THE CONSUMPTION OF ENERGY FOR DOMESTIC USE IN THREE AFRICAN VILLAGES.

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ABSTRACT.

Very little information is available on domestic fuel consumption in African villages in Southern Africa. And yet, it is a problem that concerns a large number of people, and which is contributing to environmental deterioration. At three villages, in Lesotho, Transkei and KwaZulu, the collection and consumption of wood, dung and paraffin were recorded. The largest quantities of energy are consumed in KwaZulu with the least in the Transkei (only slightly below Lesotho). The total consumption of energy largely depends on the availability of wood. When wood becomes scarce, dung is burnt for heat and cooking. Paraffin is used for light, and for cooking by some women. Wood and dung are burnt at efficiencies of below 3%. The most obvious short term solution, to shortages of energy, is to raise the efficiency with which fuel is burnt. In the long term, alternative energy sources must be developed.

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CHAPTER ONE
INTRODUCTION.

Energy is as essential to human welfare as is food. Food itself can be defined as a form of energy. The consumption of energy in rural villages throughout the world has been ignored until recently. The articulation of third world issues, and the global recognition of the central importance of energy in development, have caused an increased awareness of the shortages of energy supplies in many rural villages. The collection of fuel is putting pressure on the environment and, interconnected with other forces, is resulting in deterioration, desertification and flooding in sensitive regions. The burden of collecting fuel falls exclusively on women. The absence of many of the men, working permanently or temporarily in urban centres, reduces the possibility of remedial action.

No detailed studies on energy consumption in Southern Africa have been published. The values on wood consumption are either informed guesses or derived from studies elsewhere in Africa. Southern Africa includes a wide range of environmental conditions. The problems of desert encroachment, soil erosion and the denudation of vegetation, are recognized in Southern Africa. There is an unusual juxtaposition of traditional society and industrial society. This project is a preliminary study of the consumption of energy in rural African villages in Southern Africa without focusing on any one aspect of the whole issue. The project includes components from several different academic disciplines.

1.1 THE ENERGY SYSTEM.

In a village structure there are several energy systems which interact to form the total energy system. Some of

the systems are food, domestic energy, transport and movement and agricultural production. This project is only concerned with the consumption of energy for domestic uses. The recognized functions for this energy use are cooking, heating and light. Only the fuels which are burnt in these activities are considered and not the human energy spent in cooking, and preparing the food. The human energy used to collect the fuels is discussed in the surrogates of time, distance and money.

1.2 OBJECTIVES.

The objectives of this project are:

i. To collect reliable statistics on the consumption of all major types of fuel burnt for domestic use in three villages in three different physical environments.

ii. To examine the negative implications of the consumption of domestic energy within the village system. This is to clarify the extent to which there are shortages of available energy supplies and the extent to which obtaining domestic energy is a social problem. Secondly, it is to examine the biophysical effect of the collection of fuel.

iii. To make proposals upon which further research can be based towards implementing practical solutions aimed at alleviating energy shortages.

1.3 METHODS.

Three villages were selected for the research in different areas. The villages are in Lesotho, the Transkei and KwaZulu. The villages were visited three times during the year to obtain fuel consumption measurements in summer, autumn and winter. Consumption of fuel was measured in as many households as time permitted, by weighing a pile of fuel before and after a period of use. Interviews with the women were conducted through an interpreter in

order to determine fuel quantities collected, as well as time and frequency of collecting fuels. The source areas for wood were visited and vegetation parameters were recorded. A number of field experiments were made to determine the efficiency of combustion of the different fuels in different conditions. The project attempted to be empirical wherever possible, to avoid distortions in the data base. Wherever verbal estimates were made by the women, some measure of the reliability of this information was obtained when possible.

CHAPTER TWO

COMPARATIVE STUDIES OF ENERGY CONSUMPTION IN THIRD WORLD VILLAGES.

Although there has been an awareness of the problems of energy consumption in rural third world villages throughout this century (see MacMillan, 1930), the issue has received far more attention recently. This is probably due to an increasing awareness of developing countries and their needs, the formalization of intermediate technology and the dramatic rise in the prices of crude oil.

The significance of rural energy supplies is such that "wood, animal dung and crop residues ... provide the barest energy necessities for 50 - 60% of the world's people." (Makhijani and Poole, 1975 : 1). In some cases paraffin is also used in cooking. The consumption of each fuel type in third world villages is dealt with individually.

2.1 WOOD.

"Wood is still one of the most important fuels for personal use in the world" (Strong, 1978 : 169), and is used by 80% of all the people in developing countries (Openshaw, 1974 : 271). Those who depend upon firewood for their energy requirements in cooking and heating are amongst the poorest population group, and do not have access to alternative commercial fuel supplies. (Eckholm, 1976 : 81). Several studies have been concerned with rural energy consumption. Those studies that provide quantitative information do not always distinguish between rural and urban energy consumption in developing countries.

2.1.1 The World.

Zon and Sparhawk (1923) and Earl (1975) give estimates of fuelwood consumption in all countries (table 2.1). These figures included urban energy consumption and indicate the proportion of total energy derived from fuelwood. The accuracy to which non-commercial firewood, gathered in rural areas, has been included, is not known.

	Fuelwood m^3 p cap		% tot energy cons	
	1923	1975	1923	1975
North America	2,51	0,14	47,2%	0,7%+
Europe	0,47	0,12	46,9%	3,85%+
Asia	0,21	0,25	80,6%	
China	0,14		85,0%	
India	0,12	0,19	88,8%	30,3%
South America	0,98	0,70	88,4%	
Brazil	1,11	1,60	92,5%	59,1%
Peru	0,24		90,9%	
Africa	0,14	0,63	85,3%	
Basotuland	0,08		95,0%	
Nigeria	0,14	1,00	97,7%	90,6%
South Africa	0,22	0,04	54,0%	0,6%
Algeria	0,07	0,02	48,4%	1,9%
Tanzania	0,11	2,30	95,0%	96,0%
Australia and Oceania	0,63	0,25	61,4%	
World	0,49	0,30	54,4%	

Table 2.1 : Annual Fuelwood Consumption in Certain Areas (Zon and Sparhawk, 1923 and Earl, 1975)

\+ Averaging available countries.

In a large part the reduction in the proportional consumption of fuelwood can be attributed to the use of commercial fuels in urban areas. It seems doubtful that there has been a significant change in firewood consumption in rural

REGION	QUANTITY (tonnes)	ENERGY (10^3MJ)
Developing countries[+1]	1-1,3	22,14-28,78
India[+2]	0,24	6,43
(East Gangetic Plain)[+3]	0,18[++]	4,0
(Mangaon)[+4]	0,05[++]	1,05
Nepal[+5]	0,37[+]	8,19[++]
(hills and mountains)[+5]	0,27[+]	5,98[++]
(Terai)[+5]	0,54[+]	11,96[++]
Thailand[+1]	1,1	24,35[++]
China		
(Hunan)[+3]	0,9[++]	20,0
(Peipan)[+4]	0,95[++]	21,07
Bolivia		
(Quebrada)[+4]	2,0	44,28[++]
Mexico[+3]	0,68[++]	15,06
Nigeria[+6]	0,36	7,97[++]
(Batagawara)[+4]	0,71[++]	15,8
Gambia[+1]	1,2	26,57[++]
Tanzania[+1]	1,8	39,85[++]
(Kilombero)[+4]	1,5	23,17

Table 2.2 : Per Capita Consumption of Woodfuel in Rural Areas.

+1 Openshaw 1974.

+2 Henderson 1975.

+3 Makhijani 1976.

+4 Makhijani and Poole 1975.

+5 Earl 1975.

+6 FAO 1966.

\+ Converted to weight using specific gravity of 0,54gm cm^{-3} for wood.

++ Assuming 22,14 KJ gm^{-1}.

areas other than that due to decreasing availability of firewood. Total per capita energy consumption in India has not changed in rural areas between 1953 - 1973 (Henderson 1975 : 184).

Where firewood is abundant, only dead wood is collected, but with decreasing availability, saplings and then mature trees are cut (Openshaw, 1974 : 271). Hayes (1977 : 351) states that half the trees cut down in the world are for cooking and heat. In India, only 7% of wood consumption is from recorded sources, the remainder being collected by the people from bush land or illegally from state forests, and wood accounts for 67% of non-commercial energy consumption (30% total energy consumption) (Henderson, 1975 : 167).

In a number of specific studies, the consumption of firewood in rural villages has been recorded. These figures are shown in table 2.2.

In Nepal, a total of nine estimates of annual per capita woodfuel consumption made by five studies, covering different areas (Earl, 1975), show an average consumption of 1,06 m^3. The standard deviation of the results is 0,69 (i.e. coefficient of variability is 0,65), indicating that either there is a significant difference in consumption in different areas, or that different researchers will produce different results.

2.1.2 Southern Africa.

Concern at the supply of fuel in rural areas of Southern Africa has been voiced for many years (Dutton, 1923; MacMillan, 1930; and Fair, 1945). The Social and Economic Planning Council (1946 : 55) stated that "adequate provision for Reserve Natives' fuel and other rough wood requirements is a matter of primary importance." More recently Dr. M. Grut (in Bond, 1977 : 31) stated that "Firewood is the most important energy source in Southern Africa. Not only ...

in terms of dependent peoples, but in terms of released energy."

General figures on the consumption of firewood in Southern Africa are sparse. Sim (1921 : 23) states that from 1910 to 1916, a total of 18,544,000 ft^3 of firewood was sold or issued free from Crown indigenous land (an average of 75 000 m^3 annually). Neethling (1943 : 18) estimates that in 1939, 3,5 million ft^3 (98900 m^3) of firewood was sold from government forest and an additional 12 million ft^3 (339000 m^3) at least, from private sources. Between 1960 and 1968, on average, 28,6% of the wood production on South African Bantu Trust land administered by the Department of Forestry, was sold for firewood (Annual Reports, 1960 to 1968, Dept of Forestry). Finally, van Niekerk (1974 : 9) estimated a consumption of 0,713 million m^3 of non coniferous roundwood as firewood in 1972. All these figures are probably an understatement of the real consumption of firewood since "South Africa's total firewood consumption may be 20 times above the official estimate" (Dr M. Grut in Bond, 1977 : 32). Also none of these figures attempt to distinguish between urban and rural areas.

The only published estimate of wood consumption by families in rural areas of Southern Africa, is of 6 tons of wood per family per year (Social and Economic Planning Council, 1946 : 55). This, on the basis of 6,28 persons per family (see Appendix A), is a consumption of 0,96 tons of firewood per capita per year. This estimate is made for a family in the Transkei. The same report, on the basis that one acre of woodlot could supply a family's fuelwood needs, estimated that the Transkei would require 251 000 acres of woodlot, and the other South African Native Reserves, a total of 413 000 acres of woodlots. In 1946, the Transkei possessed 16 000 acres of woodlots and in 1967, there were 40 161 morgen of Trust land with 12 020 morgen planted by Africans for "fencing posts, cattle pens and firewood" (Horrell, 1969 : 53), excluding the Transkei.

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	Total Quantity (tonnes)	Quantity per Capita (kg)
India [1]	100 million	180
India (Mangaon) [2]		156+
India [3]	38,1 million	87 (per family)
India [4]	70 million	128
Pakistan [1]	11 million	260
Turkey [1]	14 million	390
Transkei [5]	130 000	82

Table 2.3: Annual Dung Consumption by Region.

1 Earl (1975 : 18).

2 Makhijani and Poole (1975 : 27).

3 Revelle (1976 : 139) from National Sample Survey (of India) 1963/4.

4 Henderson (1975 : 24).

5 Social and Economic Planning Commission (1946 : 54).

+ Assuming dung has a calorific value of 13,48 $KJ.gm^{-1}$.

In India, the country for which the most detailed statistics are available, estimates of the proportion of cow dung produced, which is burnt as fuel, vary from 30% (Vidyalaya, 1976) to 20-25% (Henderson, 1975) and 22-75% (Revelle, 1976). Of the total consumption of non-commercial fuels, cow dung represents 15% (Henderson, 1975); the coal equivalent per capita is estimated at 56 kg annually by Revelle (1976). Estimates of total consumption of cow dung, in India, burnt as fuel, range from 50-80 million tons of dry dung annually (see Eckholm, 1976 : 82, Hayes, 1977 : 350, and Revelle, 1976 : 970). In Bond (1977 : 32) there are loose estimates of 100 000 tonnes of cow dung consumed in the Transkei (63 kg per cap) annually and 2 tonnes consumed per family (323 kg per cap) in Zululand. The last value is potentially a maximum figure.

