained from agricultural land rather than from forests.

The Kenya Renewable Energy Development Project has revealed that by 1980 "only one tree was planted for every two cut down" and that researchers expect that unless afforestation and efficient woodburning technologies are seriously pursued by the year 2000, then only one tree would be planted for every three or four taken.[17] The serious woodfuel deficit that is developing is illustrated in the following wood supply and demand projections for the period 1980 to 2000.

Table 1-2: National Wood Supply/Demand Balance (Million Tons)

	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: Proceedings of Agroforestry Workshop for Highland - Potential Areas in Kenya 1985.[18]

Hosier (1985) argues that rural communities in Kenya are in transition from a traditional and subsistence level of production to a more market oriented system.[16] He concludes that for this reason energy consumption varies between households with access to wages and those which continue to live off the land. This conclusion is not entirely correct since small-scale farmers in the high potential agricultural areas derive incomes from cash crops, such as, tea, coffee, horticulture and livestock. The difference in energy consumption depends on the income.

Studies carried out by Hosier (1981) show how the household fuel consumption varies according to different ecological zones.[19]

Table 1-3: Average Annual Fuel Consumption by Kenya Households According to Ecological Zones in 1981.

Fuel	National Average	High Potential Zone	Medium Potential Zone	Semi-Arid Zone
Fuelwood	4753.64Kg	4636.37Kg	4270.04Kg	8473.89Kg
Charcoal	663.93Kg	786.10Kg	379.85Kg	570.[illegible]Kg
Paraffin	51.99L	56.18L	44.26L	34.[illegible]

Source: Hosier (1981)[20]

Table 1-3 shows the high degree to which Kenyan households depend on fuelwood. It is both a commercial and non-commercial fuel. However, paraffin and charcoal are commercial fuels. The consumption of paraffin and charcoal is highest in the high potential zone.

Hosier also shows that the cost of fuels varies from one zone to the next.

Table 1-4: Measures of Fuel Cost, Distance and Income in 1981

Measure	Total Survey	High Potential Zone	Medium Potential Zone	Semi-Arid Zone
Average Paraffin Price	Sh.3.20/L	Sh. 2.90/L	Sh. 3.40/L	Sh. 4.74/L
Average Charcoal Price	Sh.20.50/[illegible]	Sh.21.40/ Bag	Sh.18.60/ Sack	Sh.15.00/ Sack
Paraffin Distance Average	8.5Km	8.7Km	4.3Km	40.9Km
Paraffin Distance Mode	3.0Km	1.0Km	4.0Km	6.0Km
Annual Household Income	Sh.6219	Sh.7115	Sh.4794	Sh.2700

Source: Hosier (1981)

From Table 1-4 it can be seen that the cost of paraffin increases as one moves from the high potential area towards the semi-arid zone. The reason given by Hosier is that more suppliers are located in the high potential zone, where the population density is high. The cost of transportation increases the cost of paraffin in the other zones. He adds that middlemen along the way, and the fact that price control is not effective far from the suppliers, also contribute to the rise in price.

The commercialization of rural domestic energy is further illustrated by Mildeberger (1986) in her study of Murang'a District.[21] She explains that the district has a high population density and that it lies in the high potential zone. Table 1-5 shows the cost of the fuels.

Table 1-5: Average Fuel Consumption Costs by Households Using Commercial Fuels

Fuel	Cost: KSh.	Percentage of Total
Fuelwood	351.68	56.1
Charcoal	198.48	31.65
Paraffin	60.33	9.62
Gas (LPG)	15.61	2.49
Sawdust	0.83	0.13
Total	626.94	

Source: Mildeberger (1986)[22]

She also notes that there were some sub-locations where paraffin was not used because of acute shortages. This is a serious problem for, as the study shows, paraffin is the chief source of lighting in the rural areas.

There are regional imbalances in the availability of woodfuel in the country. The densely populated, high agricultural potential areas, such as Central, Nyanza and Western Provinces are deficient in woodfuel and import it from other provinces.[23]

The substitution of woodfuel with the popular fossils fuels for domestic use is not economically feasible. For example, calculations revealed that if paraffin were to replace charcoal in 1983, it would have created an additional cost to the economy of Kshs.31 million in foreign exchange.[24] According to this report this amount was equivalent to the annual cost, in 1983, of education in the country, and yet paraffin is considered the least expensive fossil fuel substitute for woodfuel.

Energy Constraints in the Study Area

The study area, Nyathuna B Sub-Location, is situated in Kiambu District. This is one of the three most densely populated districts in Kenya.[25] The other two are Kakamega and Kisii. The average population density in Kiambu is 280 persons per square kilometre, as given in the 1979 population census report. The population density in Nyathuna B Sub-location is even higher, being 1012 persons per square kilometre.

Wanjama (1985) reports that resource depletion in the form of woodfuel scarcity is quite severe in the study area.[26] She argues that this scarcity has forced households to turn to agricultural residues and sawdust as a source of domestic energy. She adds that woodfuel (fuelwood and charcoal) is imported from other areas and sold at high prices.

This study, therefore, intends to examine both the existing energy constraints to development and the likely substitutes of energy types suitable in the area of Nyathuna B Sub-location. It is hoped that the study could provide a methodology that can be used in similar areas and thus help to alleviate problems emanating from woodfuel scarcity.

Objectives of the Study

There is a serious need to find effective methods of woodfuel production, and alterative fuels to woodfuel. In order to address this, the study has the following objectives:

1. Establish the causes of the domestic energy problems in the study area, that is, examine the energy constraints.

2. Establish what energy choices can be adopted. These include not only alternative energy sources to woodfuel but also better methods of its production.

3. Determine what energy conservation measures can be employed in order to save the limited forms of domestic energy available in the area.

The Need for the Study

As has been noted above the woodfuel problem is national in extent. Regional disparities are especially evident in the high potential agricultural areas where the population density is also high. The human difficulties experienced from the scarcity of rural domestic energy, and the environmental degradation which has followed deforestation, have affected adversely the rate of national development. Agriculture being the back-bone of the economy is a vital sector in national development. Every effort should be made to ensure that factors, such as deforestation and conflicting land uses, do not reduce its productivity. It is, therefore, important to find solutions to the rural domestic energy problems.

Nyathuna B Sub-Location was selected as a representative area or region experiencing a serious rural domestic energy deficit. It lies in the high agricultural potential zone. For reasons explained in Chapter Three the area has a very high population density. It forms a practical case study whose broad findings will be applicable to other areas with similar ecological and socio-economic characteristics.

Study Assumptions

It is assumed that public participation is an asset in the preparation and implementation of plans, and that it will aid in the efforts to alleviate rural domestic energy problems in the area. In other words, it is assumed that the community is aware that there is a scarcity of energy and sees this as a problem that requires to be solved.

It is also assumed that the community is receptive to new ideas, such as the introduction of new fuelwood production methods, alternative energy technologies and energy conservation methods.

Scope of the Study

The study has focused on these issues that affect the domestic sector in rural areas. It has examined the various energy constraints that affect adversely the rural households, and what effect this has on rural development. Investigation has also been carried out on the possible energy choices that can be made available to such a community, and also what steps can be taken to implement such a plan.

Spatially the study has been limited to a high agricultural potential area with a high population density.

The study has also examined, to a certain degree, the Third World and national domestic energy problems in rural areas.This has included an examination of development and policy issues appertaining to such problems.

The degree to which energy conservation measures can be applied to help alleviate these problems has also been addressed.

Research Methodology

Haring and Lounsbury (1983) have defined scientific research as "the gathering and processing of data on which scientific truths are based."[27] This process, they explain, follows four stages, which are data collection, data evaluation, data analysis, and finally prediction or decision making based on the analysis. These steps have been used in this study.

Data Collection

Primary sources of data usually provide the most accurate information in that the data is close to its original form and free from alterations or modifications. For this reason it tends to be least affected by external influences or bias.[28] In this study primary sources of data included:

Household questionnaires;

Physical investigation of the sources of energy

Participant observation

Household questionnaires were administered to 101 households. This represented 11% of the projected number of households as of 1979. Based on the census reports the annual growth in the population is 4.08%. Sampling was carried out by a stratified random method in which every fourth household was interviewed.

The data sought from the questionnaire was household size and education, land uses, energy issues (cost, consumption and problems), socio-economic activities, and in general what the household felt were its personal problems as opposed to those of the community and how they could be solved.

Energy availability was determined by a physical investigation of the various sources of energy in the sub-location. The survey included Wangige Market. Wangige is located in Kibichiku Sub-location in the same location (Kabete), and many of the people in the study area obtain their energy supplies from Wangige. The data collected included the cost of coffee-husks, charcoal, fuelwood and paraffin. They were also weighed so that the quantity consumed could be more accurately calculated. This was with the exception of paraffin which was measured in terms of volume. One of the major weaknesses in planning for rural domestic energy is that consumption in terms of quantities is usually unknown.[29]

Biogas and fuelwood are two of the rural types of energy that can be produced in the study area. An investigation was carried out to establish whether or not, (and to what extent), these forms of energy technologies were in use or available in the area.

Data on the possible cost of the installation of a household - size biogas unit was obtained from Nyathuna market and at Wangige. The cost of construction materials and labour was obtained by administering a questionnaire to masons, metal worker and owners of construction material outlets. The construction techniques were also explained to them, in order to enable them to give accurate data. This data was necessary in determining whether biogas is economically viable or not.

Data was also obtained from the Kenya Industrial Estates (KIE). This company has experience in the manufacture and marketing of biogas lamps, stoves, boilers and other appliances.

Data was also obtained on agroforestry technology from the Jamhuri Agroforestry/Energy Centre in Nairobi. This is the centre that serves Kiambu District. The centre provided a list of trees that are suitable for the study area. Production methods were also investigated, that is planting and management of trees at the centre,and useful data for agroforestry systems on small-scale farms.

A brief survey was also carried out to determine what experiences biogas users have with this technology. This was necessary because while the GTZ Special Energy Programme has reported success[30] King(1980) reports that biogas technology has had widespread problems.[31] Two institutes of science and technology, which promote the use of biogas were visited. These were the Kiambu Institute of Science and Technology and Rift Valley Institute of Science of Technology. Information on the construction of digesters, and the production and utilization of gas was obtained. Problems experienced were also noted.

Two different types of groups of biogas farmers were visited and interviewed. One type had received free biogas units and appliances while the other had paid for the whole system. This was done in Nakuru, Nyahururu, Meru, Kiambu and Nairobi districts. While farm holdings, agricultural activities and the level of income of these farmers varied from that of the farmers in the study area useful data was obtained on technical aspects, such as gas production during the warm or cold seasons and maintenance problems.

Another source of primary data was the direct observation of community characteristics in the study area. Informal discussions with people in general revealed their attitudes towards energy, and various community issues.

Land use practices, livestock management, and fuel collection methods were also noted.

Information on the study area was also collected from secondary sources of data. Interviews were conducted with officers from non-governmental organisations and various government ministries at the local, district and national level. Data was obtained on energy projects in the district. It was expected that the success or failure of these projects would be valuable to the study.

Useful information was also collected from libraries, such as at the University of Nairobi, United Nations Environment Programme, Habitat, Kenya Institute of Administration and various ministries.

Relevant informaiton from the media was also noted.

Data Evaluation

The data that was collected was organised and compiled. Sets of data were compared and evaluated so as to determine their relevance to this study.

Data Analysis

Frequency distribution of various obsevations in different categories was determined. Graphical displays, such as hystograms, were made where necessary. Central tendency was measured by considering the arithmetic mean, and mode of the relevant data.

Study Limitations

Many of the senior government officers in the relevant ministries were engaged in the registration of voters exercise, and as a result it required much effort to contact them.

Difficulties in obtaining household income were encountered. A preliminary survey of the study area before the formulation of the household questionnaire revealed that people did not want to disclose this information. Many of the respondents were women and said that all matters to do with the income were handled by the male head of the household. The Central Bureau of Statistics said that it also encountered similar problems in determining household incomes. The Bureau had no income data for the study area. It, however, had data based on different sectors which gave district averages. The district includes large scale farmers, such as coffee, tea, pyrethrum and dairy farmers and such data was not reliable.

Information was however obtained indirectly through description of employment and occupation of the respondents and heads of households.

Organisation of the Study

Chapter one introduces the study problem, that is, the energy constraints. Statement of the problem is given, showing its importance in the developing countries as a whole and in Kenya, and then focusing on the study area. The purpose or the objectives of the study are given in this chapter. The scope and delimitation of the study are also described. The research methodology is also described.

Chapter two gives an indepth examination of the theoretical aspects of the study problem. This is done through a critical investigation of the literature.

Chapter three deals with a description of the study area. A brief historical background of the development of the area is presented. This is then followed by a description of the physical and socio-economic characteristics.

Chapter four is devoted to the research findings. These cover the problems that have led to energy constraints, the energy choices that are already available and the alternatives that are possible, as well as energy conservation methods in the area. The findings include what the people feel should be the solutions to their energy and community problems.

Chapter five deals with a discussion of the findings and the choices available to the people. It also covers rural development and policy issues. This is followed by the planning strategies.

Chapter six gives the study conclusions and recommendations. Following this is the bibliography and appendices.

References

1. Cipola, C.M., The Economic History of World Population, 1962, Pp. 35-36.

2. Habitat, Energy Requirements and Utilization on Rural and Urban Low-Income Settlements, 1984, P.9.

3. Goodman, G.T., Ambio Vo. XIV, No. 4-5, 1985, P. 188.

4.(a) Oelert, G., et al, Economic Issues of Renewable Energy Systems, 1987, P.15.

(b) Ibid.

5. Bhagavan, M.R., Ambio Vol. XIV, No. 4-5, P. 219.

6. Mwandosya, M.J., and M.L.P. Lunga, Ambio, Vol. XIV, No. 4-5, 1985, P.239.

7. Habitat, 1984, op. cit., P. 12.

8. Ibid.

9. Shanahan, Y., The Courier, No. 95, 1986, P. 71

10. The Independent Commission on International Humanitarian Issue, The Encroaching Desert, 1986, P. 34.

11. Ibid.

12. Barnard, G.W., Ambio, Vol. XIV, No. 4-5, 1985, P. 263.

13. Foley, G., The Courier, No. 95, 1986, P. 68.

14. Ibid.

15. O'Keefe, P., and P. Raskin, Ambio, Vo. XIV, No. 4-5, 1985, P.220.

16. Hosier, R., Ambio, Vol. XIV, No. 4-5, 1985, P.225.

17. Energy Development International, Improved Cookstoves in Kenya, 1986, P.5.

18. KENGO, Proceedings of Agroforestry Workshop for High-Potential Area in Kenya, 1983, P. VIII.

19. Hosier, R.H., Something to Buy Paraffin With, 1981, Pp. 82 and 86.

20. Ibid, P. 88.

21. Mildeberger, E., Women and Household Energy in Murang'a District, 1986, P.45.

22. Ibid.

23. KENGO, 1983, op. cit., P.19.

24. Ibid.

25. Republic of Kenya, Population Census Report: 1979.

26. Wanjama, L., Planning for Rural Energy, 1985, P.30.

27. Haring, L.L., and J. F. Lounsbury, Introduction to Scientific Geographic Research, 1983, P.36.

28. Ibid.

29. NAS, Proceedings: International Workshop on Energy Survey Methodologies, 1980, P.36.

30. GTZ, Special Energy Programme, Biogas Workshop, 1987, P.1.

31. Misiko, P.A.M., et al, Editors, Alternative Rural Energy Source, 1978, Pp. 34-40.

CHAPTER 2

THEORETICAL CONSIDERATIONS OF THE CAUSES OF RESOURCE DEPLETION

There are many theories that attempt to explain the causes of resource depletion, which is evidenced by the scarcity of woodfuel in developing countries. An examination of the literature reveals that resource depletion is the consequence of large scale environmental degradation due principally to human activities, especially in the developing countries. Cook(1976) observes that man is part of a dynamic system, the ecosystem, which includes the physical and chemical, living and inert components of his environment.[1] He adds that even though increased control over the sources of energy has brought great benefit to man, it has also entailed substantial costs, such as environmental degradation, damage to health due to pollution, and economic and social cost due to resource depletion.

Oelert et al (1987), argue that deforestation is currently the most important environmental problem in developing countries.[2] Trees are cut to provide fuel, create land for cultivation and human settlement, as well as for timber and building poles.[3]

The arguments attempting to explain the causes of resource depletion can be grouped into four categories:-

1. Mismanagement of resources;

2. Rapid and uncontrolled population growth;

3. Political economy;

4. Adverse changes in the climate.

Mismanagement of Resources

The problems arising from excessive exploitation of wood have existed since early times. Clark (1975) reveals that three thousand years ago in China forests were nearly eliminated because of the clearance of land for agriculture, and for the provision of energy.[4] He adds that the landscape was so devastated that annual floods and summer droughts became common.

Timberlake (1985) argues that bad policies and lack of effective management programmes has led to the breakdown in the relationship between people and the environmental support systems.[5] He points out that in the 1890s to 1910s, families in the United States starved to death in drought on the Great Plains, but today rural people in industrialized countries survive such natural disasters because of soil and water conservation programmes, crop insurance, rural credit, agricultural education and advice, forestry services, and fish and wildlife services. Lack of such good policies leads to greater resource depletion.

Timberlake (1987) further argues that environmental degradation in the developing countries has emanated from the economic control of the Third World by the industrialized countries.[6] He explains that one-quarter of world population which lives in the developed countries consumes three-quarters of the world's goods. He adds that the developed countries (the North) produce most of the goods and services but that the raw materials are obtained from the developing countries (the South).

The chief economic activity in the developing countries is agricultural in nature, and from this theory of the North's dominion over the South it would follow that the South would divert the best agricultural land to the production of cash crops for export to the North. Timberlake (1985) supports this argument by pointing out that in 1983-1984 five Sahelian countries harvested large quantities of cotton fibre, from their small farmers, and exported it to the industrialized countries.[7] During this same period, he explains, the same countries imported record quantities of cereals. He then adds that the fact that cotton can be grown and not grain is because of government and aid agency policies rather than with poor rainfall.

The Independent Commission on International Humanitarian Issues supports Timberlake's argument.[8] The Commission argues that because of an increasing need for foreign currency developing countries have devoted more land to cash crops. It adds that this has led to the socio-economic causes of desertification, and that these are:-

- overcultivation
- overgrazing
- woodland clearance
- mismanagement of water resources.

Such human activities lead to desertification of which the United Nations Conference on Desertification (UNCOD 1977) defines as "the diminution, or destruction of the biological potential of the land, which leads ultimately to desert-like conditions and is an aspect of the widespread deterioration of ecosystems under the combined pressure of adverse and fluctuating climate and excessive exploitation".[9]

Chambers (1985) argues that the present-day environmental degradation in the Third World had its genesis during the colonial era, and that it was basically a mismanagement of a fragile ecosystem due to the ignorance of the agricultural experts coming from the developed countries.[10] He explains that in Africa traditional agricultural practices included shifting agriculture, forest fallow techniques and mixed cropping but these colonial experts viewed this as "backward, feckless and irresponsible".[11] He adds that the African people were forced to abandon this practice and to adopt crop homogenization or mono-culture, (patterned after the agricultural practices in the temperate countries), and to eliminate fallow systems. The experts had failed to understand that the traditional farming practices were intended to preserve the environment.