The worst implication of these figures is the loss of potential nutrients and humus from the soil. The loss of nut-

rients in the dung burnt in India, is equivalent to more than one third of the country's chemical fertilizer use (Eckholm, 1976 : 82). Makhijani (1976 : 11) estimates that the use of human and animal manure in composting, could make up more than 4 times the current deficit in fertilizer for food production in poor countries. It is ironic that, by the use of biogas plants, the manure could be used to provide methane gas for energy without reducing it's nutrient value (Hayes, 1977 : 352).

2.2.2 Crop Residues.

Even less information is available on crop residues. Traditionally, the animals are left to graze on the crop residues after harvest and what was not eaten was trampled into the soil to provide nutrients and humus. In Lesotho, crop residues were mixed into the dung before it was dried and burnt (Wallman, 1969 : 47). The burning of crop residues is mentioned by MacMillan (1930 : 215) and the Social and Economic Planning Council (1946 : 16) in the Transkei and by Eckholm (1976 : 82) in Nigeria and India. In India, vegetable wastes account for 20% of the non-commercial fuel consumption (Henderson, 1975 : 23) and one fifth of all crop residues are burnt (Revelle, 1976 : 971). This amounts to 32 million tons (or 73 kg per cap) per year in rural areas (Revelle, 1977 : 135). In Mangaon, India, it is reported that, on average, crop residues accounted for 1053,36 MJ per capita per year (Makhijani and Poole, 1975 : 27). Where crop residues are barely sufficient to feed livestock "it's use for fuel means that the animals are as malnourished as the people." (Revelle, 1976 : 139).

2.3 THE COMMERCIALIZATION OF FUEL.

The commercial fuels are paraffin, electricity and wood, which has become available as a priced commodity. Paraffin was considered the solution to shortages of firewood, but with the recent shortages of oil and rise in price of paraffin,

many villagers are turning back to firewood (Henderson, 1975 : 167 and Bond, 1977 : 32). Wallman (1969 : 71) found that five families, in a village near Mafeteng, Lesotho, spent 2,43% of their income on paraffin. Gay (1978 : 12), in a village also in the lowlands of Lesotho, found women spent 6,3% of their income on paraffin (a total of R4.78 monthly). The Poverty Datum Line for Lesotho allows R6.95 to be spent on energy, which is 7,2% of the minimum monthly income (van der Weil, 1977 : 89). Electricity has been installed in many Indian villages, but was found to benefit only 20% of the villagers (Makhijani and Poole, 1975 : 22).

Wood, previously considered as a non-commercial fuel, can easily become commercial once shortages exist. In a Hausa village, Nigeria, collecting and selling wood, earned a slightly above average wage for 5% of the economically active men (Hill, 1972 : 73). The price for the wood rose during the cold Harmattan period. In Niamey, Niger, the average manual labourer's family spent 25% of their income on fuel; in Onagadongou, Upper Volta, this was 20-30% (Eckholm, 1976 : 81). In India, fuel is 10-15% of a family's food bill (Vidyalaya, 1976 : 12). In Khartoum, Sudan, 70% of the town's wood was brought in by rail, and sold at a subsidized price because of shortages in 1946 (Stebbing, 1953). Finally, in Nqutu, KwaZulu, fuel accounted for 10% of the primary cost of living (Clarke and Ngobese, 1975 : 92).

The impact of fuel becoming available only on a commercial basis cannot be fully evaluated without looking at the total income structure. But since the population group, depending on non-commercial fuel, is the poorest in the world, it seems inevitable that buying fuel will divert money away from already insufficient food purchases.

2.4 THE DETERIORATION OF THE LAND.

It is very difficult to separate the actions of fuel collection from grazing, as the cause of environmental dete-

rioration. Makhijani and Poole (1975) suggest that in Africa, overgrazing is the most serious factor, while in China, it is the cutting of trees for firewood. Even the saplings in reforestation projects are cut for fuel in China (Richardson, 1966 : 66). Forests in China were completely cut down for fuel, a process which is now occuring in India where, excluding growth, it is estimated that all the forests will be cut down, at present rates of exploitation, in 24 years time (Revelle, 1976).

Overgrazing and deforestation initiate a cycle of deterioration in which runoff increases and becomes more seasonal, thus promoting flooding, such as the recent floods in India (see Openshaw, 1974 and Agarwal, 1978), while silting and soil erosion reduce the productivity of the land. This process is occurring in the fragile mountain areas of the Himalayas and Andes (Hayes, 1977 and Earl, 1975), and also in the arid areas of North Africa where the deserts are 'creeping' (Cywin, 1978). Each year in North Africa, 100 000 hectares of land is lost to the desert (Eckholm, 1976). This is no new problem, having been raised by Stebbing in 1938, and 1953. Once trees have been removed, the dung is burnt which further deprives the soil of nutrients and humus.

In Southern Africa, the problem is frequently alluded to (Social and Economic Planning Council, 1946, and MacMillan, 1930), especially in connection with mountain catchment areas (Fair, 1945, and Department of Agriculture and Technical Services, 1961). In the indigenous Nxamalala forest, Natal, an estimated 89 acres are lost each year to the pressure of illegal wood cutting (Taylor, 1963 : 36). Generally, overgrazing is quoted as the cause of deterioration and the role of firewood collection is hard to determine and unclear. Germond (1967) traces the deforestation of the lowlands of Lesotho to the late 19th century, when the arrival of Europeans, a rinderpest epidemic (destroying livestock, and dung supplies) and an exceptionally cold

winter resulted in the clearing of large tracts of forest.

2.5 CONCLUSION.

That there are so few studies on fuel consumption in rural third world villages, is surprising, considering that "much attention has been paid to the population food equation, (yet) scant notice has been given to the question of how the growing numbers will cook their food" (Hayes, 1977 : 351), and that one is dealing with 50 to 60% of the world's population (Makhijani and Poole, 1975 : 1). Many of the reports quoted in this chapter draw their facts from an even smaller number of basic studies. A number of statistics suggest that firewood consumption, per capita, varies between 0,2 and 2,0 tonnes per annum in rural third world regions. Dung consumption has been found to vary between 80 and 400 kg per capita per annum. Other important fuels that are also consumed are paraffin and crop residues. The essential requirement of energy to all families causes severe demands on the time and money available to families in rural areas. The repercussions of burning wood and dung are far more widespread, affecting large fragile ecosystems, and contributing to flooding deforestation, soil erosion and desertification.

CHAPTER THREE
THE METHODOLOGY AND RELIABILITY OF THE RESEARCH.

This chapter outlines the methods used to collect information. It's purpose is to support the analysis of the results, and to allow the adaptation of these methods to any other research. The method is then examined to define the potential for error and misrepresentation within the data.

3.1. RESEARCH METHOD.

Three villages were selected for field research on the basis of geographical spread, remoteness and convenience. The villages were located in Lesotho, Transkei, and KwaZulu. Field work for this project covered a period from December 1977, until July 1978, of which six months were spent in the field. The field research covered as much of the annual cycle as possible in order to monitor seasonal changes in energy consumption. The collection of information was achieved through an interpreter during interviews structured around a questionaire. The consumption of individual fuel types was measured empirically.

3.1.1 The Criteria for Selecting Villages.

The decision to consider three villages resulted from the time available for fieldwork, and the absence of any other studies in Southern Africa focusing on energy consumption in rural African villages. Two approaches which could have been used in selecting the villages were:

i. To investigate microscale differences between villages adjacent to one another.

ii. To explore macroscale differences between villages widely separated spatially and environmentally.

The latter approach was adopted as being potentially more fruitful in a preliminary study.

A second criteria, in view of the rapid spread of Western culture, was to select villages in remote areas where a large degree of the traditional structure might still exist. Finally, specific villages, within the larger regions, were chosen where personal contacts could be used to gain an introduction to the village during field research.

The three villages that were selected are, Malefiloane (Mokhotlong province, Lesotho), Jozanna's Nek (Herschel district, Transkei), and Mashunka (Msinga, KwaZulu).

3.1.1.1 Geographical spread.

The purpose of selecting widely separated villages is to obtain a range of different environmental factors, and to see the extent to which these influence energy consumption. Table 3.1 lists some of the biophysical characteristics of each village.

	MALEFILOANE	JOZ NEK	MASHUNKA
Altitude (m)	2680	1710	670
Dec Temp (Av)	16,4°C	21,3°C	23,1°C
June Temp(Av)	4,9°C	7,9°C	11,1°C
Rainfall (mm)	574,7	649,0	660,1
Veld Type +	58	48/58	23

Table 3.1 : Some Biophysical Characteristics of each Village.

\+ Veld Type Numbers from Acocks (1952).

Malefiloane and Jozanna's Nek are within the Drakensberg system (with Jozanna's Nek on the southern fringe), and show similar characteristics. Mashunka, in the Tugela valley (Natal), is significantly different.

3.1.1.2 Remoteness.

Remoteness can be defined spatially as distance or time to the nearest trading store or marketing centre. Alternately, remoteness can be conceptualised as the survival of traditional structures in the face of change towards an industrial consumer society. Indicators which attempt to quantify the latter are housing structures, (the roofing material), migrant labour, the use of consumer articles (such as paraffin lamps, stoves and heaters), and other unrecorded aspects such as radios, cars, cultural traits and rituals.

	MALEFILOANE	JCZ NEK	MASHUNKA
Dist to shop	1 km	in village	4 km
Dist to town	18 km	12 km	22 km
Time to town (by foot)	5 hr	3 hr	4 hr
Time to town (by horse)	3 hr	-	-
Time to town (by car)	1 hr	20 min	25 min
% Corrig++ roofs	0	55%	0
% E.A.+ men migrants	73%	78%	-
% E.A. women migrants	0	15%	-
% with paraff lamps	100%	100%	100%
% with primus stoves	43%	92%	25%
% with primus heater	0	15%	0

Table 3.2 : Remoteness Indicators for Each Village.

+ , Economically Active.
++ Corrigated zinc sheets.

Only Malefiloane really fulfilled the criteria of remoteness, while Jozanna's Nek was the least remote village, both spatially, and conceptually. Mashunka showed a high degree of conceptual remoteness, while having relatively easy access to large urban centres in Natal.

3.1.1.3 Personal contact.

The access and introduction to each village depended on circumstance. In Malefiloane the researcher participated on a workcamp constructing a clinic one kilometer from the village. An introduction to the Headman of Jozanna's Nek, Klas Mangwana, was obtained through Lili Hlatshaneni, (Chairperson of Zenzele Women's Organisation, Herchel District) with whom the researcher had had previous contact. Mashunka is a village adjacent to the Churches Agricultural Project farm, Emduktshani, run by Neil Alcock, where the researcher stayed and through which interpreters were arranged.

3.1.2 Monitoring Periods.

Each village was visited three times to monitor seasonal changes in energy consumption. This also served to obtain a wider data coverage, improve the information collections and develop the relationship between the researcher and the community.

It was considered essential to obtain a record of energy consumption that included responses to the annual climatic cycle. This presumed an increase in energy consumption during the cold winter period. As there was not enough time for the field-work to cover a whole year, it was assumed that energy consumption in spring and autumn would be similar and the field-work was carried out in summer, autumn and winter.

Returning to the village several times, allowed the re-

searcher to concentrate on different aspects of the data base during each visit. The largest collection of data occurred in autumn when, in addition to experiments on efficiencies of combustion, biomass fuel potential and demographic data (income and age statistics), the researcher attempted to obtain two or three consecutive readings on energy consumption at each household, to estimate the daily variation. The basic data on quantities of fuel consumed was collected on each visit.

With each visit the research technique was improved in order to overcome limitations and possible errors. The first visit, in summer, collected the basic data on quantities of fuel burnt, and developed the questionnaire which was again restructured for the third visit. An example of the improvements was the change from asking women how often in a week, they collected wood, to whether they collected wood last Monday, Tuesday, etc.

Returning to the villages deepened the contact between the researcher and the community so that the people became familiar with his subject and method of operation. While most women became more helpful as a result of the contact, a few women resented what appeared, to them, to be a futile repetition of the same questions.

3.1.3 The Collection of Information.

Since the fieldwork took place in three different linguistic areas where few women spoke English, it was necessary to use interpreters. The data collection fell into two categories. Firstly, the empirical measurement of each type of fuel consumed, and secondly, information collected verbally from the women using a questionnaire as a guidline.

3.1.3.1 Interpreters.

Interpreters were arranged on arrival in each village. It required several days to find someone able to interpret

(out of a very small number of people sufficiently fluent in both languages), and required that the research be organized around the other responsibilities of the interpreter. A total of fourteen interpreters translated during the research, of which six worked for longer periods. This allowed a subjective appraisal of the impact of an interpreter on the information collection (which is discussed in section 3.2.3.2).

3.1.3.2 The measurement of empirical information.

The empirical measurement of the consumption of each fuel type formed the core of this project. Data was collected empirically in the following areas:

i. Weighing of wood, dung or paraffin:
To measure fuel consumption, the women were asked to make a pile of wood or dung sufficiently large to last for two or three days. This was weighed using two round dial spring scales (Salter model 235 calibrated 0 - 100kg x 500gm, and 0 - 10kg x 50gm). The women were asked to take all fuel from these piles for the period of the experiment, the piles were then reweighed one to three days later. If the pile was finished before reweighing, the woman was asked when the last fuel was burnt. The volume of paraffin was either estimated visually when in a glass bottle or weighed (and converted using 1 kg = 847 ml) if in a tin or plastic container, again at two time periods.
ii. Calorific value of each fuel:
Samples of wood and dung were collected and the calorific value was obtained using a macrobomb Calorimeter in the Zoology Department at UCT. (See Appendix A for all the results). The values for paraffin and coal were obtained from the Department of Planning and the Environment. (1978, v3 : 191 - 2).
The following values were used to convert fuel types to heat units.

Wood	Malefiloane	23,26	MJ/kg
	Jozanna's Nek	22,81	MJ/kg
	Mashunka	21,03	MJ/kg
Kraal dung		11,47	MJ/kg
Field dung		16,72	MJ/kg
Paraffin		38,00	MJ/l
Coal		30,00	MJ/kg

iii. Efficiencies of combustion:
A detailed description of this procedure is given in section 5.3.1. The instruments that were used are the spring scales, a 500 ml measuring cylinder calibrated to 5 ml (to measure the volume of water), and for temperatures, an instrument using two thermocouples covering the ranges 0 - 5 mV and 0 - 50 mV (for temperatures up to 115°C and 870°C respectively), built by Anton Flepp (School of Environmental Studies, UCT.)
iv. Biomass fuel potential:
A number of quadrats, at increasing distances from each village, were sampled to examine the available fuel and the vegetation structure. The quadrats were located on a vector towards the area where most women collected their firewood. In a 10 x 10 m quadrat, height and cover of vegetation, soil erosion, damage to plants and tree or bush species, were noted. In a smaller 1 x 1 m quadrat, the weight of available firewood was measured. Where the quadrat contained trees (at Mashunka), the total trunk and branch volume was estimated (taking tapering and dividing into account) and, using a measured specific gravity of 1,886 gcm^{-3} (measured in the field), converted to mass.

3.1.3.3 Information obtained verbally.

This information was obtained through the interpreter during an informal interview. The two questionnaires which were developed to organize the required information are presented in Appendix B . The questionnaire was not followed rigidly. A core of information concerning the

size of each household at home (for per capita consumption of fuel), frequencies and time of collecting fuel, and verbal estimates of fuel consumption (to measure the accuracy of verbal estimates), was collected on each visit. The other information on incomes and ages were only collected once (successive measures would have defined its reliability but increased the length of interviews too much).

3.2 THE RELIABILITY OF THE INFORMATION.

Any study covering sociological and anthropological variables inevitably incorporates a large potential for error. This section discusses the representativeness of the villages that were selected and of the group sampled within each village. Finally it examines the errors that might arise from the methods of collecting data.

3.2.1 How Representative are the Selected Villages?

The extent to which the results from one village can be extrapolated over a larger area should be limited by applying categories of narrowing spatial generality. These are tribal and clan grouping, vegetational type and topography. In addition, social structure and population densities will have an effect. From section 5.2.2, it is apparent that energy consumption relates to the available fuel resources. This is the access to and extent of wood, dung and paraffin supplies, which in turn, relate to local scale variations, and alter with each village. This study is concerned with the interaction between fuel consumption, resources and population, and does not attempt to estimate fuel consumption over larger geographical areas.

3.2.2 How Representative are the Groups Sampled.

Only Malefiloane was small enough for the whole village to be sampled. In Jozanna's Nek and Mashunka, the observations were spread between different sections of the village. Otherwise sampling was based on random visual

selection and the need for someone to be at home. As the same group was not sampled in each village (either because no-one was home or to broaden the sample), in tables 4.19 to 4.21 a control group, of households sampled on each visit, is identified.

3.2.3 Shortcomings of the Interview Method.

Two aspects of the use of the interview method in this context are liable to introduce errors. Firstly, the difficulty of translation and secondly, the presence of the interviewer.

In social surveys "it is normally impossible to arrive at a wholly unambiguous and completely acceptable measure of any variable" (Babbie, 1973 : 253), especially when the questions and replies must be translated. The interpreters were mostly fluent in the local African language with varying degrees of fluency in English. None were professional interpreters. To some extent it was possible to see if the interviewee understood the questions from her reply. An error that is far harder to notice occurs when the interpreter, aware of the form of answer desired by the interviewer (from past experience) simplifies the replies to fit this format or even prompts the respondent (Williams, 1967 , and Crane and Angrosino, 1974). The factual and empirical nature of most of the questions should have minimised these errors to a large extent.

Ideally "the interviewer's presence should not affect a respondent's perception of a question, nor the answer given" (Babbie, 1973 : 172). A white interviewer could have elicited an emotional response from the people, and whenever a woman appeared afraid, hostile or suspicious, no further questions were asked and no measurements were taken. Fear and suspicion were only noticed in Jozanna's Nek. In Mashunka, two people were suspicious of an interpreter, on one occasion, because he came from a village far away, and was too well dressed.

3.2.4 Errors Within the Measured Data.

A number of sources of error can be identified in the collection of the measured data. No estimates of these errors can be made.

3.2.4.1 The use of unrecorded fuel.

This would occur when fuel from some source other than the pile of weighed fuel was used. This was noticed on a few occasions and might have occured unnoticed on other occasions. Reasons for using other fuel could be:

i. Mistrust.
The women might suspect the motives of the researcher and deliberately falsify the results.
ii. Misunderstanding.
When the women fail to understand that all fuel should be taken from the measured pile.
iii. Relevance to the women.
Since the procedure of taking fuel from one pile provided no benefit to the women they probably used fuel from some other source when it was much easier.
iv. Other members of the household.
Children or anyone who did not know about the measured pile of fuel would take fuel from any convenient source.

3.2.4.2 Variation between energy consumption on different days.

Energy consumption varies from day to day in each household. During the second visit to each village, two or three consecutive measurements of energy consumption were made at as many households as possible. The coefficient of variability for energy consumption between different days (the average standard deviation divided by the average consumption of the consecutive measurements) for the villages was 0,55 in Malefiloane, 0,42 in Jozanna's Nek, and 0,76 in Mashunka (with 0,39 in January; but these last two figures are

unreliable because of the small number of samples). Thus the daily variation is a significant factor that averages around 50% of the mean consumption.

3.2.4.3 The transformation of the raw data.

The raw data consisted of weights of fuel consumed over different time periods by families of different sizes. To arrive at the final figures, several transformations had to be made:

i. Daily consumption.
For energy consumption, the day was divided into two halves, distinguished by midnight and midday (between breakfast and supper). This was justified since cooking took place in the morning and evening, and, where lunch was eaten, it was cooked along with breakfast and eaten cold. Energy consumed for light or heat was used at night only. As far as possible pairs of measurements were done at the same time of day, but when the above assumption was used, a potential for error from cooking of bread or jwala during the day arose.
ii. Per capita consumption.
Energy required for cooking indirectly depended on the size of a household, whereas energy required for heat or light was independent of the size of household. Both the energy consumed per household and per person, is presented in tables 4.19 to 4.21.
iii. Calorific values.
These were averages of specimens collected and will not exactly reflect each fuel type used.

3.2.5 Errors Within the Reported Information.

When information was obtained from the estimates of women, the errors are likely to be larger. Several factors affecting this error can be suggested and, in this case, estimates of the errors can be made.

Since fuel is in continual use and difficult to obtain, one can expect the women to be aware of it's consumption. In Mashunka, the women could name the tree of each piece of wood in their stockpile (the accuracy of the name can not be confirmed). Alternatively, the units for measuring the quantities of fuel, or the time taken to collect fuel, are alien to the women so that the estimates are meaningless (Wallman, 1965.) An extra log hardly makes a pile look larger. Time is not of the same importance in the village routine although it is felt the awareness of time, resulting from schooling hours, watches, clocks and radios, is far greater than what Wallman (1965 : 239-40) suggests (possibly the result of 13 years of change).

Estimates of the errors in verbal statements by the women were obtained by asking the same question on more than one visit (ages of the members of a household), and by obtaining a verbal estimate when a measurement was also made. The results of this are shown in table 3.3.

	MALEFILOANE	JOZ NEK	MASHUNKA
Age	9,30%	-	-
Wood (used)	14,87%	-14,60%	7,94%
(coll)	-34,42%	-	-
Dung (used)	-30,34%	-286,08%	-
		(-24,87%)	-
(coll)		-40,0%	-
Par. (used)	-45,52%	-93,88%	-
	(-6,27%)	(-10,56%)	-
(poss)	65%	53%	-

Table 3.3 : Errors in the estimates of women.

$E = ((m-e)/m)100\%$

() Excluding those without the fuel.

Coll - Collected.

Poss - Possessed.

m - measured fuel quantities

e - estimated fuel quantities

Claassens (1978) found an average overestimation of 191% between the estimated and actual incomes of members of a communal garden in Herschel (that is nearly a three times exaggeration). It is interesting to note that the estimates are most accurate for wood - the most frequently used fuel. The estimates for dung and paraffin are far more accurate when one excludes cases where the household had no dung or paraffin when visited. This suggests that the estimates by the women relate to when they possess the fuel and, because of a lack of money or the weather, they frequently go without that fuel type.

3.3 CONCLUSION.

The three villages which were selected for research contained two villages (Malefiloane and Jozanna's Nek) which have a similar environmental situation, and one village (Jozanna's Nek) which shows a greater degree of change towards a consumer society. The collection of information was empirical as far as it was possible, and covered the seasons from summer through to winter. The study was concerned with fuel consumption, and the factor influencing it, in each village, and does not extrapolate the findings over wider geographical areas. A number of uncontrollable errors could have appeared in the measurement of the data, and estimates of the women. These errors, where quantifiable, appear to be smaller than (or equivalent to) the measured variation in energy consumption between different days, and are unlikely to seriously distort the results.

CHAPTER FOUR
FUEL CONSUMPTION IN THE THREE VILLAGES.

The consumption of energy in rural villages is characterised by different fuel types. In this chapter the results of the fieldwork are presented according to type of fuel. The major fuels are wood, dung and paraffin; minor fuels, whose use is sporadic or confined to a few families, are coal and crop residues. The results from each village are presented together rather than discussing each village separately. This approach allows a more detailled analysis of similarities and differences between villages. The villages in which field research was conducted are Malefiloane (in Mokhotlong province, Lesotho), Jozanna's Nek (in Herschel district, Transkei) and Mashunka (in Msinga district, KwaZulu). Characteristics of each village not directly relevant to fuel consumption, are discussed in Chapter Three and Appendix A.

4.1 WOOD.

The most important fuel is wood collected from the hills around each village. The collection of wood results in a deterioration of the vegetation when the collection exceeds net primary production. Collecting wood is a severe burden to the women in each community in terms of the time spent collecting wood, distances walked and the physical hardship of collecting and carrying the bundles of wood.

4.1.1 The Vegetation.

Firewood collection and consumption is largely determined by the availability of fuelwood in the vegetation surrounding each village. The natural vegetation has been modified by the impact of grazing, agriculture and firewood collection.