Kassas (1985) explains that the fertility of the tropical moist forests is not really in the soil but rather in the vegetation itself, and that when the vegetation decomposes, (and this is quite rapid in a tropical climate), nutrients are released into the soil.[12] He further explains that this is not the case in a temperate forest system where a greater proportion of the nutrients are stored in the ground. He concludes that then in temperate climates mono-culture could be practised without interruption and without any need of a fallow period, because the soil is fertile, but in tropical countries where the trees and other vegetation hold the nutrients, clearing of the land leaves only a thin layer of nutrients which is quickly depleted or eroded during farming.

White et al (1986) have a similar view of environmental degradation.[13] They argue that "forest ecosystems display a remarkable resilience in the face of human intervention as long as the degree of exploitation is limited and does not exceed the threshold beyond which recovery is impossible".[14] These authors note that mixed cultivation, which provides specified diversity, and shifting cultivation enables the tropical environment to self-regulate and regenerate itself. From this argument it can be concluded that overcultivation and excessive deforestation leads to reduced crop and tree production.

These problems of deforestation and desertification have rendered the developing countries poorer, thus reducing their purchasing power of surplus products and services from the North.[15] Timberlake (1987) argues that the policy by the North to establish agencies to aid the South in development, and thus reduce the poverty while increasing the purchasing power, has been ineffective.[16] He explains that one of the objectives of this policy has been to enable the South to have a more disposable income in order to meet the basic needs, such as domestic energy, and the necessary infrastructure. He notes that unfortunately the strategies adopted tend to negate any possibility of success in the realization of these objectives. He shows, as an example, that the nation-to-nation aid is frequently tied to the requirement that the aid recipient country must purchase products and services from the donor country regardless of whether or not they are needed. He concludes that these policies tend to block development in the South.

The Independent Commission on International Humanitarian Issues (1986) explains how such policies have led to a greater degree of environmental mis-management and therefore accelerated resource depletion. According to the Commission the balance of payments and the foreign exchange situation in the developing countries has deteriorated because of international trade and commodity pricing structures. It adds that as a result prices given to developing countries for raw materials are at their lowest level in over thirty years, while at the same time prices of many of the imports needed by the developing countries have risen. The Commission then notes that since the chief export products from the poor countries are agricultural, the tendency has been to increase even faster the area under cash crops. The result is that fallow time and crop rotation systems have been wiped out and more forested land has been cleared. The conclusion that can be drawn from this argument is that in trying to raise foreign exchange and increase disposable income, the process of desertification has been exacerbated and the consequences are seen, for instance, in greater scarcity of woodfuel.

What is evident from the literature is that while much of the development aid is well-intentioned and humanitarian in nature, a lack of understanding of the social, cultural and religious factors of the recipient countries has tended to increase the problems. This is illustrated by Timberlake (1987), who sites an example of a project in Northern Kenya.[18] He explains that a missionary group on seeing the hardships experienced by the nomadic Rendille because of drought introduced a deep bore hole which would provide water on a permanent basis at Korr. Soon the area around Korr was reduced to desert as the pastoralists settled in the area and grazed within a radius of few miles around the bore hole. He argues that for generations the Rendille people have understood their environment and that they have traditionally depended on shallow wells, which would support life for short periods at a time. The people would then move and dig another shallow well leaving the former area to regenerate. He adds that the Government of Kenya, through the Integrated Project in Arid Lands (IPAL), is now providing shallow wells and encouraging the people at Korr to resume their traditional pastoralist activities.

Timberlake (1987) also argues that governments in the developing countries do not consider desertification as a high-priority item, and lack political will to mobilize action in an attempt to correct it.[19] He claims that it is not often to find a government project such as the IPAL project in which the most important variable to be considered was the people rather than the rainfall, water tables or the soil.

It appears from the foregoing that too much emphasis is placed on the poor or ineffective policies of the industrialized countries and their economic control of the developing countries as a reason for the mismanagement of the environment. After a few generations of colonial rule and the promotion of modern farming methods from the North, people in the South appear to have forgotten the farming techniques that traditionally helped to preserve the environment. For example, in his illustration of the project at Korr, Timberlake observed that the young wives who had settled in the town no longer remembered how to load household items onto a camel's back in preparation of moving to new sites.

Again, lack of research and demonstration capacity in developing countries has affected the degree to which mismanagement of the resources could be halted. It would appear that the effort to increase the disposable income if realised would provide the investment in technology that would be required in order to manage the resources efficiently.

The argument that governments in the developing countries do not consider desertification as a high priority item seems exaggareted, at least in reference to Kenya where several programmes have been initiated and are being implemented in an effort to correct the problem.[20] For example an entire ministry, the Ministry of Environment and Natural Resources, has as its main concern the management of the environment and resources. Again lack of financial resources is a major constraint.

Population Growth and Woodfuel Scarcity

Unprecedented population growth in the developing countries has been given as a cause of environmental degradation leading to resources depletion, such as woodfuel scarcity.[21] In 1984 the International Conference on Population in

Mexico City drew world attention to "a worsening situation of expanding population size, diminishing resources, intensifying underdevelopment and continuing environmental deterioration particularly in the developing countries."[22]

The President of Kenya, H.E. Daniel T. arap Moi (1986) supports this argument and writes that "Kenya's phenomenal rate of population growth in a land which is 75% arid or semi-arid gives no one comfort. This is so especially since agriculture remains the backbone of the economy. Moreover, aridisation, desertification, and the southward spread of the Sahelian conditions, with the devastating drought of 1983/84 have shocked us".[23]

As a result according to Milas (1984), the world is unable to provide basic human needs of food, fuel and shelter for large populations.[24] He sees the problem as one of lack of a balance between people, resources, development and the environment leading to resource wastage and depletion, emanating from underdevelopment and poverty. These resources are land, forest and water.

He further argues that while over the last two decades many developing countries have achieved significant economic growth, such economic gain has been rapidly consumed by the additional population. The result, he says, has been increased poverty, food deficits, insufficient investment resources for increasing land productivity and employment, and intensified pressure on land, water and forest resources.[25] He adds that because of the increased population pressure on the land there is no longer any land available to be left fallow so that it can regain fertility, and the ensuing overcultivation leads to soil infertility and exposes it to erosion.

Kassas(1985) also argues that chiefly due to population pressure and poor management of the 'forest-society relationship' the rate of deforestation is ten times the rate of planting.[26] Fuelwood is the main source of energy for some 2,000 million people in the Third World, he adds, and therefore, deforestation has diminished a valuable resource and increased human suffering.

Chambers (1985) supports this argument and adds that because of rising pressure of population, land is becoming more scarce through sub-division for inheritance.[27] He explains that population growth and uncontrolled exploitation of natural resources combine in a vicious circle: the more the people there are, the greater their destruction of fragile environment, and the poorer this leaves them and their descendants.[28]

Hardin (1968) in his article, "Tragedy of the Commons", argues that the reason why the population growth leads to resource depletion and environmental deterioration is that people being rational seek to maximize their personal gains over the common good.[29] He illustrates this by giving the analogy of a pasture open to all - the commons. He explains that each herdsman will try to keep as many cattle on the commons as possible, and that because of tribal wars, poaching and disease, the number of animals is kept below the carrying capacity of the land. As the population increases, each herdsman continues to increase his herd without limit in a world that is limited. As each follows his own best interest, in a society that believes in the freedom of the commons, overgrazing follows and produces erosion and wind dominance.

In general, Hardin's argument is that a commonly owned environment, such as air or water is misused because nobody owns it, in other words, it is a "commons".[30] Murdoch (1975) supports this argument especially when renewable resources are seen as the "commons" and he therefore argues that because the majority of people have no real sense of ownership of these resources, then they fail to treat them with care.[31]

While Hardin's "tragedy of the commons" argument may be valid to a certain point, that is, each individual pursues his own maximization of good, it does not really follow that this is what has led to resource depletion. It has already been noted that traditional farming methods were discouraged by agricultural experts, and to a great extent this knowledge has been lost. It has also been pointed out that in response to population growth land has been subdivided to uneconomical units leading to over-exploitation of the land. Reduced productivity of the land has been followed by underdevelopment and poverty. In such an environment of ignorance and hardship, the people appear to be trapped in a vicious circle, so that even if they wished to maximize the common good they do not appear to have the right means.

Political Economy

The commercialization of wood adds another dimension in the depletion of resources and environmental deterioration.

Trade in wood includes timber, poles and woodfuel. Timberlake (1985) argues that while this provides employment, the problem of resource depletion far outweighs this benefit.[32] Foley (1986) points out that the major impact is the commercialization of wood to meet urban demands for energy.[33]

He argues that the emergence of a commercial market is the recognition that wood has become scarce and, therefore, a valuable commodity. He adds that woodfuel trade does not bring lasting prosperity to the rural areas because the price paid by the urban dealers is usually too low. It is sufficient to encourage the rural people to cut free trees but it is rarely enough to encourage farmers to invest in woodfuel by converting some of their land to growing trees to meet the urban demand.

The question of political economy, that is the way resources are affected by the distribution of power, becomes important in encouraging deforestation. Foley's argument indicates that the production and distribution of woodfuel as a resource is influenced by the urban dwellers. In discussing the question of rural urban migration in Africa, Arrghi and Saul (1973), point out that the large number of urban workers consists of rural immigrants who are periodically engaged in wage employment.[34] They add that the growth of these workers' incomes is very slow. It can then be concluded from this that in order for the urban woodfuel dealers to stay in business they have to keep the costs low.

Foley (1986) further argues that the urban dealers are indifferent to the disapparance of resources.[35] He adds that when all the salable wood in an area has been depleted, they simply move to another area.

O'Keefe et al (1986) predict that Africa's urban population will double by the year 2000, and that it would be the low-income sector that would increase fastest and, therefore, increase the demand for woodfuel.[36]

They point out that in certain cities, such as Nairobi, charcoal is the popular domestic fuel, and that because the production of charcoal involves large losses of energy the process of deforestation is thereby accelerated. They explain that charcoal production is particularly destructive also because live trees are cut instead of using dead twigs and branches, which is what rural people usually collect to meet their own energy needs.

They also explain how the urban dealers maximize their own profits as the distance to the supplies increases. They show that in Kenya, for example, truck drivers buy charcoal when coming back from trips delivering goods to outlying areas. In this way the cost of transport is reduced and, therefore, a much wider area of collection is opened up. They claim that some of the charcoal comes into Nairobi from the Sudanese border - 600 kilometres to the North.

They argue further that the opening up of rural roads has the effect of making the urban wood-fuel market more accessible to remote areas, and therefore increases deforestation.

This argument is really a classic example of Hardin's "tragedy of the commons" concept mentioned above. The environment becomes a "commons" from which the individual farmer or urban dealer reaps immediate gains and the destruction of the environment is not immediately felt. Unfortunately, this type of resource depletion eventually brings human hardship seen, especially, in the scarcity of domestic energy in the rural sector.

Climate as a Cause of Drought and Environmental Deterioration

In trying to find causes of environmental degradation the preponderance of the literature revolves around the theories of mismanagement of resources, and excessive and uncontrolled population growth in the Third World. A smaller volume of literature argues that climate is a cause of drought and, therefore, of environmental deterioration and resource depletion.

Glantz and Katz (1987) argue that droughts are a recurring climatic phenomenon.[37] However, they point out that the time between consecutive droughts, as well as the duration and intensity of a drought are uncertain. Because of this uncertainity, they claim that planning for the impacts of future droughts is very difficult.

They argue further that climatic anomalies in different parts of the globe can be linked to drought episodes.[38] They site, for example, the hypothesis that many droughts may have been due to an atmospheric - oceanic phenomenon called El Niño, which they describe as "a warming of ocean surface water in the eastern equatorial Pacific off the coasts of Peru and Ecuador".[39]

Human activities have also been reported, by various authors, to cause inadvertent modifications in climate and this change has caused drought and deforestation. For example, air pollution in industrialized countries, produced by fossil fuel combustion, has caused acid precipitation which in turn has destroyed trees.[40] The air-borne pollutants travel beyond the countries where such pollution occurs. Again due to industrialization, the level of carbon dioxide in the air is claimed to have increased, creating a greenhouse effect which has increased the atmospheric temperature and variability in climate.[41] It is also argued that rainfall in tropical moist forests comes from loss of water by evapotranspiration and that deforestation reduces this source of rain.[42] Again overgrazing in marginal areas reduces the vegetation cover and, it is reported, that this increases the reflectivity of the earth's surface and decreases what is known as 'biogenic nuclei' which is important in the formation of precipitations and therefore reduces rainfall.[43]

Changes in the climate, whether natural or the result of human activity, lead to drought and human suffering in the developing countries. Such hardships are evidenced, for instance, in the scarcity of domestic energy.

Summary

From the arguments already presented the process of resource depletion whether due to mis-management because of poor policies, or whether due to overexploitation of the environment by a rapidly growing population, is basically the same. Excessive clearing of trees and other vegetation so as to provide land cultivation, human settlement, woodfuel, timber and poles, as well as overgrazing, deplete the land of nutrients and renders the land incapable of absorbing the rain.

This coupled with adverse changes in the climate leads to droughts and floods. The impact of rain on over-exploited soil causes massive erosion. For example, it has been observed, in the high potential zone of Kenya, that when forests exist the rate of soil loss is 0.2 to 0.3 tons per hectare per year, but when the forests are destroyed the rate of soil loss rises to 20-40 tons per hectare per year.[44]

The result of the excessive resource depletion in the developing countries has been human hardships. It is most evident in the domestic sector because of the depletion of the sources of woodfuel.

References

1. Cook, E., Man, Energy, Society, 1976, Pp. 1-20.

2. Oelert, G., et al, Economic Issues of Renewable Energy Systems, 1987, P.22.

3. Timberlake, L., Africa in Crisis, 1985, P.104.

4. Clark, W., Energy for Survival, 1975, P.17.

5. Timberlake, L., 1985, op. cit. P.10.

6. Timberlake, L., Only One Earth, 1987, P.13.

7. Timberlake, 1985, op. cit., P.19.

8. The Independent Commission on International Humanitarian Issues, The Encroaching Desert, 1986, P.24.

9. Ibid, P.21.

10. Chambers, R., Rural Development, 1985, Pp.85-86.

11. Ibid, P.41.

12. Kassas, M., Desertification Control Bulletin, No. 12, 1985, P.12.

13. White, I.D., et al, Environmental Systems, 1984, P.441.

14. Ibid.

15. Timberlake, L., 1987, op. cit., P.13.

16. Ibid, P.16.

17. The Independent Commission, 1986, op cit, P.59.

18. Timberlake, L., 1987, op. cit., P.69.

19. Ibid, P.65.

20. Moi, D.T., Kenya African Nationalism, 1986, Pp. 54-60.

21. Milas, S., Desertification Control Bulletin, No. 11, 1984, P.13.

22. Ibid, P.7.

23. Moi, D.T., 1986, op. cit., P.55.

24. Milas, S., 1984, op. cit., P.8.

25. Ibid.

26. Kassas, M., 1985, op. cit., P.12.

27. Chambers, 1985, op. cit., Pp. 38-39.

28. Ibid.

29. Hardin, G., Science, Vol. 162, 1968, Pp. 1243-1248.

30. Ibid.

31. Murdoch, W.W., Editor, Environment, 1975, P.473.

32. Timberlake, L., 1985, op. cit., P.103.

33. Foley, G., The Courier, No. 95, 1986, Pp.68-69

34. Arrighi, G., and J.S. Saul, Essays on the Political Economy of Africa, 1973, Pp. 13-22.

35. Foley, 1986, op. cit.

36. O'Keefe, P., et al, The Courier, No. 95, 1986, Pp. 74-75.

37. Glantz, M.H., and R.W. Katz, Desertification Control Bulletin, No. 14, 1987, P.24.

38. Ibid.

39. Ibid.

40. Kassas, M., 1985, op. cit., P.12.

41. Timberlake, L., 1985, op. cit, P.29.

42. White. I.D., et al, 1984, op. cit., P.450.

43. Glantz, M.H., and R.W. Katz, 1987, op. cit, P.26.

44. KENGO, Proceedings of Agroforestry Workshop for High-Potential Areas in Kenya, 1983.

CHAPTER 3

THE STUDY AREA

Historical Background

Nyathuna B sub-location is situated in the Kabete Location of Kikuyu Division in Kiambu District. Kiambu District is the southern-most district in the Central Province of the Republic of Kenya. Nyathuna B sub-location lies between 36° 39.76' east and 36° 41.64' east, and between latitude 1° 10.32' and 1° 12.03' south of the equator, and covers an area of 4 square kilometres. It is one of seven sub-locations of Kabete Location. It is about twenty kilometres from the central business area of the City of Nairobi. (See Figues 3-1 to 3-4).

Muriuki (1987) writes that the area was settled in the 1880s.[1] The initial process of land acquisition determined the system of land tenure that emerged. Land acquisition by the pioneers was on the basis of who arrived in a particular area first. When the settlers were agriculturalists they would claim the area of virgin forest which they had cleared. Land could also be acquired as a gift, as for instance between in-laws or friends.