4.1.1.1 The vegetation types.

Following Acocks (1952) the vegetation at each village is: Themeda-Festuca Alpine veld (Malefiloane), Cymbopogon-Themeda veld bordering on Themeda-Festuca Alpine veld (Jozanna's Nek) and Valley Bushveld (Mashunka). Themeda-Festuca Alpine veld covers most of the Drakensberg mountain system between 1850m and 2150m with a rainfall of 600mm to 1900mm p.a. The Alpine veld extends south-west into the Eastern Cape and covers the Witteberg above Jozanna's Nek, lying on the boundary with the Cymbopogon-Themeda veld. This veld type ranges from 1200m to 1500m with 450mm to 750mm p.a. of rainfall. The Valley Bushveld occupies most of the larger river valleys draining into the Indian Ocean and is associated with steeper valley slopes and 500mm to 900mm of rainfall. Edwards (1967) describes the vegetation at Mashunka as Euphorbia tirucalli Succulent scrub with Semi-deciduous Bush (acacia-boscia-olea-schotia scrub) on the higher valley slopes.

The main firewood species in each village are Chrysocoma tenuifolia and Pentzia cooperi (Malefiloane), which are both small herbaceous multistemmed bushes with a maximum stem diameter of $\pm$20mm; Leucosidea serica (Jozanna's Nek), which is a bushy tree growing to 2m with a maximum trunk diameter of 50mm (all the other fuel species in Jozanna's Nek are small multistemmed bushes), and a range of different trees in Mashunka. A full list of species is given in Appendix A. The species list for Jozanna's Nek corresponds better with Alpine veld than Cymbopogon veld, this is because firewood is collected on the mountains above the village. In Mashunka the women had a detailled knowledge of the trees and could name the tree of each log on their woodpile, they also had preferences for certain trees (table 4.1).

4.1.1.2 The availability of firewood.

The quantities of fuel available as fuel were measured in 10m x 10m quadrats selected randomly along a vector from

NAME	SPECIES	USE	REASON
umHlaba	Aloe sp.	jwala (bier)	lots of flames, unpleasant flavour on food
umSululu	Euphorbia tirucalli		
umThomboti	Spirostachys africana	avoided	smoke, poisonous sap
umBondwe	Combretum apiculatum	warmth	good coals
umVithi	unknown		
umQuma	Olea africana	light	burns green & wet
Hlokoshiyane	Rhus sp.	avoided	too much smoke

Table 4.1 : Wood Preferences among Zulu Women.

the village towards the area of maximum fuel collection. At Mashunka it was impossible to weigh trees and an estimate was made of equivalent wood volume which was converted using a density of 1,886 $g.cm^{-3}$. The results are shown in Table 4.2 where the figures represent green wood weight. The figures do not indicate the extent to which the quadrat is representative of larger areas, and only loosely suggest firewood potential assuming the stripping of all vegetation. They do suggest that the vegetation has been denuded nearer the villages, forcing women to walk further to fetch firewood.

Very rough estimates on the annual production of biomass in different ecosystems are given in Earl (1975 : 46). The productivity of the vegetation surrounding each village will probably fall between 1,0 to 4,0 tonnes of wood per hectare (of which 80% will be above the ground). The vegetation surrounding Malefiloane and Jozanna's Nek can be expected to fall towards the bottom limit with that at Mashunka nearer the top limit.

	MALEFILOANE		JOZANNA'S NEK		MASHUNKA	
Quadrat 10x10m	dist km	wood kg	dist km	wood kg	dist km	wood kg
a	0,9	152,0	2,3	294,0	0,0	213,3
b	1,7	141,6	3,0	burnt	0,3	6376,5
c	2,3	121,5	3,1	658,8	1,5	5312,6
d	2,6	48,1+	3,7	288,0	1,9	9950,5
e	3,1	312,5				
f	3,6	546,0				
g	3,8	405,9				

Table 4.2 : Biomass Fuel Potential (kg)

546 Areas where most women fetch wood.
+ South facing slope.

4.1.1.3 The pressure on the vegetation.

The relation between population pressure and environment is highly complex (Anzagi and Bernard, 1977) and beyond the scope of this project, which simply documents parameters of soil erosion, damage to plants, and numbers of tree stumps (Figure 4.1 and Appendix A);

The wood source areas at each village do not show erosional features. This suggests that erosion does not result primarily from firewood collection. Vegetation changes in Herschel district, resulting from human activity, are mentioned by MacMillan (1930 : 202); "the arid land suffers likewise, and even the mountain slopes, most utterly denuded of bush by persistent veld fires and by the search for domestic fuel, are visibly scarred and eroded by the rush of water." In the Lowlands of Lesotho Germond (1967), Poynton (1966) and Heywood (1908) document the destruction of indigenous forests with firewood collection listed as one important contributing factor. In the Highlands, although weed species "are a sign

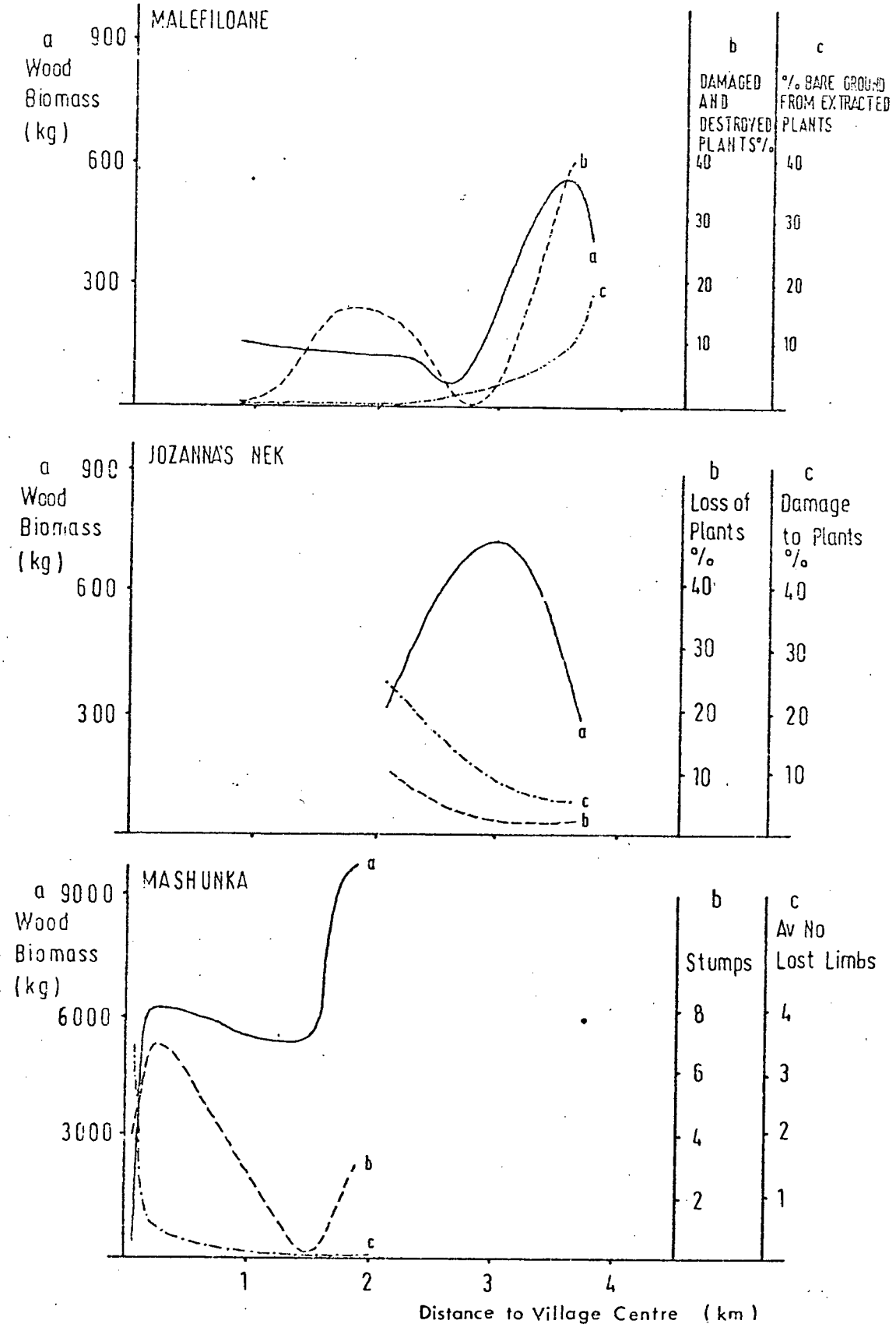


Figure 4.1 : Vegetation Characteristics around each village.

of overgrazing and mismanagement of the pasture land, (they) provide a source of fuel in the case of Chrysocoma and Aster filifolius ... Such weed species do not survive long where the grassland slopes are withdrawn from grazing for a season or two."(Guillarmod, 1971 : 45). At Jozanna's Nek the women tended to collect firewood from burnt patches on the mountains where herdboys had started veld fires. Everyone denied that there was any collusion between the herdboys and the women.

4.1.2 The Collection of Firewood.

Collecting firewood is one of the most time consuming and arduous routine tasks that the African village women must perform. They walk to the firewood source area, gather a bundle of wood and then carry it home on their heads. Girls collect from the age of eight years. In Mashunka the married women traditionally raise their hair over a hat shaped frame and paint it red (isiCholo). In order to carry a bundle of wood without damaging their isiCholo, the women balance a round tin can on their foreheads and then balance the bundle on top of the can.

4.1.2.1 The time factor.

The reliability of time estimates is discussed in section 3.2.5 but where estimates could be checked they seemed accurate. The average times for wood collection are shown in Table 4.3. Women spend longest collecting wood in Jozanna's Nek, where it takes on average over 14 hours a week. In a large village near Mohales Hoek, Lesotho, Gay (1978 : 8) found women spent on average 22 minutes a day (2 hours 12 minutes for a 6 day week) collecting wood but amongst women over 45, single and poor this increased to 49 minutes a day (4 hours 54 minutes a week).

	MALEFILOANE	JOZANNA'S NEK	MASHUNKA
One Bundle	3hrs 10min	4hrs	3hrs 30min
Per Week	13hrs 50min	14hrs 45min	11hrs 15min

Table 4.3 : Time Spent Collecting Firewood.

At Malefiloane, 12 women were asked to estimate how long it had taken them to collect one bundle of firewood when they had first arrived in the village (the village was first settled in 1965). This was to discover if they felt wood was becoming harder to get. The correlation coefficient of % increase in time against the span of years was 0,389, but insignificant at $p = 0,05$. Thus no significant deterioration can be defined, but using a simpler test there is a significant difference at $p = 0,01$ between the time taken to collect firewood now and in the past. Thus, within the accuracy of the information, wood has become less easily available.

At a very simple level of analysis, women in each village were asked whether they found collecting wood was a burden, whether collecting wood or water was a worse burden, and whether, since they had arrived in the village, collecting wood had become more difficult. The results (Table 4.4), which cannot be rigorously validated, show that wood is felt to be an especially serious burden by the women in Malefiloane and Jozanna's Nek. In Mashunka water is also a problem because it must be fetched from the Tugela river, while the two other villages have a well nearby. In Mashunka the vegetation has not deteriorated significantly in the women's perception.

4.1.2.2 The distances involved.

The major firewood source area in all three villages is towards, or on, the surrounding highlands (at Mashunka it is the top of the valley sides). In all villages a distinct area for collecting firewood exists. This is because it has become harder to collect wood nearer the village as over-

exploitation has pushed the area of nearest dense woody vegetation further away (Table 4.3). Some women suggested that the change in firewood availability is due to smaller sized logs near the village requiring longer journeys to find large logs, although the areas covered by bushes remain the same. Mabel Mangwana (Jozanna's Nek) said that previously women only took the tree trunk, but now they take all the branches as well.

	MALEFILOANE	JOZ NEK	MASHUNKA
Is coll wood a burden?			
YES	73%	70%	62%
NO	27%	30%	38%
DON'T KNOW	0%	0%	0%
n (%vill pop)	15 (75%)	10 (5%)	13 (22%)
Is wood or water the worse burden?			
WOOD	87%	83%	46%
WATER	0%	0%	23%
SAME/DON'T KNOW	13%	17%	31%
n (% vill pop)	15 (75%)	6 (3%)	13 (22%)
Has coll wood got worse?			
YES	80%	90%	46%
NO/SAME	20%	10%	39%
DON'T KNOW	0%	0%	15%
n (% vill pop)	15 (75%)	10 (5%)	13 (22%)

Table 4.4 : Answers to Questions on the Collection of Firewood.

Table 4.5 shows the vertical and horizontal distances to the major fuel source area. It must be remembered that women still can, and do, collect wood anywhere else where they can find it.

	MALEFILOANE	JOZ NEK	MASHUNKA
Horizontal Dist	3,0 km	3,0 km	1,7 km
Dist on Foot	3,5 km	3,2 km	2,5 km
Local Relief	300 m	300 m	250 m

Table 4.5 : Distances to Major Fuel Source Areas from the Centre of the Village.

4.1.2.3 The bundles.

Wood is collected into a cylindrical bundle for carrying on the woman's head. The bundle extends in front of, and behind, the woman. Initially one end is raised to get the head under the point of balance, and then the front of the bundle is lifted. The bundle is usually tied together with string or platted grass.

The heaviest bundles recorded were 39,5 kg (Mashunka), 34 kg (Jozanna's Nek) and 32 kg (Malefiloane). A typical bundle in Jozanna's Nek weighed 17 kg and was 1,9 m long and 45 cms across (giving a density of 14,06 $kg.m^{-3}$). Bond (1977) records a bundle of 90 kg weighed in the Natal highveld near tall indigenous forests. This large difference in bundle weight can only be explained by assuming that the shape of the logs limits the size of bundle that a woman can carry. In Natal the long straight poles can form a heavier bundle than in Malefiloane and Jozanna's Nek where a large bundle of bushes could not hold together.

Using the frequencies of collection, and the weights of the bundles (substituting the average village bundle weight if there was no bundle weight for the specific woman), it is possible to estimate wood collection in each village (Table 4.6). The frequency of collecting wood bundles in Malefiloane (per week) was 6 (summer), 4,6 (autumn) and 2 (winter). The drop in autumn and in winter was due to harvesting and the further drop in winter was probably due to the substitution of dung for wood.

	MALEFILOANE	JOZ NEK	MASHUNKA
Av bdle wt (kg)	21,30	15,20+	20,62
(nearby)			(11,70)
(mtn top)			(24,93)
Av freq coll (wk)	4,38	3,59	3,41
(nearby)			(5,80)
(mtn top)			(2,40)
Av wood coll (wk)	95,16kg	62,22kg	66,46kg
" (day)	13,59kg	8,89kg	9,49kg

Table 4.6 : The Collection of Firewood.

+ Taken from a larger sample described below.

The lower average bundle weight in Jozanna's Nek is due to a larger proportion of school going girls fetching wood. This value was recorded by stopping women and girls entering the village carrying bundles (n=49). The average bundle weight from house to house interviews was 19,44 kg. Possibly the method or that one of the days was a school holiday accounted for the number of school girls. School girls frequently go to fetch wood on Saturdays and holidays, while some girls, whose mothers are old or sick, go every day after school. Figure 4.2 shows a correlation between the age of a woman and the weight of her bundle. In Jozanna's Nek the two independant approaches to monitoring the collection of wood (by stopping those entering the village and by house to house interviews) allow a comparison of the results (Table 4.7).

4.1.2.4 The effect of tradition on firewood collection.

African society maintains a strong division of labour between the sexes, and all the domestic chores, including collecting firewood, are the woman's task (Krige,1936 and Sheddick, 1954). In Jozanna's Nek two families contravened this custom and sent their young sons to collect tree stumps in a sack.

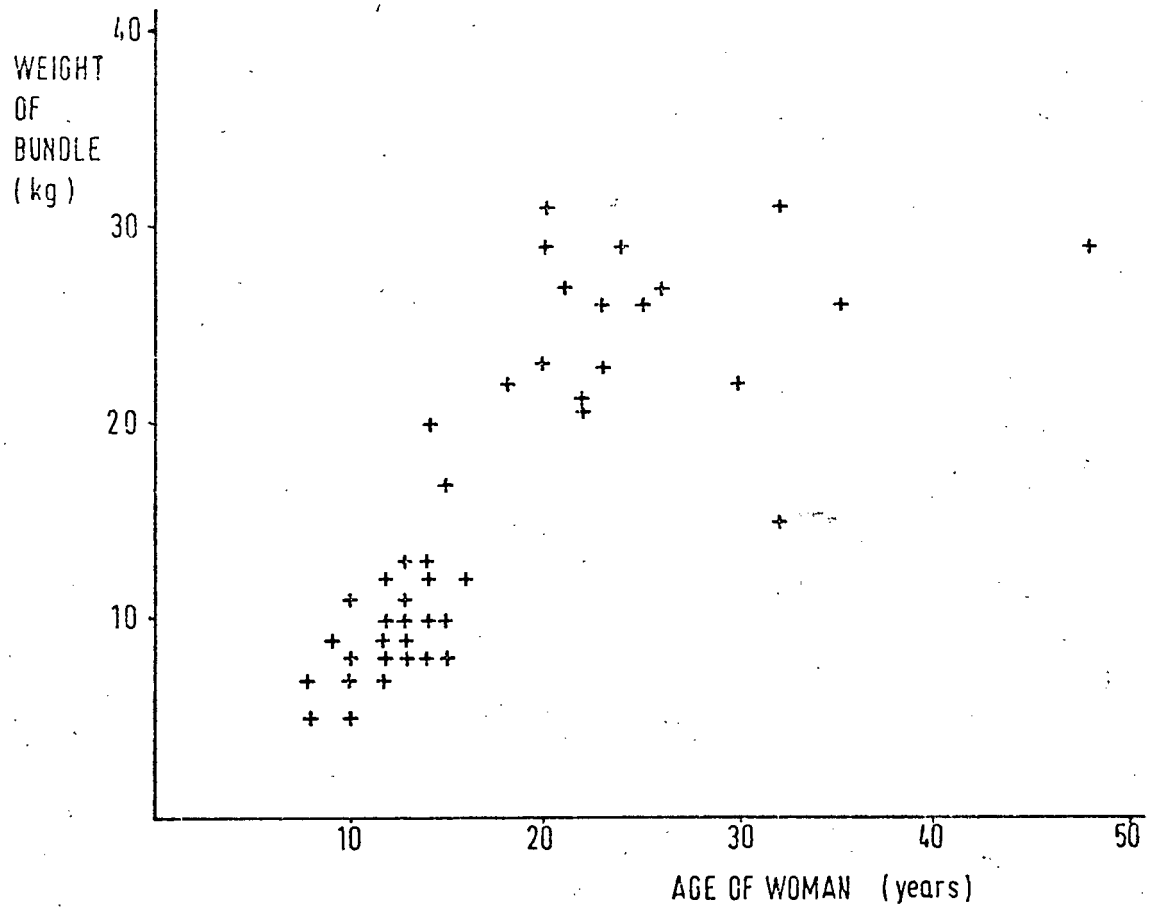


Figure 4.2 : The Age of a Woman Plotted against the Weight of the Bundle she Carried.

	Hse to hse interviews	Women entering vill	% diff over mean
Av bundle (kg)	19,44	15,20	24,5%
Av time p jour	4 hrs	4hr 20min	8,0%
Av freq (wk)	3,59	3,20	11,5%
Av time p wk	14hr 45min	13hr 10min	11,3%
Av coll p wk	62,22kg	53,76kg	14,6%
Av coll p day	8,89kg	7,68kg	14,6%

Table 4.7 : Difference in Results from Different Methods in Jozanna's Nek.

Traditionally the men and boys collect wood for a feast using oxen and a sleigh. The sleighs severely exacerbate erosion along the paths. This wood is kept distinct from the women's wood (which bakes bread and brews bier) and is used to cook the meat of the slaughtered animal.

Amongst the Hlubi tribe (the largest tribe in Herschel district), the women are traditionally forbidden to carry wood into the village at midday. This is one of the pre-requisites for protection of the village against lightening and thus not enforced during winter when storms do not occur. If 'stubborn', a woman can be fined for breaking the custom. According to Ashton (1952) a similar custom amongst the Basotho protects the crops from hail or frost.

Sheddick (1954) and Ashton (1952) mention that natural bush and forest are traditionally protected. Where control was maintained, only deadwood could be collected from the forests but "in the mountain areas there are scarcely any indigenous woods..... Brushwood, such as sehalahala, which is extensively used as fuel and is indeed the principal firewood, is not protected at all and may be gathered whenever required." (Ashton, 1952 : 152-153).

In Jozanna's Nek, noone is allowed to cut a tree in the village and the yearcamp (grazing land left fallow for a year), with fines of 50 cents or R10 respectively for infringement. Elsewhere, there are no restrictions on cutting live trees. In Mashunka, the women denied that trees were traditionally protected, but Bond (1977 : 33) quotes a chief saying "we have a law that green wood may not be cut. But people are too many. They have to fell green trees. They say what must they do? We can't catch them all, and as you can see, the bush is getting finished."

4.1.3 The Consumption of Firewood.

In all three villages, wood was the most commonly used fuel; used by nearly every household. The quantity of wood consumed is determined by the availability of firewood. Because of fluctuations in the time available to each woman to collect wood, they maintained a stockpile of wood next to their house. The only other important use for wood was in the construction of houses.

4.1.3.1 The quantities burnt.

By far the largest quantities of wood per capita are consumed in Mashunka (see Table 4.8). The peak consumption in all villages occurred in autumn. In order to obtain an aggregated annual value for wood consumption the three seasonal figures are averaged and extrapolated over 365 days.

In Mashunka the autumn figure was obtained from estimates by women (making a pile of wood equivalent to one days consumption) because they were building up their stockpiles for winter and reluctant to burn this wood. The wood they used was collected on a daily basis just before cooking. With three women it was possible to obtain both an estimate and a measured value, and this suggested an exaggeration factor of 1,481. Reducing the estimates by o,6752, the autumn figure becomes 11,03 kg per day, which is below both the values for winter and summer. Neither value appears more reliable and the unadjusted figure is given in Table 4.8.

In Malefiloane and Jozanna's Nek there is a drop in wood consumption in winter when there is also a sharp rise in dung consumption. Thus the women shift their consumption from wood, which requires a long journey to collect, to dung, which is available from nearby once the dry season has started (kraal dung requires 3 rainless weeks to dry out).

	MALEFILOANE			JOZANNA'S NEK			MASHUNKA		
	per fam sampled kg	% fam using wood	per fam using wood kg	per fam sampled kg	% fam using wood	per fam using wood kg	per fam sampled kg	% fam using wood	per fam using wood kg
SUMMER	2,79	64%	4,38	2,74	80%	3,43	11,57	100%	11,57
AUTUMN	5,52	100%	5,52	6,44	93%	6,94	15,08	100%	15,08
WINTER	4,01	90%	4,46	4,83	92%	5,24	13,00	100%	13,00
Average	4,11		4,79	4,67		5,20	13,22		13,22
ANNUAL CONSUM. per fam	$1,499 \times 10^3$kg			$1,705 \times 10^3$kg			$4,824 \times 10^3$kg		
Fam per village	20			202			58		
Village consum.	$30,0 \times 10^3$kg			$344,4 \times 10^3$kg			$279,8 \times 10^3$kg		

Table 4.8 : Firewood Consumption.

4.1.3.2 The importance of wood availability on firewood.

Although annual mean temperatures at Malefiloane are the lowest for the three villages, and suggest that wood consumption would be highest, Table 4.8 shows that this is not the case. It is probable that the low consumption of wood per family at Malefiloane is related to the low biomass fuel potential near this village (Table 4.2). This relation is discussed in more detail in section 5.2.2.

4.1.3.3 Stockpiles of wood.

A few women collect wood on a daily basis. The majority maintain a stockpile that could be of 20 or more bundles. Reasons given for keeping a contingency supply of wood included : for periods of heavy agricultural work, for winter, for rainy days and times of sickness.

Table 4.9 gives the average size of stockpile in each village which again follows the trend in wood biomass potential. In Malefiloane the small bushes (maximum diameter stem of 10mm) would disintegrate if kept outside too long; in Jozanna's Nek stockpiles were only of the larger Leucosidea logs.