Initially land belonged to individuals or a small group of relatives, but as the population

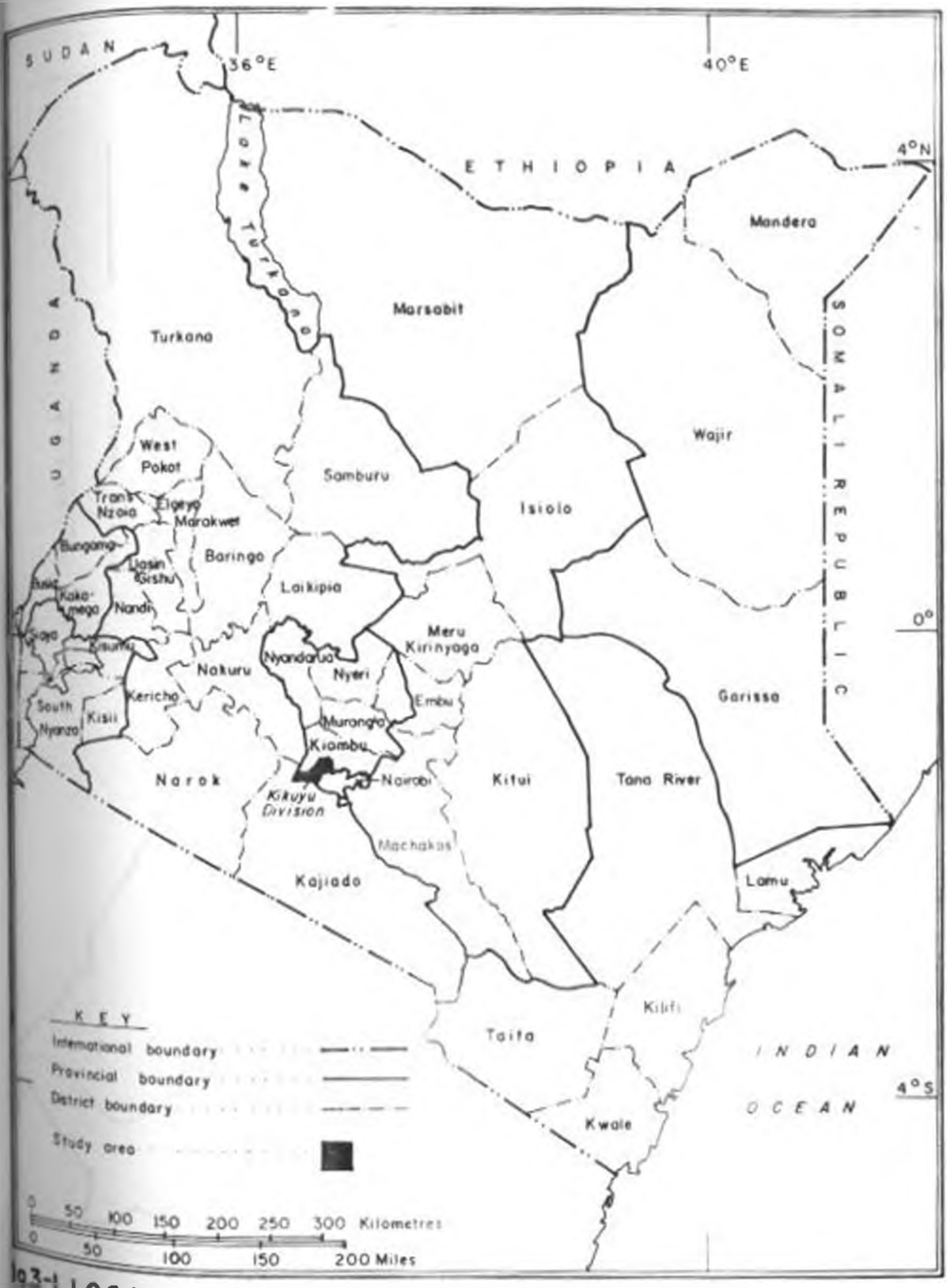


Fig 3-1 LOCATION OF THE STUDY AREA IN KENYA

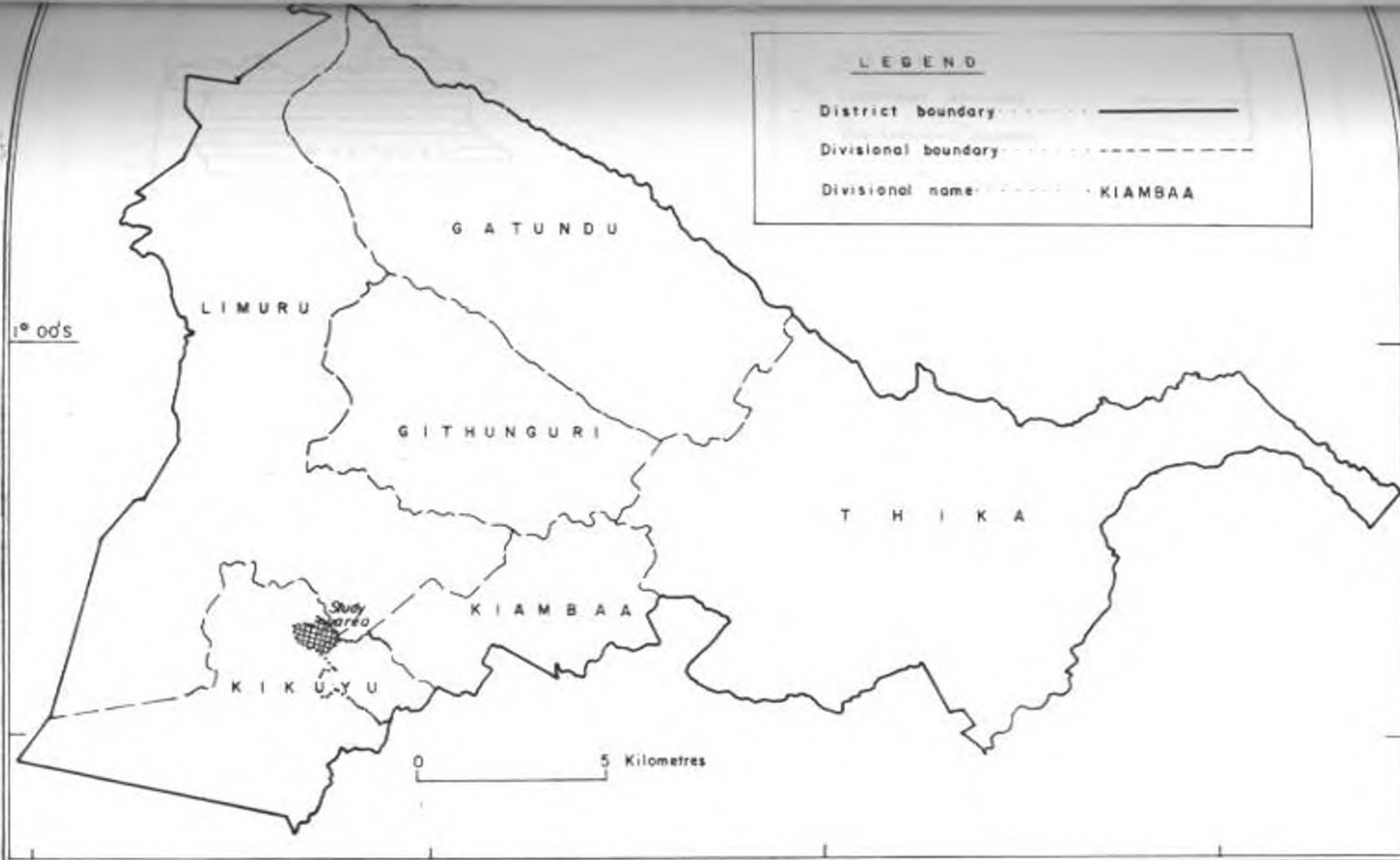


Fig. 3-2 LOCATION OF THE STUDY AREA IN KIAMBU DISTRICT

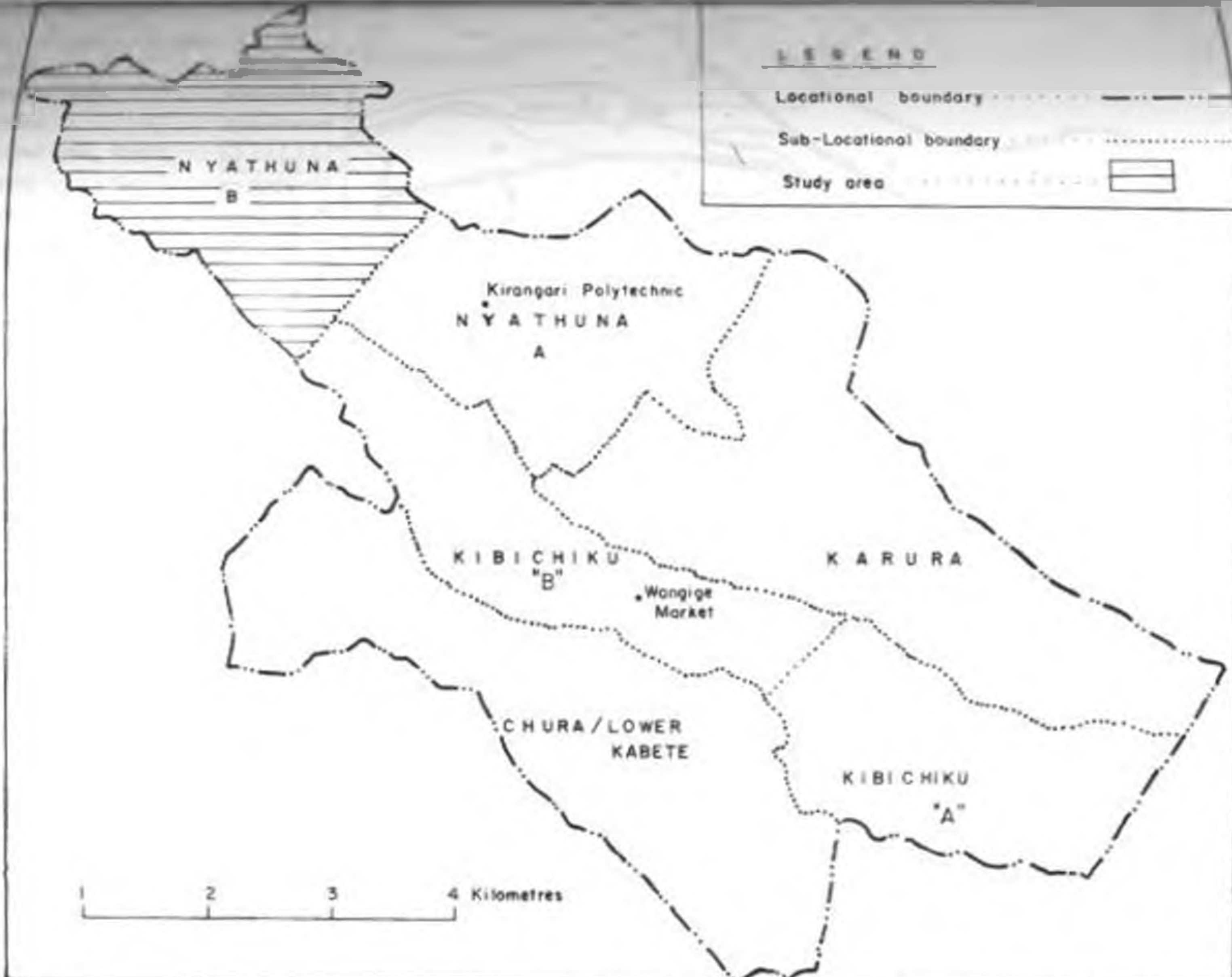


Fig.3-3 POSITION OF NYATHUNA B IN KABETE LOCATION

Fig. 3-4 TOPOGRAPHIC AND PHYSICAL FEATURES OF NYATHUNA B

increased the circle grew wider to include descendants of the original pioneers. The land belonged to the clan ("mbari") as opposed to being either communal or individual in ownership. Communal rights were limited to salt-licks, rights of way and the collection of fuelwood.

The system of inheritance that developed was that the pioneer would apportion his land to each of his wives. The sons had equal rights to all the land cultivated by their mother, and when they got married their wives would cultivate the same land. All the uncultivated land and woodland was jointly owned by all the sons. After a few generations the sub-division gave the land a patchwork appearance. This is the present appearance of land in the study area.

By 1910, when the country was already a British Colony, a group of landless people had grown. This group (the "ahoi") and white infiltration posed a threat to the traditional land tenure by the land-owning Kikuyu, leading them to consolidate their hold on land by demanding titles to individual ownership. Many of the landless became squatters on white-owned farms.

An understanding of the evolution of land tenure system and various community problems is important because it has influence on the present rural problems which include domestic energy scarcity. With individual land ownership, communal sources of fuelwood disappeared.

Physical Characteristics

Nyathuna B sub-location lies at the Southern end of the Aberdare ranges. The area is characterized by well drained hills and parallel rivers or streams, (Wanjama 1985).[2]

The average annual rainfall is nearly 1100mm. The rainfall is bimodal in character, with the long rains starting in mid-March and ending in mid-May and the short rains come between November and December.

The temperature ranges from a minimum annual temperature of 8°C to a mean maximum annual temperature of 23°C.

The soils are moderately fertile and well drained. They consist of a range of types, form deep dusky red to dark-redish-brown friable clays with acidic humic top soil.

Much of the indigenous vegetation has been cleared to make room for human settlement and agriculture.

Socio Economic Profile

The 1979 population census show Kikuyu Division to be the second most densely populated division of the district. In the study area, Nyathuna B sub-location this is due chiefly to high birth rate and low mortality rate. The District Development Plan indicates the population will increase steadily during the plan period.[3]

Table 3-1: Nyathuna B Sub-Location (1979) Population

Area	4 Sq. Km.
Population	4048
Number of Households	701
Density	1012 Persons/Km^2

Source: 1979 Population Census Report.[4]

The pattern of land uses is determined to a high degree by the road network and the rivers or streams. The area is hilly and the rural access roads run along the tops of the ridges or hills.

Homesteads are built next to the roads. Agricultural activity is concentrated behind the built structure towards the streams. The main agricultural activity is the production of vegetables. The proximity to the rivers or streams is important because vegetable production is through irrigation using pumps. Irrigation pumps are owned on individual basis.

Another source of income in the area is livestock, dairy cows and poultry. The market for poultry is Nairobi, while milk is sold to the Kenya Cooperative Creameries at Ngecha in Limuru Division.

As a result of the high population density and small landholdings many members of the households are under-employed. Unemployment is also high especially among the school leavers and other youth.

In general, the agricultural sector is the main source of employment and income for the majority of the people. However, data on employment and income levels is not available for this area. Non-farm employment is scarce. It includes employment in Nairobi and trading centres in the location such as at Nyathuna or Wangige markets.

References

1. Muriuki, G., _A History of the Kikuyu: 1500-1900_, 1987, Pp.72-76.

2. Wanjama, L.N., _Planning for Rural Energy_, 1985, Pp. 19-23.

3. Republic of Kenya, _Kiambu District Development Plan: 1984-1988_.

4. Republic of Kenya, _1979 Population Census_.

CHAPTER 4

RESEARCH FINDINGS

The research exercise has established to a certain degree the nature of the community characteristics. What the people consider to be their problems and how they think they can be solved has been examined in relation to the study problem.

Farming and livestock practices have also been examined in the light of the study problem. This has included the availability of water.

The causes of woodfuel scarcity and other domestic energy problems have been established. This has included a study of the existing fuels and their availability.

The study has also examined the possibility of increasing sources of energy and thereby give the households a wider choice of domestic fuels.

As a result of the existing energy problems conservation methods have been investigated in order to save whatever little energy exists in the area. This has included cooking habits and the types of stoves used.

Community Characteristics

Information obtained from the administration of household questionnaires showed that while heads of households are predominantly male (84.2%), the daytime population at the level of the farmstead is mostly wives, being 83.2%. Male heads at the farmstead made only 5% of the daytime adult population while adult daughters accounted for 9.9% and adult sons for only 2%.

Most of the adult population goes away during the day in search of income generating activities. This is because the small size of the landholding does not provide sufficient employment for all the members of the household. The study has revealed that the average landholding is 0.87 hectares (2.15 acres). The main occupation is farming on one's own land or elsewhere.

The following table shows the main occupations.

Table 4-1: The Chief Occupations

Occupation	Head of Household %	Respondent (excluding Housework) %
Farmer	69.0	86.0
Wage Employment	10.0	5.0
Business Person	6.0	2.0
Student	-	4.0
Unemployment	-	3.0
Not Indicated	15.0	-
Total	100.0	100.0

The average age of those who were interviewed was 39.9 years. The level of education attained is shown in the following table.

Table 4-2: Level of Education Attained

Level	Frequency %
Primary School	39.8
Secondary/High School	23.8
Reading & Writing (Adults)	8.0
No Education	28.4
Total	100.0

Those who were illiterate were mostly the elderly (above the age of 50 years).

The average size of the household is 6.3 persons. Most of them own the land on which they live, i.e. 95.0% own land while 5.0% are landless.

They were quite articulate about what they considered or felt to be their household problems. They identified thirteen different problems, in order of importance. They also indicated through what channel these problems could be solved. The following table gives the important individual household problems, that is the problems that were mentioned most frequently.

Table 4-3: Individual Household Problems

Problem	Frequency in %			
	Total:	Ranking		
		1	2	3
Lack of Land	80	43	32	5
Lack of Fuelwood	87	38	43	6
Lack of Communication	13	3	5	5
Lack of Water	19	9	4	6
Lack of Transportation	7	-	1	6
Health Centre Too Far	5	2	1	2

Since the majority of the respondents were women it is understandable that fuelwood should feature so strongly. Women have the responsibility of cooking.

Most of them (72%) said that government assistance is required. They felt that government should find them more land. With more land the fuel-wood problem would be reduced as they would grow their own trees. 6% of them said that they did not know what steps could be taken to solve these problems. Other methods that were mentioned included:

- Village meetings to discuss fuelwood substitutes such as biogas;
- Loan facilities from the government or co-operative societies;
- Family planning to reduce land sub-division due to population growth;
- Tree planting programmes;
- Harambee meetings to raise money for energy projects.

Asked what they felt to be the community's problems in general and what method should be followed to solve them, they gave similar answers to their individual problems.

Table 4-4: Community Problems in General

Problem	Frequency: % with ranking			
	Total	1	2	3
Lack of Land	81	50	24	7
Lack of Fuelwood	89	36	50	3
Poor Transportation	5	-	1	4
Poor Communication	14	3	4	7
Insufficient Supply of Water	20	8	9	3

Again the majority (88%) of those interviewed felt that these problems can be solved only through government assistance. A few (7%) seemed to have given up all hope of finding solutions and declared that they did not know how the community problems could be alleviated.

Apart from membership in Christian Churches, the people of Nyathuna B Sub-location did not appear to be very active in community activities. 77.2% of those interviewed belonged to nine different churches. The sub-location is only 4 km^2 in area and this seems to be a large number of denominations. It would appear that the people do not work collectively to any appreciable degree. Membership in other organizations was quite low. Some of the farmers (28.7%) who kept dairy cattle belonged to the Limuru Dairy Farmers Co-operative Society. Dairy farmers who sell milk to the Kenya Co-operative Creameries Limited usually belong to such a society. There were several small women's groups of which 24.6% of the women interviewed were members. Membership in other organizations was:

- Teachers Savings and Credit Society: 2%
- Kenya National Union of Teachers : 1%
- Young Mens Christian Association : 3%

This type of information is useful in planning. In a community where people tend to work individually, projects that require community effort may not be successful. Development plans should be such that individual households can participate on their own.

While 95.1% of the people own their own land, the average size being 0.87 hectares, 4.7% are landless and rent the land on which they live.

The following table shows the crops grown and the livestock that is kept.

Table 4-5: Livestock Reared and Crops Grown

Livestock	Frequency %	Crop	Frequency %
Cows	53.5	Maize	85.2
Grade Cows	14.9	Beans	74.3
Bulls	9.9	Horticulture	72.3
Grade Bulls	1.0	Potatoes	74.3
Pigs	2.0	Napier Grass	58.4
Poultry	49.5	Bananas	6.9
Goats	26.7	Nothing Grown	5.0
Sheep	17.8		
Rabbits	20.8		
None	8.9		

Fruit trees were not mentioned. Several visits to Wangige market revealed that the fruit being sold had been brought from other parts of the district. Bananas though grown in some farmsteads were not considered of commercial or of household importance. Maize, beans and potatoes are grown as subsistence crops, while vegetables are cash crops. Irrigation enables the farmers to grow the vegetables throughout the year.

Of those iterviewed 8.9% kept no livestock. Some kept only one type of livestock. The largest number (13.9%) kept cows alone. Out of the nine types of livestock, many households had certain combinations. There were 33 combinations in total. The largest combination was poultry and cows which was kept by 13.9% households. This information is important in planning for biogas as will be seen later.

Figure 4-1 Clearance of Trees to Create Land for Cash Crops.
(Vegetable Production Under Irrigation).

Among the various District Development strategies outlined in the development plan one is livestock development, to be achieved by increasing the population of the dairy cattle in the study area. Coupled to this is the increased production of fodder and the construction of more zero-grazing units.

Table 4-6 and 4-7 show the fodder and feeds being used as well as the grazing methods.

Table 4-6: Sources of Fodder and Feeds

Own Land	Frequency: %
Maize Stalks/Cobs	63.4
Weeds	12.9
Napier Grass	59.4
Vegetable Residues	17.8
Banana Stalks	6.9
Purchased	
Poultry Feeds	56.4

As a result of the small landholdings zero grazing is being practiced more often, but the units are not the ideal design promoted by the Ministry of Livestock Development.

Table 4-7: Grazing Methods

Type of Livestock	Zero Grazing %	Night Boma %	Tether %
Cows	81.5	13.0	5.6
Grade Cows	73.3	26.7	-
Bulls	62.5	37.5	
Grade Bulls	100.0		
Pigs	100.0		
Poultry	86.5	9.6	3.8
Goats	73.1	19.2	7.7
Sheep	72.7	18.2	9.1
Rabbits	100.0		

The District Plan had also proposed an intensification of horticultural crops in the study area by way of pumped water irrigation. This would increase on-farm employment and incomes.

Existing Domestic Energy Situation

In summary the following table shows the types of energy used and the proportion of households that use them.

Table 4-8: Summary of Types of Energy Used

Type	Frequency: %	% Purchased
Fuelwood	96.0	46.5
Charcoal	61.4	100
Coffee Husks	76.2	100
Paraffin	88.1	100
Electricity	11.9	100
Liquid Petroleum Gas (LPG)	1.0	100
Maize Stalks/Cobs	68.0	Nil

Fuelwood

Fuelwood was obtained from one or all of the following sources. Some had trees on their land (47.5%) so that they did not have to buy it, or if they purchased it the quantity required was reduced. A few (24.8%) collected or bought it from their neighbours. Those who purchased some or all of their fuelwood supply made up 46.5% of those interviewed. No household collected wood from communal land, because there is no such land in this sub-location. There was no wood to be collected from the roadside since the individual plots reached the access roads.

Figure 4-2: Women Carrying Green Fuelwood from Neighbours Land

The cost of wood varies depending on where it is bought and the quality required. A large quantity is sold by volume. There is a standard volume known locally as "ibuti". One "ibuti" is a stack of wood with a volume of 60 cubic feet ($1.7M^3$), in this area. Such a quantity costs between KShs. 300/- and 360/- and lasts for approximately two and a half months. Small quantities of wood tend to be more expensive. Two pieces which weigh about 3.5Kg are sold at between KSh.3/- and KShs.5/-. Calculations show that those who buy in pieces spend more money at the end of the month than those who purchase an "ibuti". One "ibuti" weighs approximately 1213Kg. This is based on Hosier's conversion figure in which he gives the weight of $1M^3$ air dried wood as 714Kg.[1] From this then the unit cost of wood is 25 cents to 30 cents per kilogramme. When bought in small pieces the unit price is 85 cents to Sh.1.45 per kilogramme of wood.

The chief source of commercial wood is at Wangige Market.

Figure 4-3: Fuelwood Outlet at Wangige Market.

Charcoal

The chief source of charcoal is Wangige Market. One bag of charcoal costs from KSh.65/- to KSh.80/-, not including the cost of transport. Wangige Market is 3 to 6 Km from the households at Nyathuna B Sub-Location. A debe of charcoal costs between KSh.16/- and KSh.18/-. A half debe and quarter-debe cost Ksh.8/- and KSh.4/- respectively at Wangige Market. Charcoal dust is not sold. Buying charcoal in small quantities tends to be more expensive than buying a whole bag. One to two bags are used per month. Approximately six debes of charcoal make one sack.in which case the cost would be Sh.96/- for the sack.

Figure 4-4: Charcoal Outlet at Wangige Market

Coffee Husks

As has been noted above 76.2% of the households use coffee-husks. This is really an indication of the scarcity of fuelwood in the area. Dealers buy coffee husks from the Kenya Planters Cooperative Union (KPCU in Nairobi). The retail cost of a sack of coffee-husks is KSh.60/- and lasts about two weeks, while a debe costs Kshs.5/- and lasts only a few days.

Paraffin

Paraffin is the most common fuel for lighting. 88.1% of those interviewed use it. Its cost varies according to where it is purchased. At the petrol station at Wangige Market the cost is constant at KSh. 3.79 per litre. The price from shops or from neighbours varies widely.

Figure 4-5: Women Buying Coffee Husks at Nyathuna

Table 4-9: Various Prices of Paraffin

Source	Container	Size in L	Cost: KSh.	Cost/L: KSh.
Duka (Shop)	Soda Bottle	290ml	2.50	8.62
Shop	Squash Bottle	800ml	5.00	6.25
Shop	5-L Container	5l	20.00	4.00
Petrol Station	Various	Per l	3.79	3.79

It can be seen that buying paraffin in small quantities from the local shops is quite expensive. Transport charges from the petrol station and a profit margin account for the high cost.

Electricity

Of those interviewed 11.9% use electricity.

Installation costs are quite high. The Kenya Power and Lighting Company Ltd. gave the following figures:

KShs.130,000 per Km transmission line
KShs. 60,000 transformer
KShs. 2500 to KShs.4000 per house for cable.

In addition the farmer has to pay for the wiring and electrical fittings within the house.

Monthly charges vary greatly as they depend on the consumption style of the individual household.

Commercial Gas (LPG)

Only one household was found that used gas. This constituted nearly 1% of those interviewed. Gas was not sold at Wangige Market. The gas outlets were either at Nairobi or Kikuyu Town.

Agricultural Residues

It was found that 68.3% of those interviewed use maize cobs and maize stalks as a fuelwood substitute. This is an indication of the scarcity of fuelwood. A conflict in use here appears since maize cobs and stalks are also used as animal fodder. There is, therefore, a need to find different substitutes to fuelwood.

Uses of Biomass Fuels

As already noted the biomass fuels used are fuelwood, charcoal, coffee-husks, and crop residue.

All of these fuels were used for cooking. A number of households (84.2%) heated water either for bathing or for washing dishes. A smaller number (21.8%) used the fuels for space heating.

Problems of Biomass Fuels

Apart from the problems of finding fuels and its cost, smoke was identified as a problem by 93.9% of the respondents. Those who mentioned specific problems associated with smoke identified the following problems:-

1) Health - eye problems, sneezing, coughing, headache, unpleasant smell;

2) Smell in clothes;

3) Destruction of cooking pots;

4) Destruction of corrugated iron sheets (used for roofing).

Summary of Energy Problems

The research findings have revealed the following energy problems.

1) High population density leading to small landholdings and the clearance of trees

to create land for cultivation and settlement.

2) Lack of woodfuel production because of an emphasis on monoculture and the production of cash crops (vegetables).

3) Ignorance of alternative energy production methods, and energy conservation techniques.

4) High cost of the different forms of energy found in the sub-location.

5) Pollution problems from the biomass fuels.

Research Findings on Alternative Sources of Energy

An investigation was carried out to find out the possible alternative sources of energy in the sub-location. This would increase the energy choices available to the people.

Agroforestry

Through the administration of the household questionnaire it was shown that only about 3% of the households had ever heard of agroforestry. The balance, 97%, claimed that they had never heard of it. This was rather suprising because the Ministry of Energy, which is leading in the promotion of agroforestry, and other organisations have frequently used the media (newspapers and the radio) to publicize it.

Those who claimed never to have heard of agroforestry were given a brief explanation, at the end of which they were asked if they had understood it. Only 13.9% answered positively. The other 86.1% answered in the negative. The problem did not appear so much to be in the explanation as it was that they did not accept that trees can be intercropped with food crops. For generations in this area trees have not been planted on the same piece of land as crops. It has come to be accepted that the presence of trees would decrease production of crops. However, 2% of the households interviewed practice agroforestry.

Biogas

Biogas can be used as a substitute for fuel-wood and paraffin. The slurry or sludge which is left after gas production improves the environment. However, for successful implementation, sufficient livestock dung and other organic matter, such as vegetable wastes are required.

The first step that was taken was to find out what the people knew about biogas and what they thought about it.

While 70.3% of those interviewed had heard about biogas, only 17.8% had seen it. A large number (98.0%) said that they would like to use it if someone would show them what was required. Biogas plants can be owned by an individual household or communally. When the question of ownership was posed 93.9% said they would like to own it on individual basis. It was noted earlier that the people of this community tend to carry out their activities as individual households rather than on group or community basis. They gave several reasons for their preference of individual units or plants; viz:- (why community plants were not accepted):

. there would be lack of unity and therefore mistrust;

. there would be gas shortages;

. others did not forsee any problems, but it was just their preference or choice.

The few (6.1%) who preferred to own biogas plants jointly with others were asked how they would manage the plant. They gave various answers; viz:-

. they would make a management agreement;

. they would agree to cooperate and follow or accept other members suggestions;

. they would try and get instructions on biogas together;

. they would provide livestock dung alternatively.

From these findings, it is clear that in planning for biogas in this community, designs for individual households should be considered. As already pointed out (Muriuki 1987) the development of the Kikuyu people tended towards individual ownership of land and therefore individual ownership or control of various spatial activities.

While the degree of ignorance of biogas appears to be quite high, it is not a new technology in Kiambu District. The present district plan proposes the implementation of 10-20 biogas demonstration projects within the plan period.[2] The Ministry of Livestock Development has a dairy project, funded by the Dutch Government, which promotes the use of zero-grazing units for small-scale farmers. This project promotes the use of biogas. A number of the farmers in the project have built biogas units. This project did not appear to be present in the study area. The Ministry of Energy has also assisted technically several farmers in Limuru Division to construct such units. It has put up demonstration units at Waruhiu Farmers Training Centre in Githunguri Division, and at Limuru Boys Centre (in collaboration with the Kenya Industrial Estates).

A community demonstration project was established at Nderu Village in Limuru Division in 1981 with assistance from the Ministry of Energy and technical assistance from the United Nations Centre for Human Settlements (Habitat). The project failed. The people of the community say that during the 1984 drought they lost all the livestock, and consequently there was no dung to feed the biogas digester. The area is marginal in character and the farmers take their livestock to graze far from the village.

Water

The common types of biogas units require that the organic material should be mixed with water in order to produce gas effectively. For this reason it was important to find out what the water situation is in the study area.

Investigations through the administration of the household questionnaire revealed the following:

Table 4-10: Availability of Water

Source	Frequency: %	Average Monthly Cost per Household: KSh.
Tap Water on Ones Plot	80.2	19.94
River or Spring	18.8	-
Pump	5.0	46.00
Communal Points	None	

From this data it is evident that the area is well served with water. Livestock officers recommend that a zero-grazing unit should be washed regularly, for instance once a day. That type of water, if not mixed with disinfectants and detergents, is quite suitable for biogas.

Organic Material Required for Biogas Production

Biogas production is commonly based on livestock dung. Calculations based on household domestic energy needs have been carried out in this country. The quantity of dung required has been established. In the study area cattle and poultry are reared for commercial reasons. The District

Development Plan proposes to increase the number of dairy cattle in the area. The production of biogas in the study area is, then, based on cattle and poultry dung. Table 4-1 shows the excepted quantity of dung from each type of livestock and the average quantity of gas that can be produced.

Table 4-11: Dung and Gas Production.

Livestock (One)	Quantity of Dung: Kg per day	Mixture of Dung/water: % of organic solids	Gas Generated L
Cattle	15	9	760
Poultry	0.12	9	9.6

Source: Wesenberg

Studies in Meru District show that 2500 litres ($2.5m^3$) of biogas will meet the energy requirements of a family of seven to ten persons, in cooling, heating water and cooking.[4] Working with data from Table 4-11, this quantity of gas can be produced by dung from any of the following:

1) Three heads of cattle (plus some vegetable waste);

2) Two heads of cattle and 102 poultry;

3) One head of cattle plus 181 poultry;

4) 260 poultry.

These calculations assume that the livestock is kept in a zero-grazing unit. Urine which also produces gas has not been considered because data is lacking. The final quantity of gas would therefore be higher. Poultry dung is usually mixed with sawdust, but this would not interfere with gas production. Sawdust also produces biogas but it takes a very long time to do so. Vegetable wastes and grass can also be added.

Data obtained from the administration of the household questionnaire revealed that 35.6% of the households fitted into one or more of the above four categories. What these households have to consider is whether or not biogas is economical when compared to what they already spend on existing forms of fuel.

Cost of Biogas Systems

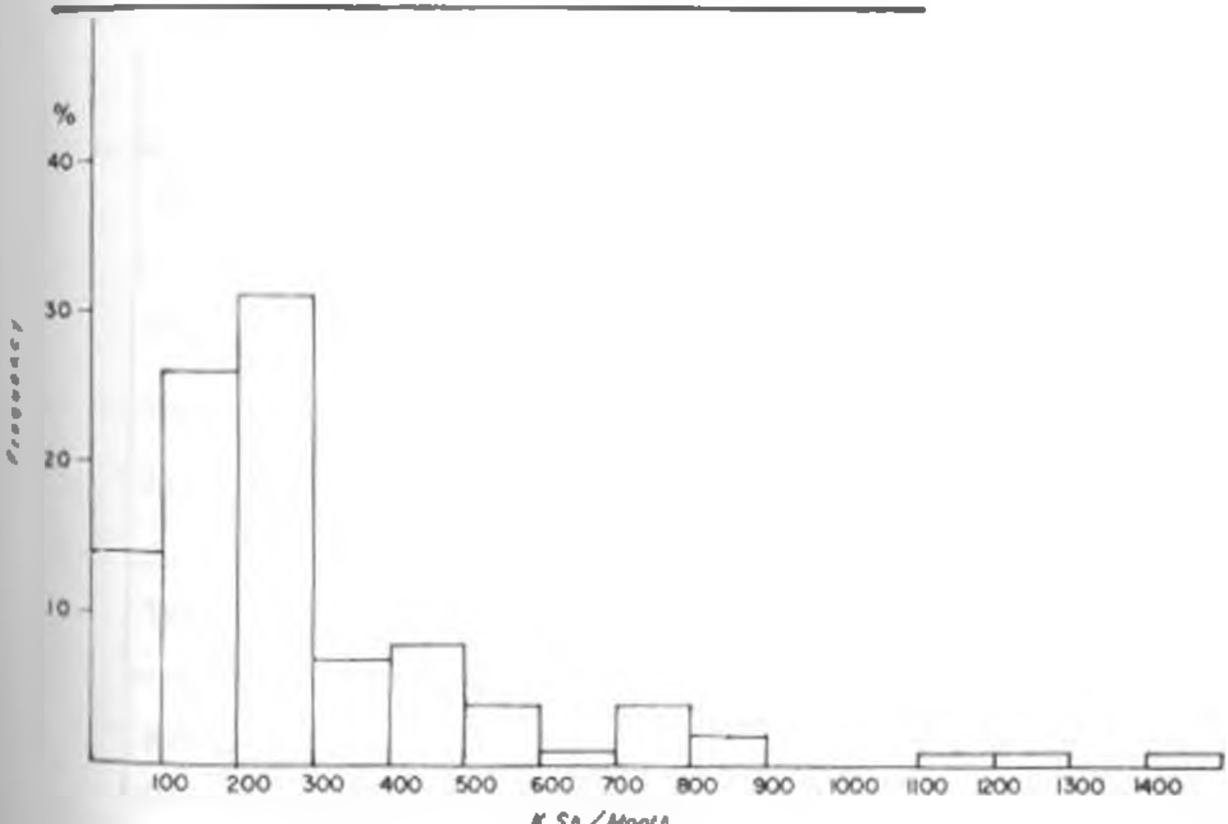
The cost of biogas system can be broken into three components. These are:

- the digester, including the slurry (mixture of dung and water) inlet and outlet and all the piping;
- the gasholder and its support;
- the appliances (cooker and lamp).

Different designs can be built. The standard size for a household of about ten persons is $10M^3$. The design or type that has been promoted in Meru costs KSh. 20,000/-. The Indian type costs a similar amount. The China design costs about KShs.28,000/-. The fourth type is a simple rectangular pit with an air-tight canvas or PVC gas holder, and costs about Kshs.10,435/-. The Meru, Indian and Chinese types required more skill to construct than the slurry pit type.[5]

Data on the cost of household consumption of domestic energy was obtained through the administration of the questionnaire. Figure 4-6 shows the cost of the energy per month. The mode or most frequently occuring value is KSh.250/- per month. The mean or average is the monthly expenditure of the sum of the cost of fuelwood, charcoal, coffee-husks, and paraffin consumed in one month by each household. (Appendix 4 gives more details). The range was from KSh.10/- per month to KSh.1408/- per month. In these calculations

Fig. 4-6 ENERGY CONSUMPTION PER MONTH



electricity was not included because it is a much more superior form of energy than biogas and it is not expected that a farmer would use biogas as a substitute for electricity. Except for one household, those using electricity were also using these other fuels, and were included in the analysis.

Table 4-12: Recovery of Biogas System Capital

Component (Slurry Pit Type)	Investment* KSh.	Lifetime in Years	Interest %	Annuity KSh.p.a.
Digester	2500	20	14	377
Gasholder	6500	15	14	1058
Appliances	1435	5	14	418
Total System	10435			1853
Running Costs p.a. (Operation, Maintenance, Repair)				350*
Total Annual Costs				2203
Total Monthly Costs				184

* Source: Wesenberg[6]

Annuity is calculated using the formula:-[7]

$$A = P\left(\frac{i}{\left[1-\left(\frac{1}{1+i}\right)^{t}\right]}\right)$$

where A = annuity
P = principal
i = interest p.a.
t = expected life of component

The household data shows that 63% of the households spend more than KSh.184/- per month on fuel. They would therefore make a net saving by investing in a biogas system. However it also depends on the quantity of cattle and/or poultry dung available. Some of the households who have a a sufficient quantity of organic material spend less than KSh.184/- per month. Only 27.7% of the households have the required number of livestock and spend above KSh.184/- per month on domestic fuel. 35.3% of the households which could benefit economically by turning to biogas cannot do so because of insufficient organic material.

The environmental benefits of biogas production have not been costed. These are the improvement of the slurry as an organic fertilizer, and the destruction of harmful micro-organisms and parasites. Farmers usually complain that poultry manure is difficult to use because of a high incidence of worms. Such worms are destroyed during anaerobic fermentation.

Comments from Biogas Users

Several farmers who use biogas were visited and their experiences with this technology were noted.

Twenty four households at the ADC Ngata Farm have been supplied with biogas free of charge through technical assistance from the Peoples Republic of China. The digesters are of the Chinese design and all the appliances are also Chinese.

The users are labourers at the farm. They did not know how much the system had cost the donor. Each digester serves three households. Except for one digester which had been abandoned from lack of maintenance the others were operating well. The main problem was that they did not know where to get maintenance parts or new appliances since they are not available in the country. For this reason a number of households were not using the gas. They made no effort to look for similar parts. They expected the government to supply them free of charge.

Farmers who had paid for the entire system in Nyahururu and Meru District said that the initial cost was very high especially the Meru design which costs about KSh.20,000/-. Those who depended on hired labour to operate and maintain the system complained of gas shortages because the workers were not really conversant with the technology. There were no operational or maintenance problems where the wife and older children were involved. All of these farmers had zero-grazing units.

The two institutes that were visited, Kiambu and Rift Valley Institutes of Science and Technology use biogas to a small extent in their kitchens. The construction of the units was part of the training of artisans and technicians and was financed by the Ministry of Energy together with the Chinese Government. These projects were quite recent and, therefore, more training has not been undertaken.

Farmers in Meru District also commented that the training of biogas artisans in the district had enabled more farmers to use biogas. The artisans were trained by the Special Energy Programme of the Ministry of Energy. Some of these artisans are now self-employed as biogas contractors.

Construction of a Biogas Unit

The construction of a biogas unit was discussed with various masons and metal workers at Wangige and Nyathuna. None of them knew anything about biogas. They were given building lists and drawings of a biogas digester which are normally supplied to builders by the Ministry of Energy. (See Appendix 2 and 3).