	MALEFILOANE	JOZ NEK	MASHUNKA
Sample size	18	23	6
Av no bundles	3,1	16,7	21,1
Av size (m^3)	0,80	4,77	1,50
Av weight (kg)+	65,57	251,05	441,18

Table 4.9 : Stockpiles of Firewood (also given in number of bundles and size of pile).

+ Densities : Mal. $0{,}259\ m^3 . bdle^{-1}$
$0{,}0122\ m^3 . kg^{-1}$
J Nek. $0{,}286\ m^3 . bdle^{-1}$
$0{,}0190\ m^3 . kg^{-1}$
Mash. $0{,}071\ m^3 . bdle^{-1}$
$0{,}0034\ m^3 . kg^{-1}$

The change in stockpile between autumn and winter was measured at the Mzayifani Dladla family kraal in Mashunka (8 houses accommodating 3 men, 5 women and 11 children). Of the six distinct piles, for the different houses, five increased in size from autumn to winter, with an overall change of 71,2% (from 12,105 m^3 to 20,72 m^3 of stacked wood).

4.1.3.4 Other uses for wood.

The only other significant use for wood which was noted was in the construction of houses. Buildings in Malefiloane and Jozanna's Nek did not use wood except for rafters which were gumpoles purchased from the nearest store. In Mashunka, houses were stone (using a wood frame) or wood only. The first type held large 1 x 1 m stone slabs and was estimated to require 24 logs ~~of~~ 1,8m high and 20 cm diameter (0,419 m^3 solid wood or 10+ bundles). The second type involved a continuous wall of vertical logs requiring 19 logs ~~of~~ 1,7 m by 35 cm round per metre (for a round house 9 m across that is 87,05 m^3 of solid wood). Both houses are plastered with mud and dung on the inside.

4.1.4 Strategies to Increase the Supply of Firewood.

As traditional non-commercial supplies of wood dwindle, two strategies become feasible. First, firewood can be brought into the village on a commercial basis, and second, woodlots can be established to provide a controlled renewable supply of firewood.

4.1.4.1 The commercialization of wood.

The sale of wood occurs within the community and with the introduction of wood from outside the village. The former approach occurs in Malefiloane and Jozanna's Nek where the poorest women, generally those without fields or a husband (who can earn money as a migrant), collect more wood than

they need and sell the surplus. In Malefiloane, one woman suppliments the R40 every fourth month from her migrant husband with R6 a month from selling wood (5 bundles a week at 30 cents), and another woman has not heard from her husband, also a migrant labourer, for two years, and, when strong, sells wood at 20 cents a bundle and makes jwala for money. In Jozanna's Nek, two women sold wood, both without any other source of income, the one sold 10 bundles a month at 60 cents each and the other 4 bundles a week at 70 cents each. The latter sells wood to buy the ingredients to make jwala (using another 36kg of wood), which she sells at R6 for 3 20 liter tins.

Wood is not brought into any of the three villages from outside. Clarke and Ngobese (1975 : 73-74) reports that at Nqutu (KwaZulu), hawkers sell 8 ft logs at 35 cents each and the average family spends R4 on wood a month. The Social and Economic Planning Council (1946 : 56) emphasized that "the problem is so serious and so potent a cause of land deterioration in some areas, that the council recommends the provision of cheap supplies of wood and/or coal." Gay (1978 : 10) in a village near Mohales Hoek, Lesotho, found trade in wood between the mountain villages and the lowland villages. The women from the mountains sell bundles of wood at 50 or 60 cents in the lowland villages, and then buy goods from the shops with the money.

4.1.4.2 Woodlots.

The most viable longterm solution to the provision of firewood is to establish woodlots. A woodlot was established in Jozanna's Hoek (adjacent to Jozanna's Nek) on 8 morgen. The first sale involved cutting 3,5 morgen in 1977, when trees were sold at from 15 to 40 cents each, depending on size, for a total revenue of R 82.

In Lesotho, the Lesotho Woodlot Project has established 1,500 ha of woodlots of Eucalyptus grandis on request from

villages. They estimate a requirement of 1,1 ton (1000 kg) wood annually per family requiring 0,16 ha of woodlot for a sustainable yield (that is 40 000 ha for the population of Lesotho). Trees are felled yearly over a 12 year cycle by the project since the cutting can increase coppice growth and productivity by 300% (also see Venter, 1972). The wood is to be sold at 20 cents per cu.ft. to cover planting costs of R600 per hectare. Beyond 2000m, growth of the trees is halved and no woodlots are planned.

4.2 DUNG.

A Mosotho described dung as 'Lesotho coal'. The manure is allowed to dry and then burnt in much the same way as coal. The most important dung, for fuel, comes from the cattle. The burning of dung withdraws an important nutrient source from the natural cycle, and destroys a potentially free fertilizer.

4.2.1 The Collection of Dung.

There are two methods of obtaining dung. It can be collected, once dry, from the grazing lands. Alternatively, dung collects on the floor of the kraal where the livestock spend the night, and is dug out in blocks twice a year.

4.2.1.1 The collection of dung from the land.

Dung is collected from fields and grazing camps in sacks or dishes by women and young girls. The weight of a sack of field dung, was measured at 20 kg and a dish at 7 kg. If still damp, the dung is spread out in the sun to dry. At Jozanna's Nek it took, on average, 1 hr 15 min to collect a sack of field dung.

The manure left by livestock grazing stubble in the fields after harvest, is all collected. The women also collect dung from the grazing lands, but never travel as far as the journey to collect wood. After rain dung is wet and

will take four to six days to dry. Women then prefer to collect wood because the small herbaceous bushes burn when damp. Only dried cow pats are sufficiently large to be worth collecting. The collection of dung is shown in Table 4.10.

	MALEFILOANE	JOZ NEK
% sample using field dung	86%	60%
Estimated frequency per week	2,1	3,8
Kg per day	5,24	8,36
Measured frequency per week		1,5
Kg per day		4,29

Table 4.10 : Collection of Field Dung per Household (July).

In Malefiloane, one woman took fresh cow dung and formed it into oval 'plates' which she then left to dry. These are called Mapharoa. It was reported by the women that dung cakes mixed with straw were made in other villages.

4.2.1.2 The collection of dung from cattle kraals.

Livestock, especially oxen and milking cows, are kept in a kraal overnight. Manure from these animals accumulates on the floor of the kraal and is dug out several times a year. The kraal dung is stacked along the wall of the kraal to dry in blocks roughly 30 x 25 x 10 cm. Dung can be dug after only one days sunshine, but it requires a month of dry weather to dry the kraal dung adequately for burning. It was reported that dung from sheep and goats only requires two weeks to dry. The average weight of a block of kraal dung (dry) was 3,4 kg and the density was 709 $kg.m^{-3}$.

Most families dug out their kraals twice a year; generally once in summer and in winter after the start of the dry

season. Malefiloane was visited just as most families were digging out their kraals (before it had dried enough to be used), and it was possible to estimate annual kraal dung production at 670 kg per cow, 6 kg per sheep or goat, and 457 kg per horse. These were based on the livestock kept in the kraal and the extraction of dung. It was estimated that 51 000 kg of kraal was extracted each year in Malefiloane, of which 98% was cow dung. An equivalent figure for total kraal dung consumption could not be calculated for Jozanna's Nek, but the annual production of kraal dung per cow was estimated to be 417 kg and 37 kg per goat.

4.2.2 Livestock.

Livestock fulfil several important roles in traditional African society. The production of dung does not appear to be seen as important although it provides fuel and could provide fertilizer.

4.2.2.1 The cultural significance of livestock.

Gay (1977), examining the attitudes of Basotho farmers towards livestock, found livestock valued for the provision of milk, wool and the potential cash earnings when sold. There was no mention of fuel or fertilizer. Livestock represent a fixed deposit, naturally increasing, that can be disposed of according to the needs of the owner. Livestock are required in marriages, taxation and to provide meat at ceremonies. They provide milk and draught animals for transport and ploughing. The sale of wool from sheep or goats and skins provides the only significant means of self-employment in many rural areas. This research found that in Malefiloane, 70,4% of reported income was derived from the returns of migrant labourers, and of the 29,6% earned locally, 74,7% came from the sale of wool and hides. Average annual earnings from the sale of wool was R158 p.a. The numbers of livestock are also contributing to the problem of soil erosion.

	MALEFILOANE		JOZ NEK		MASHUNKA	
Families sampled	18		22		11	
Village population (families)	20		202		58	
	average p fam	village total	average p fam+	village total	average p fam	village total
CATTLE	5,8	116	2,7	639	6,2	359
SHEEP	21,1	422	2,8	840	0,7	41
GOATS	4,1	82	5,7	1479	8,0	464
HORSES	2,4	48	-	8		
DONKEYS	0,1	2				

Table 4.11 : Livestock Ownership in each Village.

\+ Since two families owned over 64% of all the livestock their livestock was only added in after the village total was calculated.

4.2.2.2 The production of manure.

Table 4.12 provides an indication of the average expected dung production in South Africa (Gustafson, 1941), but this is an average figure and will vary with local conditions (Malherbe, 1948). The estimated dung production in each village, using Gustafson's figures, is given in Table 4.13.

	Total Excretion	Solid Excretion	Dry Matter	Dry Matter Production
COW	11800	8200	80%	1600
SHEEP	5900	3900	70%	2000
HORSE	8400	6600	55%	1700

Table 4.12 : Annual Dung Production of Livestock (kg) from Gustafson (1941 : 286).

	MALEFILOANE	JOZ NEK	MASHUNKA
CATTLE	185,6	1022,4	574,4
SHEEP	844,0	1680,0	82,0
GOAT+	164,0	2958,0	928,0
HORSE	81,6	13,6	
DONKEY++	3,4		
Total	1278,6	5674,0	1584,4

Table 4.13 : Dung Production in Each Village (1000 kg).

\+ Assumed equal to a sheep.

++ Assumed equal to a horse.

4.2.3 The Consumption of Dung.

Whereas most of the previous results are estimates, it was possible to measure the actual consumption of dung.

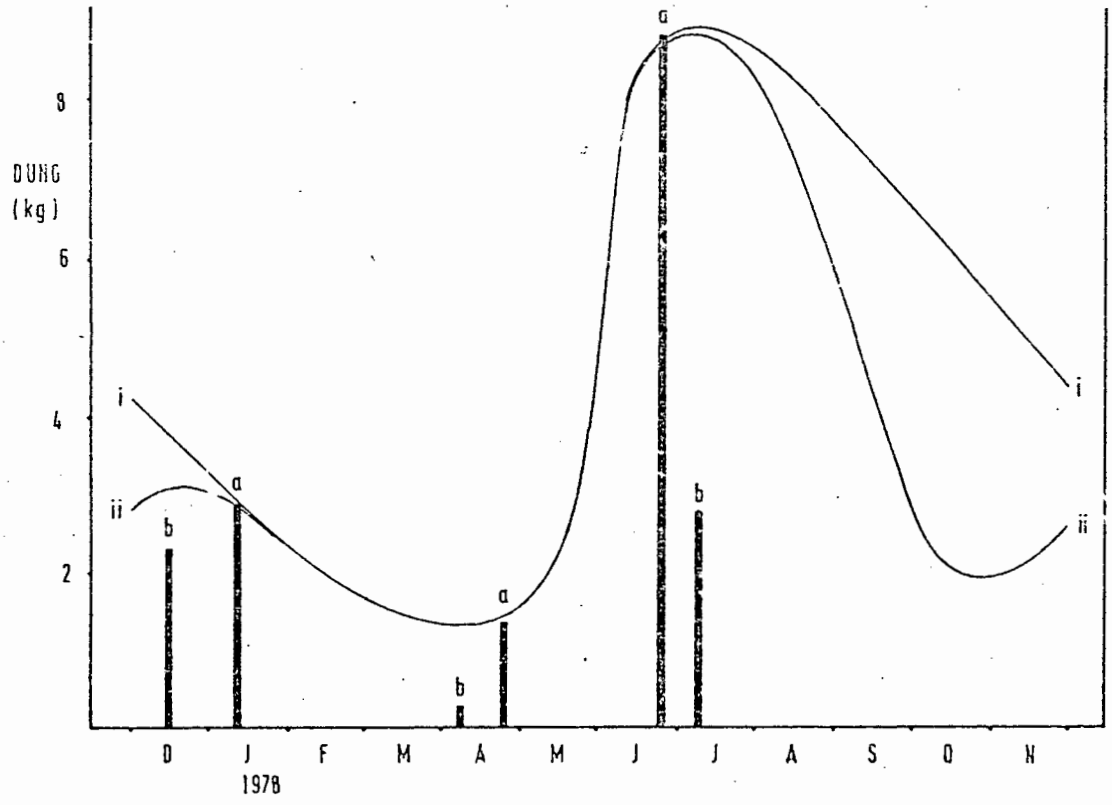
4.2.3.1 Burning dung.