They found it difficult to conceptualize the technology. They also could not agree on what it would cost. For example, while discussing the Meru design, the metal workers estimated that the cost of the metal gas-holder would be from KShs.4,200/- to KShs.9,000/-. This was based on guesswork.

A description of the other designs common in Kenya was also not comprehended.

It follows, then, that in order for biogas technology to succeed in the study area masons and metal workers have to be trained. As was observed in Meru, this type of training requires the construction of a few units under qualified supervision.

Solar Energy

Solar energy can be used to supplement or substitute fuelwood. The chief constraint to its use is cost.

Solar electricity equipment (phovoltaics) is available from Nairobi. While it will meet all the domestic needs for energy, the cost tends to be prohibitive. The cost, (as supplied by companies in the Industrial Area of Nairobi) for solar cells, battery and six lights is KSh.16,650/-. The power produced is enough to include a radio or a television set. It is not sufficient for cooking, heating water or ironing. The price does not include wiring and switches. The household would have to invest in a bigger and more expensive solar system in order to get enough power for cooking, heating water and ironing.

Solar equipment for heating water is also available from the Industrial Area. It will heat enough bathing water for an average household. The price of a solar water heating unit is KShs.23,000/-, and this includes equipment, fittings and labour.

These two types of solar systems are the only ones available on a commercial basis in Kenya. None of them were found in the study area.

Wind Energy

Wind energy can be used in the domestic energy sector. Wind machines can generate electricity for individual households or for communities.

There were no wind machines in the area. The reason for this was given by the Ministry of Energy officials. In order to generate electricity using wind, very high wind velocities are required.

Wind machines can be purchased from the Industrial Area of Nairobi. However their development is still at the "research and demonstration" stage in this country.

Information obtained from the Ministry of Energy showed that it takes at least one year to collect reliable meteorological data before it can be determined if the wind regime is sufficient for electricity generation.

Energy Conservation

The small size of landholdings and conflicting land uses has resulted in a scarcity of fuelwood.

Fuelwood has to be imported from other areas and this has led to high costs. Fuelwood substitutes such as, coffee-husks and charcoal are also expensive. There is, therefore, a need to conserve the domestic fuel. This can be done in the kitchen by using energy efficient cooking methods.

A survey of the types of cookstoves (jikos) used revealed a high degree of ignorance of fuel conservation methods. The table below shows the types of cookstoves used and the frequency at which they occur.

Table 4-13: Types of Cookstoves Used

Type	Frequency: %
Three-stone Jiko	81.2
Homemade Fuelwood Saving	1.0
Purchased Fuelwood Saving	3.0
Ordinary Charcoal Jiko	61.4
Charcoal Saving Jiko	9.9
Coffee Husks Jiko	77.2
Paraffin Cooking Stove	9.9
Electric Cooker	5.0
Gas Cooker	1.0

As noted in the previous Chapter, much energy is wasted when using the three-stone jiko and the ordinary metal charcoal jiko. The coffee-husks jiko is also made of uninsulated metal and loses heat to the space. Unless space heating is specifically needed such energy loss should be controlled. As the above table shows, these three jikos are in common use in the study area.

Different households had different combinations of cookstoves. Nineteen different combinations were found. The important ones are shown in the table below.

Table 4-14: Common Combinations of Stoves

Combinations	Frequency: %
3-Stone, ordinary charcoal jiko coffee husks jiko	32.7
3-Stone, coffee husks jiko	18.8
Ordinary charcoal jiko, coffee husks jiko	5.0
3-Stone, ordinary charcoal jiko	7.9
Total	64.4

Information on cookstoves is important because it is an investment. Different fuels usually require different types of cookstoves.

Types of Meals Cooked

It is important to know what types of foods are cooked because this gives an indication of the length of cooking and, therefore, of the quantity of fuel needed. Certain foods require specific types of cooking pots and these in turn require particular designs of cookstoves. For example, a clay cooking pot was found to be used specifically for preparing a mixture of maize and beans ("githeri"). A jiko with a flat surface, such as an electric cooker, or one with a small surface area such a gas cooker takes too long to heat the clay pots. In order to get accurate information the households listed the meals that were prepared the previous day.

Table 4-15: Types of Meals Cooked Yesterday

Meal	Frequency: %		
	Breakfast	Lunch	Dinner
Tea	99.0	-	-
Porridge	4.0	-	-
Maize + Beans(Githeri)	-	59.4	26.7
Ugali and Stew	-	23.8	56.4
Potatoes and Vegetables	-	9.9	1.0
Chapati and Stew	-	-	7.9
Rice and Stew	-	5.0	8.9
Others	2.0	4.0	2.0
Nothing Cooked	-	2.0	1.0

According to the Ministry of Agriculture officials, the staple food in this area is maize and beans. It takes about two to three hours to cook. As a result of the scarcity and cost of fuels, the people have been turning to foodstuffs that require a shorter period to prepare. The proximity of the area to Nairobi has also contributed to the change in cooking methods. However, these foods (e.g. "ugali") are less nutritious.

13.9% of the households interviewed were using energy efficient jikos in addition to the other types.

The Ministry of Energy, through a project known as "Women and Energy", has been promoting improved fuelwood jikos in Kiambu District. Women are taught to build them. A ceramic liner is all they have to buy at a cost of KSh.25/-. Several of these liners were found at the locational Assistant Community Development Officer's office. The ACDO explained that not much work in the dissemination of this jiko has been done here. The data from the study indicated that only 3% of the households were using it.

At Nyathuna Market none of the shops or workshops sold any of the improved fuelwood or charcoal jikos.

The chief constraint seems to be a general ignorance or lack of awareness of the fuel saving methods.

Summary

This study has endeavoured to establish the causes of domestic energy problems, in a rural setting. The area is of high agricultural potential and the basic economic activities are agricultural in nature.

Fuelwood is the common fuel for cooking, heating water and space heating. Population pressure seems to be at the root of fuelwood scarcity. While a few trees are grown near the homesteads, the rest of the land is under intensive agriculture. The few trees are not sufficient to meet the fuelwood requirements.

Figure 4-7: Two Neighbouring Homesteads:
(Shows Pattern of Land Use)

Another important contributor to the continued existance of fuel problems is ignorance of better methods of fuelwood production, or of conservation methods. As a result, domestic fuel has become expensive and, therefore, cost is also a constraint.

The community has tried to adjust to the problems by examining choices available to it. Substitutes to fuelwood adopted by the people are charcoal, coffee-husks and crop residue. Saw dust was once used in the area but has been replaced by coffee husks. The ability of the people to choose has been limited by an ignorance of other alternative sources of energy. Their choice of better cooking stoves has been limited also by a lack of awareness.

However, the study has established that fuel-wood production can be increased through agroforestry. A significant number of the people also qualify for a biogas system. The community is well-educated and therefore it can understand these technologies as well as the conservation methods.

In the area of lighting, the people have had two choices, that is, electricity and paraffin. Those who meet the requirements of a biogas system can then have a third choice in lighting.

REFERENCES

1. Hosier, R.H., Something to Buy Paraffin With, 1981.

2. Republic of Kenya, Kiambu District Development Plan: 1984-1988, Pp.43, 91.

3. Wesenberg, R. GTZ - Special Energy Programme, Ministry of Energy, Interview, 1988.

4. Ibid.

5. Wesenberg, R., and P.M. Gichohi, Ministry of Energy, Interview, 1988.

6. Wesenberg, R., Interview, 1988.

7. Jorgensen, N.O., Housing Finance for Low Income Groups, 1977, P.164.

CHAPTER 5

ENERGY CHOICES AND PLANNING STRATEGIES

The research findings have revealed not only the energy constraints in the study area but also the existing energy choices. Possible sources of alternative choices within the sub-location have also been established.

Whose Choice?

In this study "choice" is taken to mean the selection of different types of domestic energy. In other words alternative supply from which to select.

"Choice" here is also seen to stand for the act or instance of choosing or selecting different types of energy by a household. The household is seen as having the right or privilege to decide what to use. The power to make the choice is limited by many variables, such as, the supply, the information regarding the applicability of the different types of energy, and the cost of the fuels.

Woodfuel

Fuelwood

From the research findings it was found that fuelwood is the predominant source of domestic energy at Nyathuna B Sub-location. As a result of the depletion of trees in the area 46.5% of the households in the area have to purchase their supplies. However, the study has revealed that there is a potential to increase the production through agroforestry systems.

Fuelwood is used primarily for cooking, heating water and space heating. However, its use poses a health danger. It causes pollution within the home, chiefly in the kitchen and in any room which is heated.[1] Smith (1985) argues that even though little systematic research has been carried out there is evidence that smoke and other pollutants from biomass fuels affect adversely the health of households.[2] He explains that the evidence has revealed the following:

- High indoor concentration of carbon monoxide, particulates and hydrocarbons in levels higher than those found in dirty industrial cities;

- Householders, especially women, receive exposure to pollutants, such as carbon dioxide, formaldehyde and carcinogenic substances in quantities greater than those experienced by heavy cigarette smokers.

- Several types of chronic and acute respiratory diseases are associated with exposure to smoke. He adds that in developing countries the greatest source of mortality is respiratory diseases.

Health problems due to the use of fuelwood and other biomass fuels were also reported in the study area. Other problems that were reported were:-

- Smell of smoke in clothing;

- Destruction of cooking utensils;

- Destruction of corrugated iron sheets (used for roofing).

A household should be aware of all the facts regarding a fuel before making a choice. Methods exist for reducing pollution from fuelwood. They are discussed together with the cookstoves below.

Charcoal

Charcoal is not produced in the study area, even though the study revealed that 61.4% of the households use it. The cost of charcoal has rapidly escalated since 1981. Table 1-4 shows that a sack of charcoal costs KSh. 21.40 in 1981 in the high potential zone, while the study results show that the cost has now reached K Sh.80/- per sack. This is evidence of a growing demand for charcoal as well as of diminishing supply.

Study results also show that it is preferred to fuelwood for space heating of rooms other than the kitchen because it produces less smoke. It was also said to be quicker to use than fuelwood.

Woodfuel Production: Agroforestry

It was noted during the research that the study area has the potential to increase its woodfuel supply through the agroforestry technology.

Agroforestry is a system that promises the conditions of an integrated approach in solving the problems of a rural household.

There is no universally accepted definition of agroforestry, as a term or concept. A working definition has been provided by the International Council for Research in Agroforestry, viz:

"Agroforestry is a collection name for land use systems and practices where woody perennials (trees, shrubs, palms, bamboos, etc) are deliberately used on the same land management unit as agricultural crops and/or animals, either in some form of spatial arrangement or temporal sequence. In agroforestry systems, there are both ecological and economical interactions between the different components".[3] Agroforestry can then be seen as a system that offers a sustainable land-management system which increases the overall yield of the land, and in so doing meets the needs of the people for food, fuel,shelter and income. It should be accepted socially, culturally and economically in order to maximize its benefits and minimize environmental damage.[4]

From this definition it follows that this is a system or practice of land use that would be of great benefit to small-scale farmers in the high potential zone in this country, if accepted by these rural communities. Several governmental ministries, organisations and non-governmental organisations are engaged in the process of promoting and disseminating this technology. Some of them are: the Ministries of Energy, Agriculture, Livestock Development, Environmental and Natural Resources, the Permanent Presidential Commission on Soil Conservation and Afforestation, and Kengo (Kenya Energy Non-Governmental Organisation).

Agroforestry is not a new system. Many societies have traditionally been aware of the beneficial effect of intercropping certain tree species with food crops. For example, in Kakamega District agroforestry has been practiced traditionally for many generations.[5] It is one of the most densely populated districts in Kenya.

As one travels through the district there is not much evidence that this traditional farming method is actively practiced. Traditional farming has tended to be looked on as primitive and backward in this country and other developing countries. Farming practices inherited from the colonial era encouraged monoculture. Agricultural researchers and extension workers were foreigners or foreign trained so that their frame of reference was patterned after farming practices in Europe or North America (Chambers 1985).[6] These new, so called "modern", farming practices have tended to reduce the importance of agroforestry in the minds of the younger generations.

There are three major agroforestry systems. These are:[7]

1. Agrosilvicultural Systems, which involves the production of trees and crops on the same plot of land on a permanent or temporary basis.

2. Silvopastoral System, in which woody biomass is grown on pastures.

3. Agrosilvopastoral Systems in which trees, shrubs, etc, (woody biomass) are planted for browse, mulch, etc., together with crops and fodder.

Before a tree or shrub can be considered agroforestry species it should meet part or all of the following criteria. It should be a leguminous species so that it can add fixed nitrogen to the soil; recycle nutrients, suppress weeds and control soil erosion on slopes. Prunings should provide high-quality fodder. It should also provide mulch and green manure to increase soil fertility and retain soil moisture. In addition it should also provide woodfuel and building poles.[8] Such trees can also provide other benefits, such as fruit, shade, or exhibit aesthetic qualities.

If the wrong type of tree is used the output of the food crops may be decreased. Even when the tree is the correct agroforestry species it may impede mechanized cultivation if the spacing is not properly calculated relative to the size of the machinery, for example tractors.

A well managed agricultural system would provide the household with woodfuel, poles and fodder, and in addition it would help reduce environmental degradation. Women and children have to walk long distances to collect fuelwood. This type of hardship would be reduced by the availability of fuel on the farmstead and thus enable the women and children to engage in more productive activities. Households which have to buy woodfuel would also make a saving.

Biogas

The study area has been shown to have the potential for biogas. Its production would therefore increase the energy choice there.

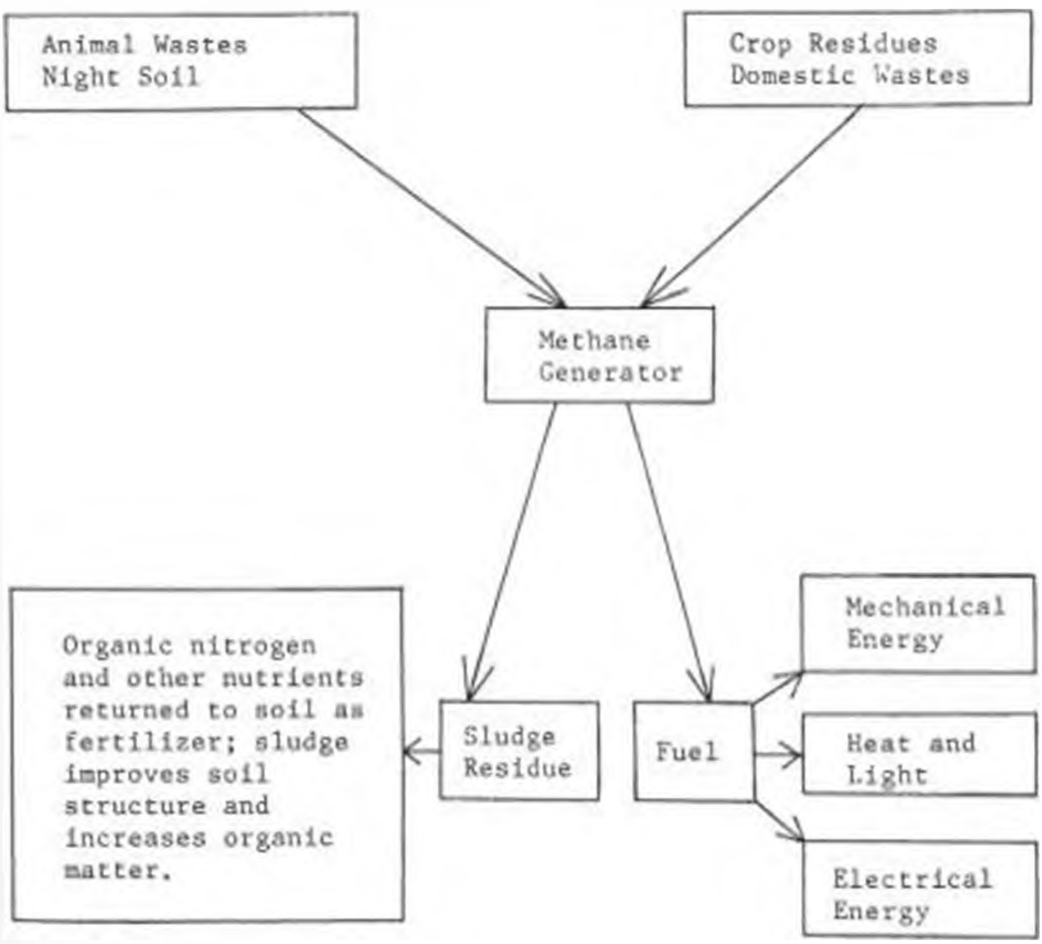
Biogas is a gas that is produced when organic matter decomposes in the absence of oxygen, that is anaerobic fermentation. It is chiefly a mixture of methane, 60-70%, and carbon dioxide making 30-40%. Some trace gases such as hydrogen and hydrogen sulphide (which smells like rotten eggs) may be present.[9] It is a clean, odourless gas that produces a blue flame, similar in colour to the flame produced by liquid petroleum gas (LPG).

Livestock dung and vegetable wastes such as grass, household leftover food and wet agricultural residues will produce biogas. In addition to the production of gas the slurry or sludge is reduced biochemically to a simpler form which is a better soil nutrient than unfermented manure. The biochemical processes also destroy various harmful organisms, such as disease causing germs or pathogens, parasites and worms. Even without the production of gas this is a benefit that is valuable to farmers. Poultry produces manure that is high in nitrogen but farmers find it difficult to use it because of the high incidence of worms. Anaerobic fermentation would destroy them.

Anaerobic fermentation also destroys the foul odours of decomposing organic matter. Farmers who keep pigs find the odour can be environmentally offensive.

The following figure gives the impact of anaerobic fermentation on the use of organic wastes.

Figure 5-1: Impact of Anaorobic Fermentation on Use of Organic Wastes.



Source: NAS 1977[10]

Biogas is a clean gas and by substituting it for woodfuel the harmful effects of smoke from wood are eliminated. Biogas also provides better quality gas than the traditional paraffin lamp. This enables school children to study at home during the evenings.

Studies carried out by the GTZ Special Energy Programme in the Ministry of Energy indicate that the use of biogas does not conflict with cultural practices in this country.[11] These studies have also shown that when the household (the head, wife and older children) participate in the construction of a biogas digester maintenance problems are considerably reduced.

Khandelwal (1984) from India argues that biogas as a device improves material prosperity as well as the quality of life.[12] He notes that the beneficiaries are women since their drudgery is eliminated by providing a clean and efficient fuel in the kitchen. In China similar experiences have been observed as in India. GTZ (1981) writes that in China the time-consuming burden of gathering fuel had been eliminated in areas where biogas has been introduced. GTZ argues that the use of biogas improves the general hygiene conditions of the household. Again women, it claims, are the main beneficiaries since common "women's diseases" in China such as eye, throat and bronchial diseases are reduced. These are problems of fuels such as wood which produces smoke.

Stotz (1983) shows that in Kenya livestock is to be found kept by most households in the high agricultural potential area.[13] This livestock is kept in "bomas" or zero-grazing units because of the small size of the landholdings. Sasse (1984)[14] and GTZ (1987)[15] explain that these are the ideal conditions for the installation of biogas units or digesters.

Crop Residues

Maize Stalks and Cobs

Maize stalks and cobs are among the fuels used in the study area, as revealed by the research findings.

As already noted, crop residues are incorporated into the soil during cultivation in order to enrich it. The study results also showed that maize stalks and cobs are also used as fodder. Their use then as fuel is to be discouraged unless excess quantities are available.

Coffee Husks

The use of coffee husks is a choice already made by the households in the study area. Coffee husks are imported into the area from Nairobi. This is really in response to the fuelwood scarcity.

It is a commercial fuel unlike the other crop residues used as fuel.

Vegetable Oils

There was no evidence that vegetable oils are used for lighting in the study area.

It is used in some developing countries for lighting.[16] Its use in the study area does not appear viable since the technology has not been tested in this country. Plants rich in oil seeds e.g. castor, grow well in semi-arid areas. However, the question of food vs energy arises, and seen from this point of view this form of energy does not appear attractive.

Solar Energy

The potential to utilize solar energy in the study area was revealed in the research findings. It was seen to be a more expensive source of energy than the widely used fuels. Nevertheless, the individual household has the priviledge of choosing what energy to use.

Habitat (1984) writes that "solar energy is by far the most abundantly available renewable energy resource, particularly in the tropical regions of the developing countries."[17] As with some other types of energy harnessing of solar energy (technology and capital costs) is expensive.

Within the domestic sector solar energy can be used for cooking, heating and lighting.

Solar cookers are boxes fitted with a reflector, and the cooking pot is placed inside the box. Much research work is being done in India to improve them but as yet they have not been widely accepted.[18] One problem is that cooking has to be done outside in the sun. In the high potential zone of Kenya, cooking is done indoors. During the cold season when the sky is overcast it would not be possible to use the cooker.

The use of solar energy to heat water is more common. The National Academy of Sciences (1976) claims that solar hot-water systems are economically competitive with fossil fuels.[19] However, in this country where woodfuel is the predominant source of fuel this claim may only be true in a few cases.

During the cold season space heating is important. Passive solar heating can help to reduce the quantity of other fuels used. This is the green-house effect. During the day solar energy enters the house and is trapped inside. This is not expensive but it requires design work from architects. The windows have to be designed in such a manner that they allow heat in but not out.[20]

Sunlight can be converted directly into electricity (that is photovoltaics). The electricity is produced during the day and stored in batteries to produce light at night. The equipment is expensive and would require to be imported.[21]

Paraffin

Paraffin was shown to be the predominant fuel for lighting in the study area. While the potential does exist to use solar energy for lighting, paraffin is the less expensive fuel at the present time.

The cost of paraffin was seen to depend on the outlet from which it was purchased as well as the type of container used. It was least expensive at the petrol station where the unit cost was constant. Quantities sold in soda bottles (about 290 ml) from shops and neighbours were the most expensive.

Its benefits have to be weighed against the pollution problems associated with it. A few paraffin users in the study complained that it has an unpleasant odour and causes nausea, headache, sneezing, eye irritation and coughing when lighting. The problem reduces if better lamps and stoves than the common ones are used.

Electricity

Electricity is available in the study area. Where used its main purpose is lighting. In this respect it is an alternative to paraffin but as shown in Chapter Four installation costs are quite high.

As the national rural electrification programme expands more of the small-scale farmers in the high potential zone will be able to use it. While the major constraints to its use will continue to be the cost, a certain proportion of small farmers, what Chambers (1985) refers to as the "rural elite" will be able to meet such costs.[22]

Wind

There is not sufficient meteorological data to determine whether or not domestic energy needs can be met through the utilization of wind energy.

There are two main applications of wind energy. It can be used to generate electricity or to produce mechanical energy in pumping water. Electricity thus generated can be used for lighting and other domestic needs. Habitat (1984) reports that wind generators have fairly high capital and energy production costs, but that small-scales designs can be cost effective over the lifetime of the system.[23]

The power thus generated can be supplied to an individual household or to an entire community depending on the wind regime and the size of the generator.

Energy Conservation

It has been established that wood is the predominant source of domestic energy in rural areas, and that its depletion has resulted in human hardship and evironmental degradation. Open fires, such as the three-stone jiko (stove) are common. Much wastage of energy follows, and unless a household wants specifically space heating, effort should be made to conserve the energy. In this country the traditional metal charcoal stove tends also to be wasteful of energy. Charcoal production using traditional methods is another area where much energy is lost.

Research findings from the Kenya Renewable Energy Development Project (1986) show that 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 75% of wood energy is lost in the conversion process.[24] The findings also show that the traditional charcoal stove has an energy conversion efficiency of 4.8%. This roughly means that only 1.2% of the original wood is effectively used in cooking. The project has designed and tested some improved cooking stoves. The following figure gives the results.

Table 5-1: Efficiency of Use of Initial Energy

Traditional Charcoal Jiko	4.8%
Improved Charcoal Jiko	7.2%
Three-Stone Fire	10%
Three-Stone Fire with Improved Cooking Methods	20%
Improved Firewood Stove	25%

Source: Energy/Development International (1986)[25]

Research and development activities of the Special Energy Programme (1986) have identified certain charcoal production methods that are much more efficient in energy terms than the traditional charcoal burning techniques.[26] The proposed charcoal kilns are more expensive than traditional ones, but the yield and quality of charcoal produced is much higher.

Habitat (1984) observes that there are certain reasons that have led to public reluctance to use improved wood-burning stoves in developing countries. These are, incompatibility of the new stoves with cooking habits, poor designs, high initial cost and very marginal improvement in efficiency.[27] This problem appears to be caused by a lack of public or community involvement in design and implementation of projects.

Rural Development and Energy Policy

Before discussing strategies that have been developed from this study it is important to understand rural development and policy issues upon which the strategies are based.

Rural Development

When the problems of a household are reduced that household is then able to contribute more productively to the community and in so doing enhances rural development.

Development has been defined as the expansion or bringing out of the potentialities of an area.[28] Seen in this light development is a dynamic process which leads to improvement, beneficial changes or progress. The role of development is then to bring out the maximum utilization of the creative potential of individuals or communities in a given area. Development also involves value judgements and what is considered as development in one area or period in time may not be so considered in another. Development can be economic, social, administrative and political and these can be inter-related or interdependent.

Seers (1978) defines development in terms of reduction of poverty and the raising of per capita income, increased employment and equity consideration.[29]

Lele (1975) defines rural development "as improving living standards of the mass of the low-income population residing in rural areas and making the process of their development self-sustaining".[30] He argues that important features to this definition are:

1. Improving the living standards of the rural poor;

2. Mass participation requiring the allocation of resources t the poor.

3. Ensuring that the process is self-sustaining.

He concludes that these features have profound impact on the design and performance of individual programmes.

It has already been noted that the woodfuel problem is the evidence of widespread resource depletion and environmental degradation which has resulted in increased poverty. Timberlake (1985) declares that "bankrupt environments lead to bankrupt nations".[31]

Poverty is evidenced when income is inadequate, or it may take the form of malnutrition as well as inadequate standards of living.[32] It is therefore important in trying to find solutions to the woodfuel problem to consider in what way these solutions help to alleviate poverty and, therefore, enhance rural development.

Chambers (1985) recommends that in order to solve the problems of rural development emphasis should be placed on the rural people's knowledge, skills and resources; and then to this local knowledge should be added modern scientific research techniques.[33] Such development then, should create conditions that enable a rural community to control its destiny.

Energy Policy

Energy policy can be considered as a course or plan of action which is designed to influence the present and future energy decisions and actions.

The government is aware of the important role played by energy in accelerating the pace of economic and social development, and of the importance of fuelwood and charcoal in the domestic sector. Government policy has been set out in the current Development Plan (1984-1988).[34]

In order to meet the requirements of rural households the Plan proposes to adopt the agro-forestry strategy because it does not require additional land to be set aside for trees, but trees and food crops can be intercropped on the same piece of land. The Plan also proposed to produce 200 million seedlings a year through the Rural Afforestation and Soil Conservation Programme. Lack of seedlings of the right types of tree species is a constraint in the production of woodfuel.

The Plan also states that the rural electrification programme would be stepped up, and one of the objectives is to supply more energy for lighting to the rural population.

The Plan also noted the importance of energy conservation and proposes to develop and improve reafforestation approaches, charcoal production methods, improved stove designs and better cooking methods. The Government would coordinate, promote and disseminate such activities.

While the Plan state that "each district, through its District Development Committee (DDC), will be responsible for rural development planning and coordination, project implementation management of development resources, and overseeing local procurement of goods and services"[35] the energy sector has been basically administered by the Central Government.

The more recent policy document, the Sessional Paper No. 1 of 1986, points out the importance of energy in agriculture, the informal sector, and in rural-urban balance.[36] Greater demand for fuelwood (chiefly in rural areas) and charcoal (mainly in urban areas) needs greater production and expansion of woodfuel supplies. To achieve these for the rural households the Paper proposes the same strategy as the Development Plan, that is, agroforestry, reafforestation and peri-urban plantations. The Paper does not specify what strategy should be used to incorporate energy in the mainstream of the DDC's rural development plans.

The policy to decentralize the Central Government through the District Focus for Rural Development strategy will facilitate more effective project planning and implementation. Public participation is incorporated in the strategy, and to ensure active participation the DDC must maintain a programme of public information. Public participation is necessary for the success of the energy technologies that can help meet the rural energy demand.

Planning should be done with the people noting carefully what they feel are their problems and the priorities they give. An integrated energy approach to planning is needed. In order to make it possible and so fulfil the policy the districts need information on domestic energy consumption and demand patterns, the local formal or informal potential of fabricating, operating and maintaining energy equipment, and the socio-economic and cultural attitudes towards energy and related sectors. Armed with this information the DDC's policy of public participation, in energy for instance, can be realized and therefore lead to greater success in the alleviation of domestic energy problems.

Energy policy in a rural setting should endeavour to arrive at a planning methodology that will enable the community to identify clearly its problems, especially the underlying issues.

This concept of popular participation is stressed by Conyers (1982) who points out that it is an important means of getting information on local conditions, needs and attitudes, which ensure the success of development programmes and projects.[37] She adds that people are more likely to participate in a programme or project if they are involved in its planning and preparation, because they will identify with it and see it as their own project.

Planning Strategies

The problem of woodfuel scarcity has been shown to be one of resource depletion and environmental deterioration. It follows then that any plan that is prepared in the rural area should take an integrated approach. The Government has declared that in order "to accommodate Kenya's rising population, the country must enter a new phase of development and the provision of basic needs" and that "within existing crop patterns, farmers will be encouraged to adopt more productive practices."[38]

From the result of this study three strategies can be adopted that will partly contribute to this broad goal and at the same time help to increase the supply of domestic energy. These are agroforestry systems, biogas technology and domestic energy conservation.

The research findings showed that the households in the study area are willing to learn new techniques of producing domestic energy. They also felt that the Government should assist them. The strategies are then designed not only to help increase the supply of energy but also to increase crop production and therefore the income, as well as improvement of the environment. Government input is seen in the form of scientific or technical assistance.

Agroforestry

There are several types of agroforestry systems and practices. A few of them are recommended for the study area. These are; alley cropping (also known as hedgerow cropping), wind breaks, soil conservation hedges, and sylvopastoral systems (that is growing trees with fodder crops).

The Agroforestry/Energy Centre at Jamhuri in Nairobi has carried out research on tree species suitable for agroforestry in the study area. These are trees which in addition to providing fuelwood will also provide fodder, improve soil condition through nitrogen fixation and mulching, decrease the number of weeds, help to retain water; and in general increase crop yield. Those used as fodder are high in protein content and will, therefore, increase the milk yield. As a result of these benefits agroforestry is recommended to all the households.

Trees which are suitable as windbreaks, soil conservation hedges and along the fences are:-

Table 5-2: Agroforestry Tree Species

Tree Species	Local Name (Kikuyu)
Grevillea robusta	Mukima
Markhamia hildebrantii	Muu
Acacia nilotica	Mugaa
Acacia seyal	Mugaa
Casuarina equisetifolia	Mvinge (Swahili)
Acrocarpus abyssinica	(Exotic from S.E. Asia)

Source: Jamhuri Agroforestry/Energy Centre

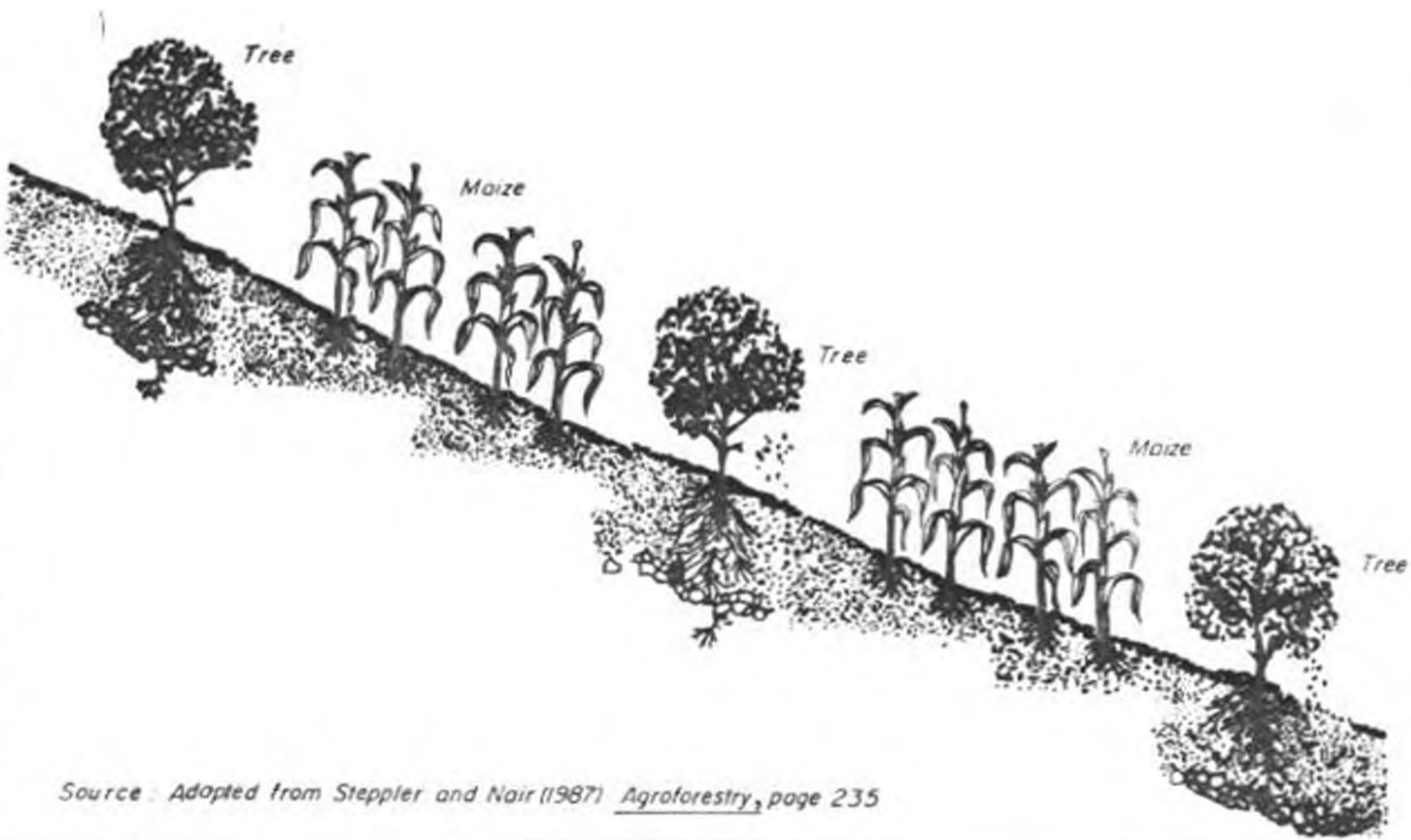
Where the topography allows they should be planted in an East-West direction so as to minimize shading. Otherwise lopping of the branches will also reduce shade. The branches can then be used for fuel and the leaves as fodder, depending on the species.

Alley cropping is recommended where maize and beans are grown. The maize and beans would be grown between hedgerows of leguminous tree species. The appropriate species for this area are Sesbania sesban (Mwethia), Sesbania bispinosa and Calliandra calothyrsus. Figure 5.2 is a diagramatical representation of one type of alley cropping.

The trees planted along the fence are a good quality for building poles. The branches form 20-30% biomass for fuelwood and fodder.

Alley cropping is not difficult but requires proper management. A time table can be prepared by the Agroforestry/Energy Centre showing what activities are required each month to be performed or when necessary. For example, planting of the tree seedlings, maize and beans is done between March and April during the long rains. Weeding follows between May and June. The small side branches and leaves are pruned and incorporated into the soil and some used as fodder. In October when the trees are about 2 to

Fig.5-2 AGROFORESTRY: ALLEY-CROPPING SYSTEM



Source: Adopted from Steppler and Nair (1987) Agroforestry, page 235

3 metres tall the small fast-burning sticks are harvested. At the end of one year before the rains in March the trees are harvested. Agroforestry experts at Jamhuri estimate that about 18 tons of biomass can be harvested from one hectare in a year. The trees grown can coppice and then a new growth begins.

The same trees used in alley cropping can be grown with fodder, such as napier grass. The fodder crop is planted with about 30% trees. When the fodder is cut together with the young trees, it increases the protein value of the feed. Some of the trees are left for other purposes, such as fuel.

Biogas

The slurry pit digester system is recommended for those who meet the basic requirements, as outlined in the previous chapter four. It is easier to maintain than the older designs (Meru type, Indian and Chinese types). It is also less expensive and requires simpler skills to construct.