A dung fire is primed with wood. The initial burn produces a heavy acrid smoke that irritates the human eye. In summer all dung fires are made outdoors. In winter the fires are moved inside once the initial heavy smoke has ceased, and in the coldest months the door might then be closed as well. This pattern is a response to avoid smoke and maintain a constant indoor temperature. Dung is often burnt in a 'Paolo', a tin bucket perforated with holes. If dung is too wet, it will not burn; the women were found to use dung with 4,9 to 8,2% water content by weight. Dung is preferred for cooking bread and jwala (beer) because of the long constant heat for simmering. In Jozanna's Nek, dung was mentioned as being preferred in winter because of its effectiveness for heating. For this reason it was often saved for winter.

Measured dung consumption is given in Table 4.14. The

	MALEFILOANE				JOZANNA'S NEK			
Seasonal Consumpt.	av kg p family sampled	%sample using dung	av kg p fam usi ng dung	% kraal dung used	av kg p family sampled	%sample using dung	av kg p fam usi ng dung	% kraal dung used
SUMMER	2,83	55%	5,19	60%	2,21	27%	8,30	92%
AUTUMN	1,58	37%	4,21	29%	0,25	7%	3,50	100%
WINTER	8,80	60%	14,67	92%	2,77	46%	6,00	6%
Average	4,40		8,02		1,74		5,93	
Annual Consumpt.								
Per Fam	$1,35 \times 10^3$ kg				$0,50 \times 10^3$ kg			
Village Cons.	$26,99 \times 10^3$ kg				$101,01 \times 10^3$ kg			
% Kraal Dung	67%				52%			

Table 4.14 : Consumption of Dung in the Villages (kg).



a Malefiloane
b Jozanna's Nek

Figure 4.3 Alternative Strategies for Extrapolating Dung Consumption over the Whole Year.

MALEFILOANE:

i	High Estimate	: 1737 kg pa.
ii	Low Estimate	: 1384 kg pa.
$\bar{x}$	Average of Field Values	: 1580 kg pa.

annual consumption is calculated from an average of the three seasonal values, but this, inevitably, introduces an error, since dung consumption varies considerably with the availability of other fuels and availability of dung itself. This variability appears greater with dung than with other fuels. In Figure 4.3, different possible annual cycles, selected randomly, of dung consumption are indicated and the annual consumption is calculated. The average of the three seasonal figures for dung consumption falls between the high and low estimates for dung consumption and is used as an adequate statistic for the annual value.

The ash content of field dung, after heating to 590°C in a kiln, was found to be 27,1% by weight and that of kraal dung 41,4% by weight. The increase in ash weight of kraal dung is presumably due to soil mixed into the dung from the kraal floor. The ash from all fires is always put on a special pile and never transferred to fields or gardens.

4.2.3.2 Factors affecting dung usage.

Two factors appear significant. The first is the availability of wood. No-one used dung in Mashunka, saying that there was enough wood. At Nqutu, 70 km north of Mashunka, wood is so scarce that all the dung is burnt and wood is brought into the area (Clarke and Ngobese, 1975). This occurs although the vegetation is Valley Bushveld, as at Mashunka. The consumption of dung in parts of Lesotho, where firewood was scarce, was documented as early as 1836 (Germond, 1967 : 122).

The second factor affecting dung usage is ownership of cattle (ignoring other livestock). The correlation coefficient between these two variables is significant at $p = 0,05$ ($r = 0,525$, $n = 18$). The coefficient does not change if kraal dung only is correlated with cattle

ownership. This suggests (although the number of observations is small) that women without cattle seldom even burn field dung.

At Malefiloane, it was possible to calculate the total annual collection of dung at 1910 kg from fields, and 51 270 kg from kraals. The total of 53180 kg is 97% larger than the estimated annual consumption of 26990 kg (Table 4.14). One possible error causing the discrepancy is that the quantity of dung extracted from kraals in summer is not the same as in winter. In summer livestock are often sent into the mountains to graze. Alternatively, with the high variability of dung consumption, the measured dung values could be unrepresentative of annual consumption figures. Of the total dung production from cattle in Malefiloane, (since only cow dung is collected from the land and most kraal dung is also from cattle), 28,7% of dung production is burnt (calculated from the collected quantity of dung) or 14,5%, using the consumed quantity of dung. If all livestock are considered 4,2% or 2,1%, respectively, of total dung production is burnt. None of the nutrients in the dung ash is returned to the natural system.

4.3 PARAFFIN.

Paraffin is the major commercial fuel that is used in rural villages. It is available through shops and trading stores in most rural villages.

4.3.1 The Availability of Paraffin.

The availability and the price of paraffin appear to determine how much is purchased. Almost all shops sell paraffin but, before the establishment of the Malefiloane Cooperative Store in 1976, the women had to go to Mokhotlong, a journey of 5 hours by foot or 3 hours by horse. Jozanna's Nek has a store in the village, and

at Mashunka the nearest store is 4 km away. Paraffin is sold by the bottle; the women apparently not distinguishing between 750 ml and one litre bottles. A prolonged rainy period will increase the demand for paraffin and can exhaust the supply. It often takes several weeks for the shops to get new supplies. In Jozanna's Nek, low consumption figures for paraffin in March are due to none being available in the local shop. Gay (1977) found paraffin the third most mentioned article (20,6% of maximum possible) people needed from village distribution points (after fertilizer and seeds).

Records from the Malefiloane Co-operative Store enabled an estimate of the average monthly purchase of paraffin to be made. In May 1978 2,35 litres (or 3,13 750 ml bottles) per household were sold. On average paraffin sales accounted for 6,4% of total sales from the store. The smoothed sales of paraffin (using a running mean of $0,25x_{i-1} + 0,5x_i + 0,25x_{i+1}$) do not show any obvious trends (Figure 4.4).

The retail price of paraffin has risen dramatically since 1970 (Figure 4.5). A short term effect of price increases is the initial price resistance and a drop in sales. Paraffin sales in Herschel (Figure 4.5) show two drops; the first, possibly due to price resistance and the second, due to migration out of the district (Keiweit, 1978 estimates that 50 000 people left in 1976/7). In the long term, the increase in prices is important in relation to remittances by migrant labourers, which also rose sharply from 1973 (see figure 5.2).

The extent to which increases in remittances exceeded increases in the price of paraffin possibly accounts for the increase in paraffin sales in both Herschel and Lesotho. Bond (1977 : 33) quotes a woman who said "we used to use paraffin, but now it is so expensive, we have started chopping wood again."

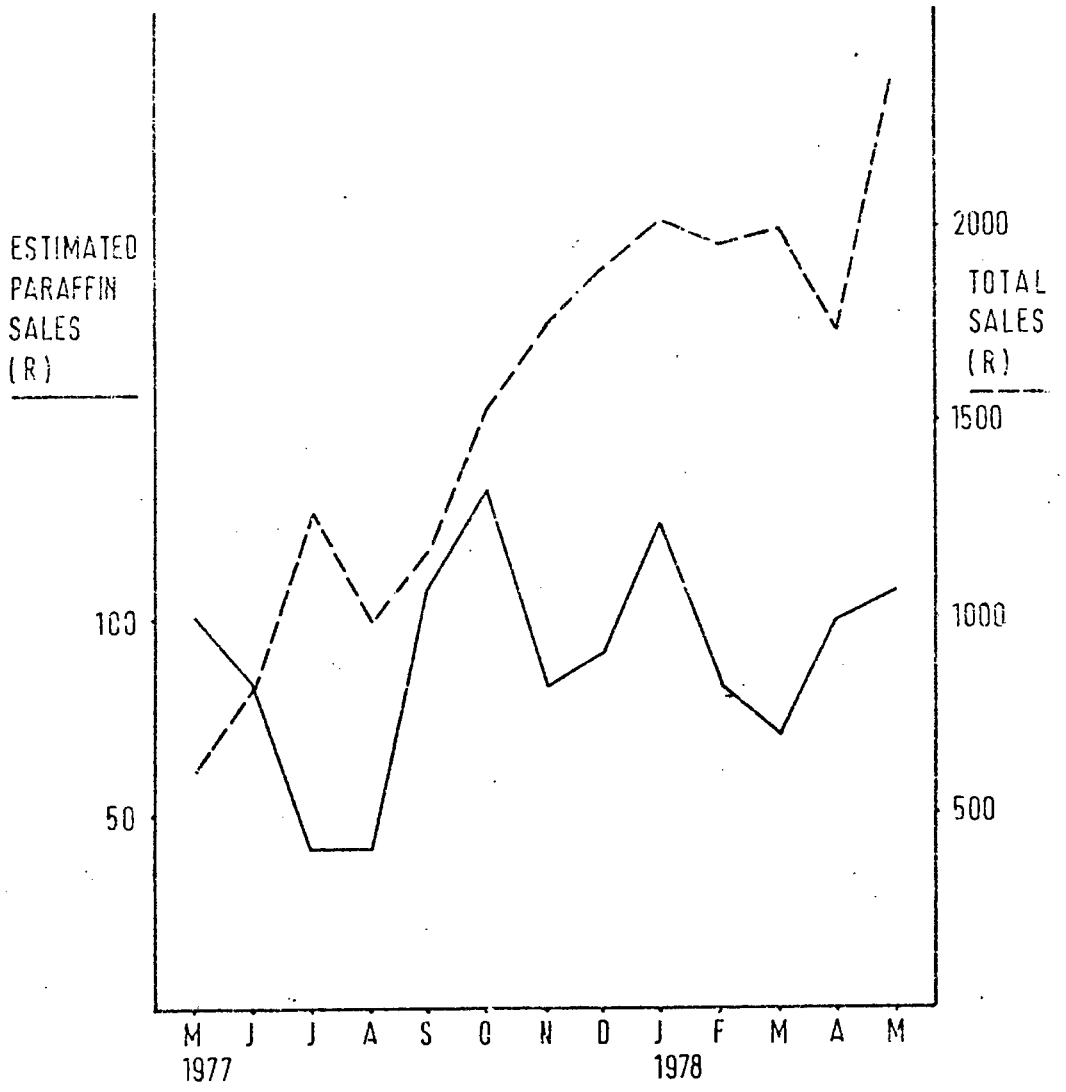


Figure 4.4 : Sales of Paraffin from Malefiloane Co-operative Store (smoothed using a running mean).

Using the annual consumption of paraffin by each family (Table 4.22), the average expenditure on paraffin in Malefiloane, Jozanna's Nek and Mashunka is 53 cents, R1,04 and 55 cents respectively; this means that the proportion of reported household income spent on paraffin in the villages is 2,49%, 3,02% and 3,59% respectively.

	750 ml bottle	liter
Malefiloane Co-op Store	20c	27c
Mokhotlong Trading Stores	18c	24c
Jozanna's Nek Store	18c	24c
Ndele's Store Msinga	20c	27c

Table 4.15 : Retail Paraffin Prices (1978).

4.3.2 The Consumption of Paraffin.

Paraffin is a multi-purpose fuel being used for cooking, light and heating. Because a primus stove is quick and easy to light, paraffin is often used to heat water for tea or for washing. A primus stove can also be used as a heater by placing a metal plate over the flame. Paraffin is used in lamps and heaters (Table 4.16).

	MALEFILOANE	JOZ NEK	MASHUNKA
Lamp	100%	100%	100%
Primus Stove	43%	92%	25%
Heater	0%	15%	0%

Table 4.16 : The Ownership of Paraffin Appliances.