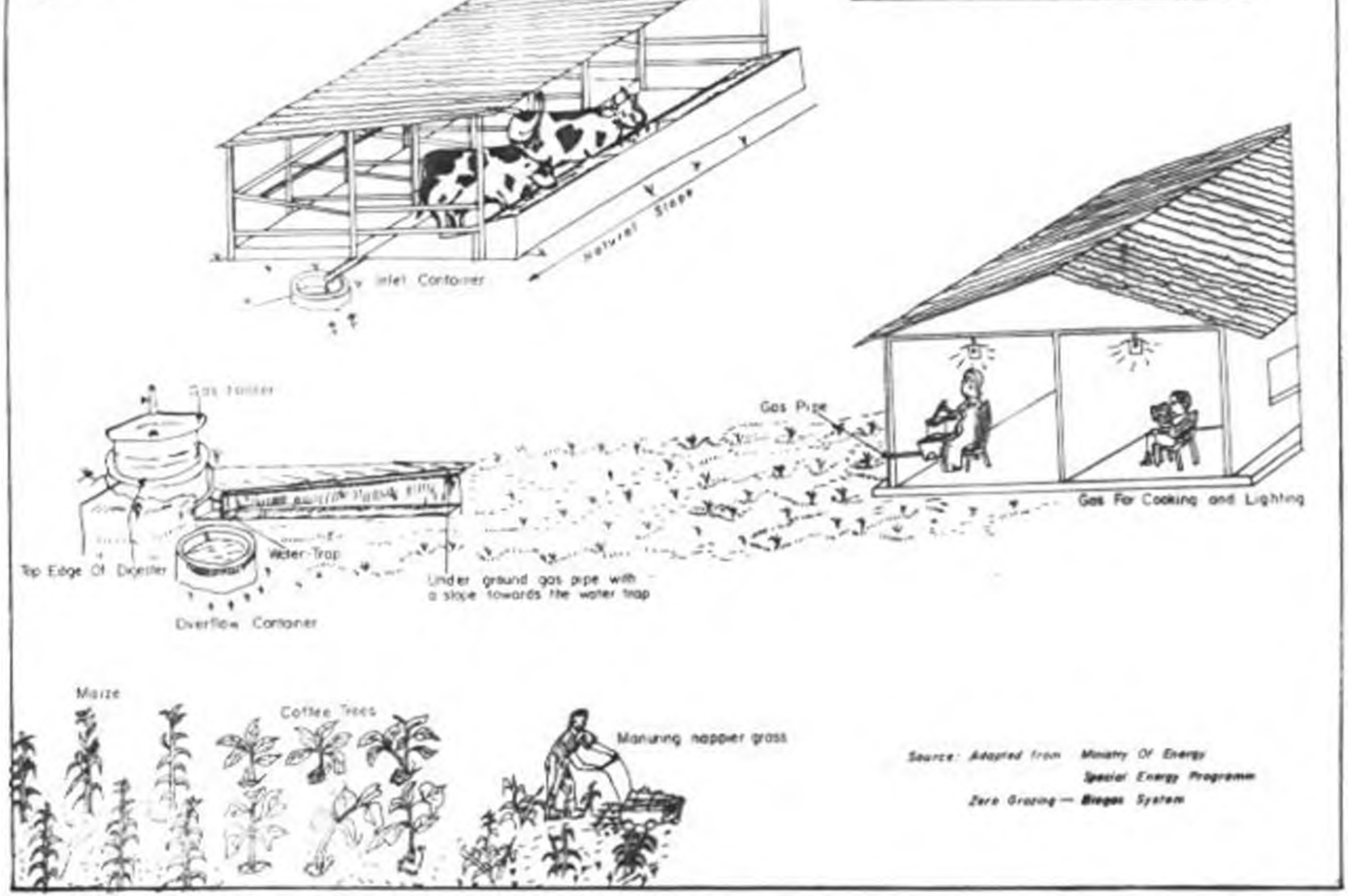
Figure 5-4 shows the biogas system in its relation to other land uses. Without the biogas unit the cow dung or other livestock dung would be heaped up at one end of the zero-grazing unit. The heap attracts flies, mosquitoes and other organisms. With a biogas unit the dung is placed into the digester. This adds to the aesthetic quality of the farmstead.

Figure 5-3: Slurry Pit Digester

Research findings showed that when a family pays for a biogas unit more care is given to its upkeep. Again if the family is involved in the construction, operational and maintenance problems are reduced.

The system is designed in such a manner that after the production of gas the fermented dung (slurry) moves through an overflow pipe (the outlet),

Fig. 5-4 THE BIOGAS SYSTEM



into a furrow that leads into the cultivated land. If fertilization is not immediately needed it flows into a compost pit for storage. This design reduces human labour especially where the terrain has a natural slope.

Energy Conservation

As with agroforestry and biogas technology, energy conservation can be embarked upon immediately.

Cookstoves that minimize the loss of energy have already been introduced in the district. Two designs are suitable for this area. The Ministry of Energy, (Women and Energy Project), design is quite inexpensive. The important part of the jiko is a ceramic liner which costs KSh.25/- (that is subsidized by the Project), and is available at the chief's camp at Wangige Market. Women can install them in the kitchen in a short time. The other type is called Karai Jiko and was developed with assistance from the Bellrive Foundation at Karai in Kikuyu Division. Investigation revealed that it costs KSh.400/-. It has a chimney and can use wood or charcoal. The wood can be in the form of small twigs. Of the two designs it is more superior. It is also quick to light and to use.

Figure 5-5: The Karai Jiko

The "kuni-mbili" jiko is recommended because it is portable besides being fuel efficient. The "kuni-mbili" jiko is designed to use two small pieces of wood to cook a meal. Charcoal is used in the study area because it is easier to light and the jiko is portable. However, even though the use of charcoal should be discouraged, the promotion of better charcoal jikos is important. As has already been noted the production of charcoal requires large quantities of wood. Those households which choose to use charcoal should do so efficiently. Such jikos are commercially available at a cost of about KSh.65/-.

This design requires half the quantity of charcoal consumed by the ordinary jiko.

Energy efficient biogas cookers are now available in the market, and can be introduced in the study area.

Figure 5-6: Biogas Cooker in a Home in Meru

On the left is the improved type.
On the right is the old design.

All the improved jikos described here can be used to prepare all the household meals, including "githeri". They are designed in such a manner that the traditional clay pot can be accommodated.

Training Programmes

Public Information

The proposed measures to help alleviate rural domestic energy problems can only be successful if the people actively participate. Public participation can only be effective if the people are well informed. Research findings revealed that public ignorance of better production methods of domestic fuels, and energy conservation measures, as well as of a wider range of energy choices, is one of the constraints to the alleviation of domestic energy problems.

Farmers' field days should be organised at Jamhuri Agroforestry/Energy Centre to acquaint them with agroforestry techniques, biogas technology and energy conservation methods. This is important because there are very few energy extension officers. Data showing the experiences of other farmers with these technologies should be provided. For example, while collecting data at the Centre, the Centre Manager commented that a farmer in Kilifi District had increased milk yield by 37% through intercropping of Leucena leucocephala with nappier grass, and then feeding the cows with this mixture.

A sheet describing these technologies should be provided by the Centre.

Diagrammatical representation of the recommended pattern of land uses, preferably with photographs, should be included. This would help the farmer to conceptualize the ideas better.

In addition an energy matrix should be prepared. This would show all the possible energy choices in the study area, briefly describing each. Figure 5-7 gives such a matrix.

The information sheet and the energy matrix can be displayed at the markets, churches and public offices. They can also be sold to individuals at cost, that is to meet the cost of producing them.

As noted in Chapter Four the people in this area tend to carry out activities on individual household basis rather than collectively. However, among the suggestions they made on finding solutions to their energy problems were meetings in which the new ideas would be discussed. For this reason "barazas" or public meetings can be organised with the technical officers, and the people would then be able to voice their opinions.

It was noted during the study that farmers did not really know the total amount of money they spend on energy in a given time. They use various combinations of fuels and while they know the cost of each fuel bought each time, they do not calculate the total amount spent, say in a month. When this is done then they can see if it is in their interest to adopt new technologies.

Training of Technical Officers

The traditional training of technical officers tends to be narrow in nature. For example foresters are trained to plan and manage plantations of a few tree species, while agricultural officers get training that emphasizes monoculture. It is therefore, important to plan seminars in which the officers from the relevant ministries participate. This would include divisional district officers, community development officers, home economists, foresters and agriculturalists. The Centre Manager at Jamhuri can organise and conduct such seminars. The district officer is important because he chairs the divisional district development committee meetings. Selection of officers is at divisional level because certain sectors, such as forestry, are not represented at the locational level.

This group of officers should then meet the community at a public meeting (normally organised by the assistant chief) and discuss an integrated approach to solving the domestic energy crisis. The officers can then draw-up an integrated plan on a spatial basis. Its implementation should be within a time frame, for example, in the case of agroforestry it would be based on the same schedule as the cultivation of the crops.

The effectiveness of this approach can be measured in terms of the number of households that adopt the technologies with success. It would, therefore, require monitoring and evaluation of the activities following a planned time-table.

Training of Artisans

The construction of biogas units and appliances, and some of the improved cookstoves requires skilled labour.

Many masons and metal workers expressed their wish to be trained in those technologies. This included instructors at the nearest Youth Polytechnic, which is at Kirangari in Nyathuna A Sub-Location. They felt that the added skills would increase their income through self-employment, (by building the necessary items for the farms).

It has been noted in Chapter Four that the on-the-job biogas training of artisans in rural areas by the Ministry of Energy was successful. Since the trainees are already qualified in their particular fields, such as masonry or metal work, the additional training involves the construction of the units, under qualified supervision, at site. The site is usually a farmstead where the farmer has already bought all the building materials.

This type of training is important because it would increase the opportunity for self-employment and thus help to reduce unemployment in the study area.

Figure 5-7: Rural Domestic Energy: Matrix

Fuel	Common Uses	Advantages	Disadvantages	Skills	Installation Cost:KSh.	Appliances		Average Cost of Consumption per month: KShs.
						Type	Cost: KSh.	
Fuelwood	.Cooking .Heating water .Space heating	.Availability on farm when agroforestry is practiced. Therefore cost is reduced. .Socio-cultural benefit in that households gather around fire. .Some improved stoves are portable	.Ecological destruction .High indoor pollution .Health problems, such as headaches and coughing .Smoke taste in food .Smoke discolours walls and ceiling .Smoke damages cooking utensils .Constant tending and blowing of fire needed with traditional stove	.With traditional type: none .Minimal with improved systems	None None	3-Stone Improved cooker	None 25-400	96.80

Fuel	Common Uses	Advantages	Disadvantages	Skills	Installation Cost:KSh.	Appliances		Average Cost of Consumption per month: Kshs.
						Type	Cost: KSh.	
Charcoal	.Cooking .Heating water .Space heating	.Better Concentration of heat than fuelwood .Less pollution than fuelwood .Portable cooker	.More expensive than fuelwood .Indoor pollution .Health problems though fewer than with fuelwood .Intense heating of insulated cookers reduces life of utensils	Semi-skilled jiko makers .Potters for liners or insulation	None None	.Traditional metal jiko .Improved jiko	25-40 65-120	88.10
Coffee husks	.Cooking Heating water	.Substitute to fuelwood	.Pollution and health problems as with charcoal .Intense heat reduces life of cooking utensils	Semi-skilled jiko makers	None	Metal cooker	45	45-15

Fuel	Common Uses	Advantages	Disadvantages	Skills	Installation Cost: KSh.	Appliances		Average Cost of Consumption per month: KShs.
						Type	Cost: KSh.	
Crop residues	Cooking Heating water	.No cost .Available on farmstead	.Same problems of pollution and health as with fuelwood .Use as fuel can increase soil erosion if no mulch is available .Depletion of organic matter from soil	None	None	Same as with fuelwood	Same as with fuelwood	None
Vege-table oils	Lighting (but only at experi-mental stage in this country).	Substitute for paraffin	.Pollution and health problems .Production would conflict with food crop production	Technician for extracting oil	None	Lamp	None in the market; still a research problem	None used in study area

Fuel	Common Uses	Advantages	Disadvantages	Skills	Installation Cost: KSh.	Appliances		Average Cost of Consumption per month: KSh.
						Type	Cost: KSh.	
Paraffin	Lighting Cooking Heating water	.Quick to use i.e. ignites at once .Portable stove and lamp	.Unpleasant odour .Pollution and health problems (such as nausea and headaches)	Technician to fabricate stove and lamp	None	Stove Lamp	100-175 120-500	64.15
Electricity	Lighting Cooking Heating water	Clean energy Quick to use (i.e. can be switched on at once)	Expensive to install Expensive appliances	Electrician	192,500	Cooker Bulbs	From 2100 11/- per bulb	100-300
Commercial gas (L.P.G.)	Cooking Heating water Lighting	.Clean energy .Ignites at once .High quality light .Portable	Expensive Expensive appliances	Only caution in handling cylinder and cooker	None	.Gas equipment .Cooker .Lamp	1060 From 2500 From 500	120

Fuel	Common Uses	Advantages	Disadvantages	Skills	Installation Cost: KShs.	Appliances		Average Cost of Consumption per month: KShs.
						Type	Cost: KSh.	
Biogas	Lighting Cooking Heating water	.Ignites at once .Clean energy .Improves quality of manure as fertilizer .Eliminates or reduces harmful micro-organisms, parasites, worms from manure .Eliminates foul odour from manure .High quality light	.Installation cost is high .Specific user education on maintenance necessary .Feedstock may not be sufficent .If livestock is given anti-biotics gas production is reduced or eliminated .If zero-grazing unit is cleaned with soap, detergent or disinfectant gas production is reduced or eliminated	Biogas artisan	10,435 (includes one lamp and cooker)	Lamp Cooker	500-850 550-600	None used in study area

Fuel	Common Uses	Advantages	Disadvantages	Skills	Installation Cost: KShs.	Appliances		Average Cost of Consumption per month: KShs.
						Type	Cost KSh.	
Solar energy	Heating water Cooking	Clean energy Clean energy	.Installation cost high .Skilled maintenance required and not easily available Still at experimental stage in Kenya	Solar energy technician	23,000	None	None	None found in study area
Solar electricity	Same as electricity	Same as electricity .No consumption charges	.Installation costs high .Still under research and demonstration	Engineer	16,500	As with electricity	As with electricity	None found in study area
Wind generator	Same as with electricity	Same as with electricity but no consumption charges	.Installation costs high .Expensive maintenance .Still under research	Engineer	Still under research	Electrical	As with electricity	None found in study area

Summary

The study has established the possibility of alleviating the rural domestic energy problems at Nyathuna B Sub-Location. The potential to reduce the energy constraints through better methods of energy production has been ascertained. The energy choices that already exist have been examined and the possibility of increasing them has been established.

Planning strategies that will help to alleviate the domestic energy problems have been prepared. They are based on an understanding of the rural development process and the relevant energy policies.

References

1. Smith, K.R., Ambio, No. XIV, No.4-5, 1985, P.285.

2. Ibid.

3. The Editors, Agroforestry System, Vol.1, 1982, Pp.7-12.

4. Ibid.

5. Chavangi, N.A., Cultural Aspects of Fuelwood Procurement in Kakamega District. 1985.

6. Chambers, R., Rural Development, 1985, Pp.85-86

7. International Council for Research in Agroforestry, Newsletter, No. 17, 1986, Pp.4-5.

8. Steppler, H.A., and P.K.R. Nair, Editors, Agroforestry, 1987, Pp.233-236.

9. Sasse, L., Biogas Plants, 1984, P.12.

10. National Academy of Sciences, Methane Generation from Human, Animal and Agricultural Wastes, [illegible], P.6.

11. Wesenberg, R., and P.M. Gichohi, Biogas Workshop, 1987.

12. Khandelwal, in Rural News and Views, Vo. 6, No.4, 1984.

13. GTZ Report, Biogas in the Peoples Republic of China, 1981.

14. Stotz, D., Production Techniques and Economies of Smallholder, Livestock Production Systems in Kenya, Vol. IV, 1983.

15. Sasse, L., 1984, op. cit.

16. Habitat, Energy Requirements and utilization in Rural and Urban Low-Income Settlements, 1984, P.23.

17. Ibid, P.29.

18. Ibid, P.31.

19. National Academy of Sciences, Energy for Rural Development, 1976, P.24.

20. Darrow, K., et al, Appropriate Technology Source Book, Vol. II, 1981, Pp.631-638.

21. National Academy of Sciences, Energy for Rural Development, Supplement, 1981, Pp.7-8.

22. Chambers, 1985, op. cit., P.162.

23. Habitat, 1984, op. cit. Pp. 48-49.

24. Energy/Development International, Improved Cookstoves in Kenya, 1986, P.7.

25. Ibid, P.9.

26. GTZ - Special Energy Programme, Manual for the Construction and Operation of the Half-Orange Fire-Brick Kiln, 1985, Pp. 1-2.

27. Habitat, 1984, op. cit, P.54.

28. Readers Digest Encyclopedic Dictionary, 1969.

29. Seers, D., Statistical Policy in Less Developed Countries, 1978.

30. Lele, U., The Design of Rural Development, 1975, P.20.

31. Timberlake, L., Africa in Crisis, 1985, P.9.

32. Killick, T., Editor, Papers on the Kenyan Economy, 1981, P.91.

33. Chambers, 1985, op. cit., Chapter 4.

34. Republic of Kenya, Development Plan: 1984-1988, Pp. 132-136.

35. Ibid, P.91.

36. Republic of Kenya, Sessional Paper No.1 of 1986, on Economic Management for Renewed Growth, Pp. 58-60.

37. Conyers, D., An Introduction to Social Planning in the Third World, 1982, P. 102.

38. Republic of Kenya, 1986, op. cit., Pp. 62-63.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Synthesis

The focus of this study has been domestic energy constraints and choices as they relate to communities living in the high agricultural potential zone with a high population density. Nyathuna B Sub-Location is such an area.

Through a study of the domestic energy situation of the developing countries in general it was found that woodfuel is the predominant source of energy. It was also found that rural communities are experiencing difficulties because of its depletion.

Research findings have established that the domestic energy situation in the study area is similar to that of other developing countries. Resource depletion, evidenced in the scarcity of woodfuel, was revealed as caused by mismanagement of the resources through agricultural practices that encourage clearance of trees and the production of cash crops. In the study area this is in the form of intensive vegetable production. It was also established that due to the high population growth in the area and a land tenure system that encourages the fragmentation of the land (due to inheritance) over-cultivation had resulted. This has led to environmental deterioration and resource depletion, such as woodfuel scarcity.

In response to the problem commercialisation of domestic fuels has followed. Money is therefore a constraint in making an energy choice. Apart from fuelwood which was not totally commercialised, all the other choices are. These are charcoal, coffee husks, paraffin, electricity and liquid petroleum gas. Maize cobs and stalks were another exception but as has already been noted their use as fuel is questionable.

Another important constraint was ignorance of production methods of energy as well as of conservation methods. However it was established that there is a potential to increase the energy choices through agroforestry and biogas technology. There is also a potential for solar energy but the major constraint in its exploitation is the cost.

There is also the possibility to conserve the energy by using improved cookstoves.

In designing the planning strategies it was realized that community participation is important and that its views should be taken into consideration. The community had indicated that the chief problems in the study area are lack of land and fuelwood. The district development plan, as noted in Chapter one, has argued that the small farms do not provide sufficient employment or income.

The planning strategies were, therefore, designed not only to address the problem of fuelwood scarcity, but also land scarcity and degradation. By examining the research findings it was seen that agroforestry systems will help to increase the supply of fuelwood and at the same time increase crop production and enrich the soil. Even though the size of the land would not be increased, its productivity would be enhanced. Biogas technology was also seen to contribute energy and improved organic fertilizer which would also improve the quality of the soil and increase crop production. Energy conservation is also important, because in using the fuels efficiently there will be less need to cut many trees.

This study has also revealed the need to train farmers so that they can understand these technologies. The research findings also showed that farmers in the study area do not keep records of the cost of the total energy they consume. While they know the cost of the individual fuels, they do not consider, for example, how much they have spent in a month. When they are informed, then they realize it is in their interest to take active interest in finding solutions and taking the proposed technologies seriously, and in so doing reduce the expenditure.

The study also established the possibility of training local artisans in the production of improved stoves and the construction of biogas system.

Recommendations: Future Research

In order to successfully implement the recommended plans additional research is required.

The production of horticulture is one of the chief economic activities in the study area. Agroforestry has been recommended as a method that can improve agricultural productivity in addition to providing fuelwood. It is important to investigate what trees if any can be beneficial in the production of vegetables. Spatial arrangement should be well defined so as to minimize any additional need for labour.

A major constraint in agroforestry is the availability of seeds and seedlings. Research in this area is important. The possibility of on-farm seedling production should be studied so as to enable farmers to keep their own supplies of the trees of their choice. The World Bank has observed that "farmers outnumber foresters by 1000 to 10,000 to 1" and that "if farmers spend, say, only ten days per year on the planting and care of trees, as an 'off-farm' activity, their combined labour inputs would outweigh that of the foresters by 40 to 400 to 1."[1] Research into the ways in which farmers can be mobilized to participate to such a scale are important.

In order to monitor biogas production the Ministry of Energy should install gas metres (as has been the case in Meru District), and also study gas consumption. Further research is also recommended in the use and storage of the slurry.

The scope of this study has been domestic energy in a rural setting. Some of the farmers have the potential to produce more energy than they need for domestic purposes. For example, 21.8% of the households kept over 300 poultry. Some need energy for use in incubators. Research is required to see what types of incubators can use biogas. A different size of biogas digester would be required. The particular design and its cost should be investigated. Chicken manure is sold to other farmers if it is in excess to what a farmer requires. The slurry is a better organic fertilizer than the unfermented dung. However, the slurry is liquid and methods of its disposal and sale should be investigated.

It was noted that 21.8% of the households use fuel for space heating. This number would probably increase if the fuels were less expensive. To meet this need it is recommended that the Housing Research and Development Unit of the University of Nairobi carry out research on passive solar heating. The literature indicates that it is a practical method of trapping the heat from the sun in a dwelling. This would reduce the use of fuels already utilized for space heating.

A component of all the various types of research is socio-cultural characteristics. Without an accurate understanding of the people it would be difficult to get their cooperation in the planning and implementation of projects. For this reason, a more detailed socio-cultural study is recommended.

Summary

It has been noted that the two basic problems in the study area are a scarcity of fuelwood and land. While no plan has been proposed to address specifically the issue of lack of land the methods proposed for increasing the supply of fuel, agroforestry and biogas, help to increase the productivity of the existing land.

The study methodology can be applied to other areas of high population density in the high agricultural potential areas of the country.

Study findings and information from the literature show that the strategies proposed for increasing the supply of domestic energy in rural areas are acceptable in similar areas in other parts of the country. Socio-cultural differences are important. For instance in the study area women and men can plant and cut trees. However, in Kakamega District men plant and cut trees while women collect fuelwood.[2] While research methodology may be similar, the types of spatial plans adopted would depend on the findings in a particular area.

References

1. Anderson, D., and R. Fishwich, Fuelwood Consumption and Deforestation in African Countries, 1984, P.7.

2. Chavangi, N.A., Cultural Aspects of Fuelwood Procurement in Kakamega District, 1985.

BIBLIOGRAPHY

1. Anderson, Dennis, and Robert Fishwick, Fuelwood Consumption and Deforestation in African Countries, The World Bank, Washington, D.C., 1984.

2. Arrighi, Giovanni, and John S. Saul, Essays on the Political Economy of Africa, Monthly Review Press, New York, 1973.

3. Barnard, Geoffrey, W., "The Use of Agricultural Wastes as Fuel", Ambio: A Journal of the Human Environment, Vol. XIV, No.4-5, Royal Swedish Academy of Sciences/Pergamon Press, Stockholm, 1985.

4. Bhagavan, M.R., "The Energy Sector in SADCC Countries", Ambio, op cit.

5. Campbell, William Giles, Stephen Vaughan Ballou, and Carole Slade, Form and Style: Theses Reports, Term Papers, 6th Ed., Houghton Mifflin Co., Boston.

6. Chambers, Robert, Rural Development: Putting the Last First, Longman, London, 1985.

7. Chavangi, Noel, Cultural Aspects of Fuelwood Procurement in Kakamega District, Kenya Woodfuel Development Programme, Working Paper No.4, Nairobi, 1984.

8. Cipolla, Carlo M., "Sources of Energy/Conversion of Energy", "The Economic History of World Population, Penguin Books, Baltimore, 1962.

9. Clark, Wilson, Energy for Survival: The Alternative to Extinction, Anchor Books, New York, 1975.

10. Cook, Earl, Man, Energy, Society, W.H. Freeman, San Francisco, 1976.

11. Conyers, Diana, An Introduction to Social Planning in the Third World, John Wiley and Sons, Chichester, 1982.

12. Darrow, Ken, Kent Keller, Rick Pam, Appropriate Technology Source Book, Vol II, Volunteers in Asia Publications, Stanford, 1983.

13. Energy/Development International, Improved Cook-stoves in Kenya: Experiences of the Kenya Renewable Energy Programme, E/DI, Nairobi, 1986.

14. Foley, Gerald, "Woodfuel: The Energy Crisis of the Poor", The Courier, Africa - Caribbean - Pacific - European Community, No. 95, 1986.

15. Glantz, Michael H., and Richard W. Katz, "African Drought and Its Impacts: Revived Interest in a Recurrent Phenomenon", Desertification Control Bullletin, United Nations Environment Programme, No.4, 1987.

16. Goodman, Gordon, T., "Energy and Development: Where Do We Go From Here", Ambio, op.cit.

17. Gregory, S., Statistical Methods and the Geographer, 4th Ed., Longman, London, 1978.

18. GTZ, Biogas in the Peoples Republic of China, Report, Bremen, 1981.

19. GTZ - Special Energy Programme, Manual for the Construction and Operation of the Half-Orange Fire-Brick Kiln, Nairobi.

20. Hardin, Garrett, "The Tragedy of the Commons", Science, Vol. 162, 1968.

21. Haring, L. Lloyd, and John F. Lounsbury, Introduction to Scientific Geographic Research, 3rd Ed., Wm. C. Brown Co., Iowa, 1983.

22. Harriss, John, Editor, Rural Development: Theories of Peasant Economy and Agrarian Change, Hutchinson University Library, London, 1982.

23. Hosier, Richard H., Something to Buy Paraffin With: An Investigation Into Domestic Energy Consumption in Rural Kenya, Ph.D. Dissertation, Clark University, Worcester, 1981.

24. Hosier, Richard, "Household Energy Consumption in Rural Kenya", Ambio op. cit.

25. Independent Commission on International Humanitarian Issues, The Encroaching Desert: The Consequences of Human Failure, Zed Books, London, 1986.

26. International Centre for Research in Agroforestry, Newsletter, No. 17, 1986.

27. Jorgensen, N.O., Housing Finance for Low Income Groups: With Special Reference to Developing Countries, University of Nairobi, Nairobi, 1977.

28. Kassas, Mohammed, "Deforestation, Desertification and Soil Loss", Desertification Control Bulletin, No.12, 1985.

29. Kenya Non-Governmental Organisations, (KENGO), Proceedings of Agroforestry Workshop for High-Potential Areas in Kenya, E/DI, Nairobi, 1983.

30. Khandelwal, K.G., "Biogas in India, "Rural News and Views, Vol.6., No.4., Consortium on Rural Technology, New Delhi, 1984.

31. Killick, Tony, Editor, Papers on the Kenya Economy: Performance, Problems and Policies, Heinemann Educational Books, Nairobi, 1981.

32. Lapin, Lawrence, L., Statistics for Modern Business Decisions, 3rd Ed., Harcout Brace Jovanovich, New York, 1982.

33. Lele, Uma, The Design of Rural Development: Lessons from Africa, John Jopkins, University Press, Baltmore, 1975.

34. Milas, Seifulaziz, "Desert Spread and Population Boom, "Desertification Control Bulletin, No. II, 1984.

35. Mildeberger, Elizabeth, Women and Household Energy in Murang'a District, Maendeleo Ya Wanawake/

GTZ, Unpublished Report, Nairobi, 1986.

36. Misiko, P.A.M., Madhu, S., Singh, and Mutuku Nzioki, Editors, Alternative Rural Energy Source, Egerton College, Njoro, 1978.

37. Moi, Daniel T., Kenya African Nationalism: Nyayo Philosophy and Principles, MacMilian, 1986.

38. Murdoch, William W., Editor, Environment: Resources, Pollution and Society, 2nd Ed., Sinauer Associates, Sunderland, Massachusetts, 1975.

39. Muriuki,Godfrey, A History of the Kikuyu 1500-1900, Oxford University Press, Nairobi, 1987.

40. Mwandosya, M.J., and M.L.P Luhanga, "Energy Use Patterns in Tanzania", Ambio, op. cit.

41. National Academy of Sciences, (NAS), Energy for Rural Development: Renewable Resources and Alternative Technologies for Developing Countries, NAS, Washington, D.C., 1976.

42. NAS, Supplement: Energy for Rural Development, 1981.

43. NAS, Methane Generation from Human, Animal and Agricultural Wastes, NAS, Washington, D.C., 1977.

44. NAS, International Workshop on Energy Survey Methodologies for Developing Countries, NAS, Washington, D.C., 1980

45. NAS, Microbial Processes: Promising Technologies for Developing Countries, NAS, Washington, D.C., 1981.

46. Ndegwa, P., L.P. Mureithi and R.H. Green, Editors, Development Options for Africa in the 1980s and Beyond, Oxford University Press, Nairobi, 1987.

47. Oelert, G., F. Auer, K. Pertz, Economic Issues of Renewable Energy Systems: A Guide to Project Planning, GTZ, Eschborn, 1987.

48. O'Keefe, Phil, and Paul Raskin, "Fuelwood in Kenya: Crisis and Opportunity", Ambio, op. cit.

49. O'Keefe, Phil, Calestous Juma and Jean-Marion Aitken, "Wood in Towns: No Money to Burn", The Courier, op. cit.

50. The Readers Digest Association, Reader's Digest Great Encyclopedic Dictionary, 3rd Ed., Pleasantville, 1969.

51. Republic of Kenya, African Socialism and Its Application to Planning in Kenya, Nairobi, 1965.

52. Republic of Kenya, 1979 Population Census Report.

53. Republic of Kenya, Development Plan, 1984-1988.

54. Republic of Kenya, Kiambu District Development Plan, 1984-1988.

55. Republic of Kenya, Sessional Paper No.1 of 1986

on Economic Management for Renewed Growth.

56. Sasse, Ludwig, Biogas Plants, GATE/GTZ, Eschborn, 1984.

57. Shanahan, Yvonne, "Woodfuel and the Rural Household", The Courier, op cit.

58. Smith, Kirk, "Biomass Fuels, Air Pollution and Health", Ambio, op. cit.

59. Steppler, H.A., and P.K.R. Nair, Agroforestry: A Decade of Development, ICRAF, Nairobi 1987.

60. Stotz, D., Production Techniques and Economics of Smallholder Livestock Production Systems in Kenya, Ministry of Livestock Development, Nairobi, 1983.

61. Timberlake, Lloyd, Africa in Crisis, Earthscan, London, 1985.

62. Timberlake, Lloyd, Only One Earth: Living for the Future, BBC/Earthscan, London, 1987.

63. United Nations Centre for Human Settlements, Habitat, Energy Requirements and Utilization in Rural and Urban Low-Income Settlements, Nairobi, 1984.

64. Wanjama, Leah, N., Planning for Rural Energy With Special Reference to Kikuyu Division, M.A. Thesis, University of Nairobi, 1985.

65. Wesenberg, R. and P.M. Gichohi, Biogas Workshop, East Africa, Unpublished Paper, GTZ -

Special Energy Programme, Nairobi, 1987.

66. White, I.D., D.N. Mottershed and S.J. Harrion, Environmental Systems: An Introductory Text, Allen and Unwin, London, 1986.

Appendix No. 1

HOUSEHOLD QUESTIONNAIRE

I. RECORD IDENTIFICATION

Interviewer:.......................Date:.................

Village:...........................

Household No:......................

Name of Respondent:................

Head of Household:.................Occupation............

Respondent Identification: Education

	Occupation:	Std.:	Form:	Age:
1. Husband:	....	.....	.....	....
2. Wife :	....	.....	.....	....
3. Other Individual:	....	.....	.....	....
4. Daughter:	....	.....	.....	....
5. Son :	....	.....	.....	....

Household Size:

Adults:.........................

Under 16 Years:................

Size of Landholding: Acres:.......... Hectare:.......

Do you own it: Yes......... No......

What do you produce on it?

....

II. WOODFUEL

Fuelwood (Firewood)

Quantity Used Yesterday: Kg:.......... Pieces:........

Quantity Used in a Day : Kg:.......... Pieces:........

Quantity Used for Cooking:............................

Quantity Used for Other Reasons:......................

....

What Were the Other Reasons?:.........................

....

....

If Collected:

Source:	Distance From Home:	Time Spent:
1. Own Shamba:.........	....	....
2. Neighbour:..........	....	....
3. Common Land:........	....	....

If Purchased:

Price per unit: KShs:.............. KShs./Kg.

Distance to Purchase: Km:..........

Agroforestry ....

Do you understand it?..................

Do you practice it? ....

III. CHARCOAL

How Much Used:............Per Week ....Per Month

Cost:................Per Bag Other Container:.....Cost

Where Purchased: Distance in Km:.......................

Do you burn your own charcoal?:........................

....

Is it Available when Needed?:..........................

If not Why?:...

....

IV. COFFEE HUSKS

Do You Use Coffee Husks,,..............................

....

Cost:..............Per Bag ....Per Kg.

Distance to Purchase: Km.:....................

How Long Does It Last?:......................Days

V. OTHER SOURCES OF WOODFUEL

Name:..

Source:..

Quantity:......................................

Cost if Any:...................................

Distance Km:...................................

VI. PARAFFIN

Quantity Used: Per Day........... Per Week..............

Cost KShs.: Per Bottle.......... Size of bottle........

Other Container:......... Size of Container:.............

Distance to Purchase:...................................

Is It Always Available When Needed?:....................

If Not, Explain:..

....

....

VII. COOKING STOVES USED

1. 3-Stones:..
2. Homemade Fuelsaving:.................................
3. Purchased Fuelwood Saving:...........................
4. Ordinary Charcoal Jiko:..............................
5. Energy Saving Charcoal Jiko:.........................
6. Coffee Husks...
7. Paraffin Stove:......................................
8. Others:..

VIII. LIGHTING

Type of Lamp(s):..

....

....

Cost of Lamp: KShs:.....................................

How Often Does it Need a New Glass:.....................

....

Cost of Glass:..

How Often Do You Change the Mantle?:.......................

....

Cost of Mantle:..

IX. COOKING

Food Cooked by:..

Cooked for How Many People?.................................

Types of Meals Cooked Yesterday:

	Breakfast:	Lunch:	Dinner:
1. Githeri:	....	......	....
2. Ugali and Meat + Vegetables:	....	......	....
3. Ugali & Vegetables:	....	......	....
4. Potatoes & Vegetables:	....	....	....
5. Tea:	....	....	....
6. Porridge:	....	....	....
7. Others:	....	....	....
	....	....	....

X. SMOKE:

Is it a Problem?:..

If Yes - with which Fuel?:......................................

What Kinds of Problems?:.......................................

....

XI. WATER: Do you pay for Water? Yes........ No........

Source — Cost KShs.

Tap Water:.................. ....per month

Communal Point:............. ....per month

Other Sources:.............. ....per month

Time Spent on Collecting Water - Hours:...............

Distance to Collect - Km:............................

Do you Practice Irrigation?:.........................

XII. LIVESTOCK: Number:

Cows: ....

Grade Cows: ....

Bulls: ....

Grade Bulls ....

Pigs: ....

Poultry: ....

Goats: ....

Sheep: ....

Rabbits: ....

Methods of Grazing

Permanent Zero Grazing:........................

Night Boma:...................................

Tethering:....................................

Taken Out to Graze:...........................

Other Methods:................................

Livestock Feeds: Type:

Grown on Shamba: ....

....

....

Agricultural Residue: ....

....

Purchased: ....

....

Cost Per Month: KShs.: ....

Livestock Dung

Do you Use it for Cultivation:...................

If Yes. How:.....................................

....

If Not - Why Not?:...............................

....

What else do you do with dung ....

....

XIII. BIOGAS

Have You Ever Heard of It?:......................

Have You Seen It?:...............................

What Do You Think of It After Explanation?:.......

....

Would You Be Interested In Using Biogas?:.........

If Yes - Would You Want to Own the Biogas Unit

by Yourself Alone or Own It Jointly with Neighbours?

<u>Alone</u> <u>Own Jointly</u>:

....

If Jointly, How do you propose to manage it?.............

....

What Problems if any do you foresee with the neighbours?:

....

....

How can these problems be solved?:......................

....

....

If you own a Biogas Unit what problems have you had?:

....

....

XIV. <u>SOCIO-ECONOMIC ACTIVITIES</u>

Head of Household:......................................

Are you an active official of the Church?:...............

If Yes, which Denomination?..............................

Are you a Member of a Cooperative Society?:..............

Name(s):...

....

If a Man: Is your Wife a Member of a Women's Group?:

..............If Yes, which one(s)?:....................

....

If a Woman: Are you a Member of a Women's Group?.........

If Yes - Which One(s)?:...

....

Are You a Member of Other Organisations?:.................

If Yes, Which Ones?:..

What role do you think the following can play so that the energy problems can be solved in your area?:

1. Women's Groups?:..
   ....
2. Church?:...
   ....
3. Youth Polytechnic?:..
   ....
4. Cooperative Society?:..
   ....
5. Others?:..
   ....

In your opinion what are the problems you have in order of priority?:

1. ....
2. ....
3. ....

How do you think they can be solved?:.....................

....

In your opinion what are the Community Problems in order of importance?:

1. ....

2. ....

3. ....

How do you think they can be solved?:..............

....

Where do you expect your help to come from?:.......

....

Appendix 2

COST ANALYSIS FOR GASHOLDER FABRICATION FOR AN AVERAGE FAMILY BIOGAS DIGESTER, 9.4 M^3

1. Owner/Name of Workshop ------------------------------
   Location of Workshop ------------------------------

2. Cost of 4' x 8' x 1/8" M.S. Sheet Metal Sh. ---------
   Number of Sheets used ------------------------------

3. Cost of 20' x 2½" GI pipe. Sh. ---------------------
   Length of pipe used -------------------------------

4. (a) Cost of 1½" x 1½" angle line. Sh.--------------
   Total Length used ------------------------------

   OR

   (b) Cost of 20' x 3/8" Reinforcing bar. Sh. --------
   Total Length used -----------------------------

5. Cost per 5 Kg Welding rods used --------------------
   No of welding rods used ----------------------------
   Cost per welded rod Sh. ----------------------------

6. Cost of 2 lit. Red Oxide Primer. Sh. ---------------
   2 lit. green oil paint. Sh. ---------------
   2 lit. black oil paint. Sh. ---------------
   Painting Charges. Sh. ------------------------------

7. If any other fabrication costs
   Please specify --------------------------------------

   Cost Sh. --

Total cost of the gasholder. Sh. ----------------------

M.S. - Mild Steel
GI - Galvanised Iron

Source: Ministry of Energy (Builders' List)

Appendix 3

B I O G A S

Materials required for the construction of an average family's biogas digester, 9.4 M^3.

CONSTRUCTION MATERIALS

No.	Item	Quantity
1.	Stones	550' x 4" x 9" or 550' x 6" x 9"
	or	
	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 ton
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.

F I T T I N G S

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 4

Mean Monthly Total Energy Consumption per Household

KShs.	Frequency: %
0 - 100	14
101 - 200	26
201 - 300	31
301 - 400	7
401 - 500	8
501 - 600	4
601 - 700	1
701 - 800	4
801 - 900	2
901 - 1000	0
1001 - 1100	0
1101 - 1200	1
1201 - 1300	1
1301 - 1400	0
1401 - 1500	1
Total	100

Mean Monthly Consumption per Fuel Per Household

Fuelwood	Shs. 96.80
Charcoal	Shs. 88.10
Coffee Husks	Shs. 45.15
Paraffin	Shs. 64.15