Frequently women reported using paraffin, but had none at the time of questioning (Table 4.17). This appeared to relate to the availability of supplies in the shop and whether the women possessed any money to purchase

it. Often they had to wait for remittances, from sons or husbands, that came every four months.

	MALEFILOANE	JOZ NEK	MASHUNKA
Reported using paraffin	100%	100%	78%
Possessing paraffin	65%	53%	67%+
Using paraffin	37%	49%	33%+
For light only	25%	17%	100%
Never use paraffin	0%	0%	22%

Table 4.17 : Paraffin Use (average of three visits).

\+ Unreliable because of few figures.

The measured consumption of paraffin is shown in Table 4.18. The highest measured values were recorded in Jozanna's Nek. This can be attributed to the availability of paraffin, higher household incomes and a less traditional society. The values for Mashunka are all estimates and thus less reliable (see section 3.1.5). No seasonal pattern in the consumption of paraffin is obvious.

Sales of paraffin in Herschel district and Lesotho were obtained from a consortium of four of the major oil companies reputed to hold the largest share of the market (Mr R.Byrnes, BP South Africa). The growth in annual sales is shown in Figure 4.5.

One factor influencing paraffin consumption is the weather. It was reported by Tlala Nkone, who measures out paraffin at the Malefiloane Co-operative Store, that after it rained the sales of paraffin increased for a few days. This is because dry wood and dung is burnt and the women

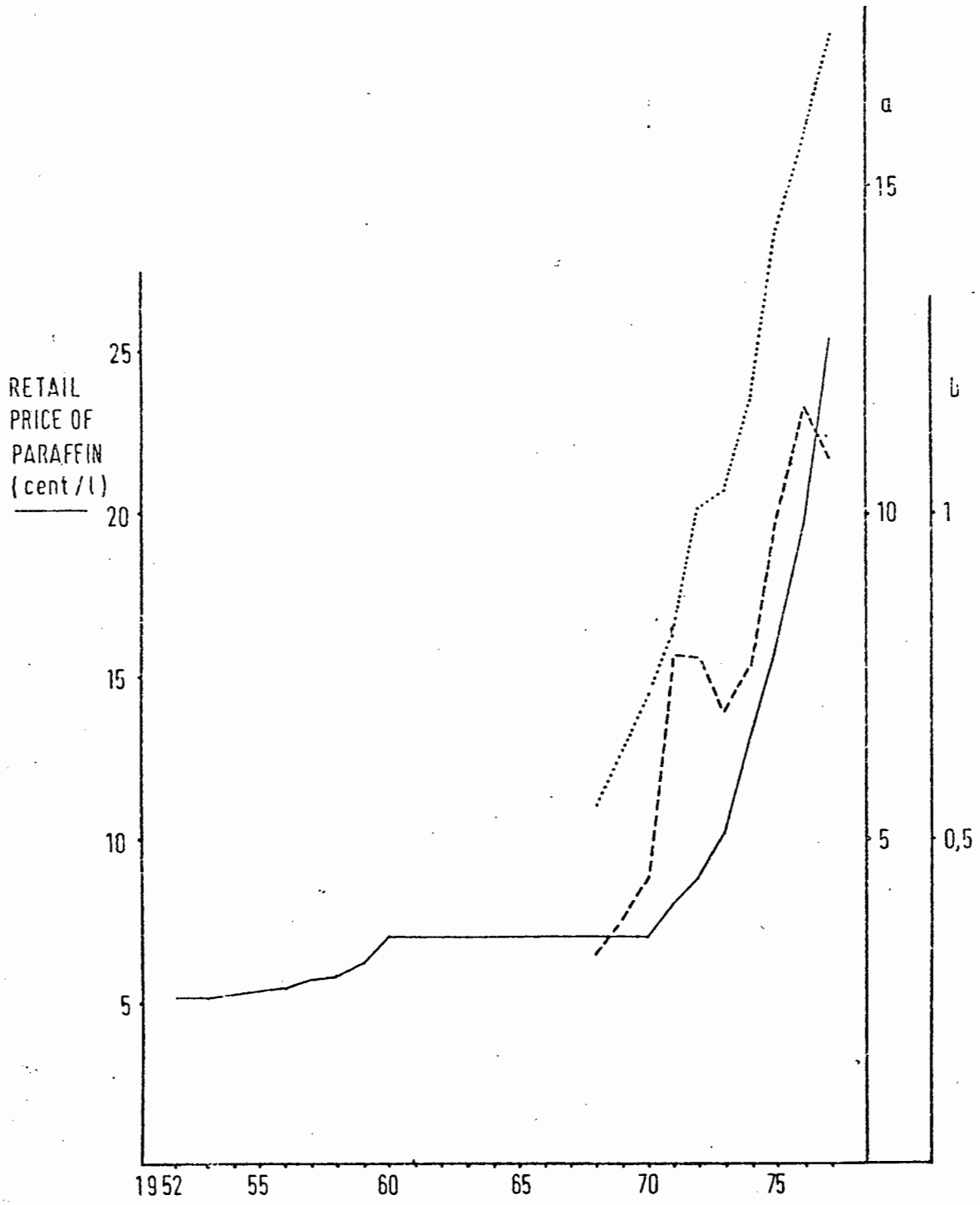


Figure 4.5 : Paraffin Prices and Sales in Lesotho and Herschel District, Transkei.

Seasonal Consump.	MALEFILOANE			JOZ NEK			MASHUNKA		
	Per fam in vill.	% fam using paraff.	per fam using paraff.	per fam in vill.	% fam using paraff.	per fam using paraff.	per fam in vill.	% fam using paraff.	per fam using paraff.
SUMMER	76	54%	139	259	60%	389	75	78%	96
AUTUMN	126	50%	251	154	36%	432	91	85%	108
WINTER	15	20%	150	115	38%	300	34	60%	57
Average	72		180	176		374	67		87
Annual Consump.									
Per Family	26,4 l			64,2 l			24,3 l		
Per Village	528,0 l			12976,5 l			1411,3 l		

Table 4.18 : Consumption of Paraffin (ml).

are reluctant to collect more wood in the rain. They thus use paraffin instead.

A second factor is wealth. As paraffin is a non-essential item which requires money, it may be anticipated that the richer households would use more paraffin. The correlation between reported household income and estimated paraffin consumption was significant in Joanna's Nek at $p = 0,01$ ($r = 0,598$, $n = 17$); with measured paraffin consumption it was only significant at $p = 0,15$ ($r = 0,396$, $n = 17$). Withholding the richest family from the sample (that of Klas Mangwana), causes both correlations to become insignificant. In Maiefiloane, both correlations were also insignificant (Mashunka was not attempted). These inconclusive results could be due to a lack of sufficiently large differentiation in household incomes in each village or the overriding importance of the immediate availability of money, which relates to intermittent remittances by migrant labourers as opposed to average income.

4.4 AGGREGATED FUEL CONSUMPTION.

African rural women are able to choose between different fuels almost on a daily basis. This section aggregates all the different fuels in order to examine total energy consumption. It also attempts to distinguish between energy consumed for cooking, heating and light.

4.4.1 The Statistics.

The final data from field results are presented in Tables 4.19 to 4.21 and in Figure 4.6. The calorific values used to transform all measurements into heat units are given in section 3.1.2.

The smaller control sub-sample represents the group of families that were monitored on each visit. The total sample is more representative of village consump-

	SUMMER january	AUTUMN april	WINTER june
CONTROL SUB-SAMPLE			
n	7	7	7
per family consumption	95,15 (0,35)	155,97 (0,29)	225,24 (0,51)
per capita consumption	24,43 (0,87)	34,90 (0,37)	47,48 (0,61)
TOTAL SAMPLE			
n	11	16	10
per family consumption	106,23 (0,47)	151,93 (0,29)	198,85 (0,58)
per capita consumption	28,45 (0,65)	35,17 (0,31)	46,88 (0,63)
variability+		80,93	
coefficient of variabil.		0,55	
FUEL TYPE++			
WOOD Kg	2,79	5,52	4,01
MJ	64,80	129,14	93,46
%	61%	85%	47%
DUNG Kg	2,83	1,58	8,80
MJ	38,24	19,75	103,40
%	36%	13%	52%
PARAF- Ml	76	126	15
FIN MJ	3,19	3,04	1,99
%	3%	2%	1%
total	100%	100%	100%

Table 4.19 : Daily Energy Consumption in Malefiloane (MJ).

() Coefficient of variability (s/x).
+ Variability of consumption per family (s).
++ For total sample consumption per family.

	SUMMER december	AUTUMN april	WINTER july
CONTROL SUB-SAMPLE			
n	8	8	8
per family consumption	83,64 (0,63)	148,78 (0,38)	164,31 (0,25)
per capita consumption	15,15 (0,56)	33,22 (0,49)	36,00 (0,54)
TOTAL SAMPLE			
n	15	14	13
per family consumption	98,57 (0,14)	156,93 (0,51)	164,63 (0,33)
per capita consumption	15,05 (0,79)	37,36 (0,82)	32,54 (0,48)
variability+		58,46	
coefficient of variabil.		0,42	
FUEL TYPE++			
WOOD Kg	2,74	6,44	4,83
MJ	62,10	145,94	110,30
%	63%	93%	67%
DUNG Kg	2,21	0,25	2,77
MJ	26,61	3,14	44,45
%	27%	2%	27%
PARAF- Ml	259	154	115
FIN MJ	9,86	6,28	4,94
%	10%	4%	3%
COAL Kg		0,05	0,15
MJ		1,57	4,94
%		1%	3%
total	100%	100%	100%

Table 4.20 : Daily Energy Consumption in Jozanna's Nek (MJ).

() Coefficient of variability (s/x).
+ Variability of consumption per family (s).
++ For total sample consumption per family.

	SUMMER january	AUTUMN may	WINTER july
CONTROL SUB-SAMPLE			
n	3	3	3
per family consumption	280,92 (0,38)	296,97 (0,31)	292,27 (0,75)
per capita consumption	39,26 (0,42)	86,88 (0,83)	64,01 (0,61)
TOTAL SAMPLE			
n	9	13	5
per family consumption	243,61 (0,34)	320,54 (0,50)	274,68 (0,63)
per capita consumption	60,05 (0,57)	83,29 (0,75)	89,88 (0,50)
variability+	72,67	133,83	
coefficient of variabil.	0,39	0,76	
FUEL TYPE++			
WOOD Kg	11,57	15,08	13,00
MJ	241,17	317,33	273,31
%	99%	99%	99,5%
PARAF- Ml	75	91	34
FIN MJ	2,44	3,21	1,37
%	1%	1%	0,5%
total	100%	100%	100%

Table 4.21 : Daily Energy Consumption in Mashunka (MJ).

() Coefficient of variability (s/x).
+ Variability of consumption per family (s).
++ For total sample consumption per family.

tion, while the control sub-sample reflects seasonal changes more accurately. The tables also give household and per capita consumption of energy. The average coefficients of variability for these two statistics are 0,48 and 0,60 respectively (n = 18), suggesting that household consumption of energy shows a lower proportional variance and thus is the more relevant statistic. Presumably this is due to the consumption of energy for heat and light which are both independant of the size of a family. Secondly, differences in age within a family and cooking methods will mask any causal link between energy consumption and the size of a family.

The final annual consumption of energy and of each fuel type is presented in Table 4.23. The values are aggregated from Tables 4.19 to 4.21 by averaging the seasonal quantities of each fuel type consumed over the whole year. It was felt that variability within the data invalidated more complex techniques of extrapolation.

Wood is undoubtedly the most important fuel accounting for between 65% and 99% of the energy consumed in the three villages. In Mashunka only wood, and the largest quantities of wood, is consumed. Where wood is not so easily available, as at Malefiloane and Jozanna's Nek, dung is burnt. Dung is most important in summer and in winter, the times when kraal dung is dug out and when both forms of dung can dry out for use (dry weather in winter and heat in summer). Thus the use of dung is indicative of difficulty in collecting wood, and replaces wood consumption. In itself dung consumption relates to the ownership of cattle. Paraffin replaces wood and dung mainly when the weather is wet, but also depends on the availability of paraffin in the trading stores. In Mashunka paraffin is only used in lamps for light. The low winter average (Table 4.21) is due to 40% (n = 2) of the households using no paraffin. Coal is only used in winter by the wealthiest families in Jozanna's Nek.

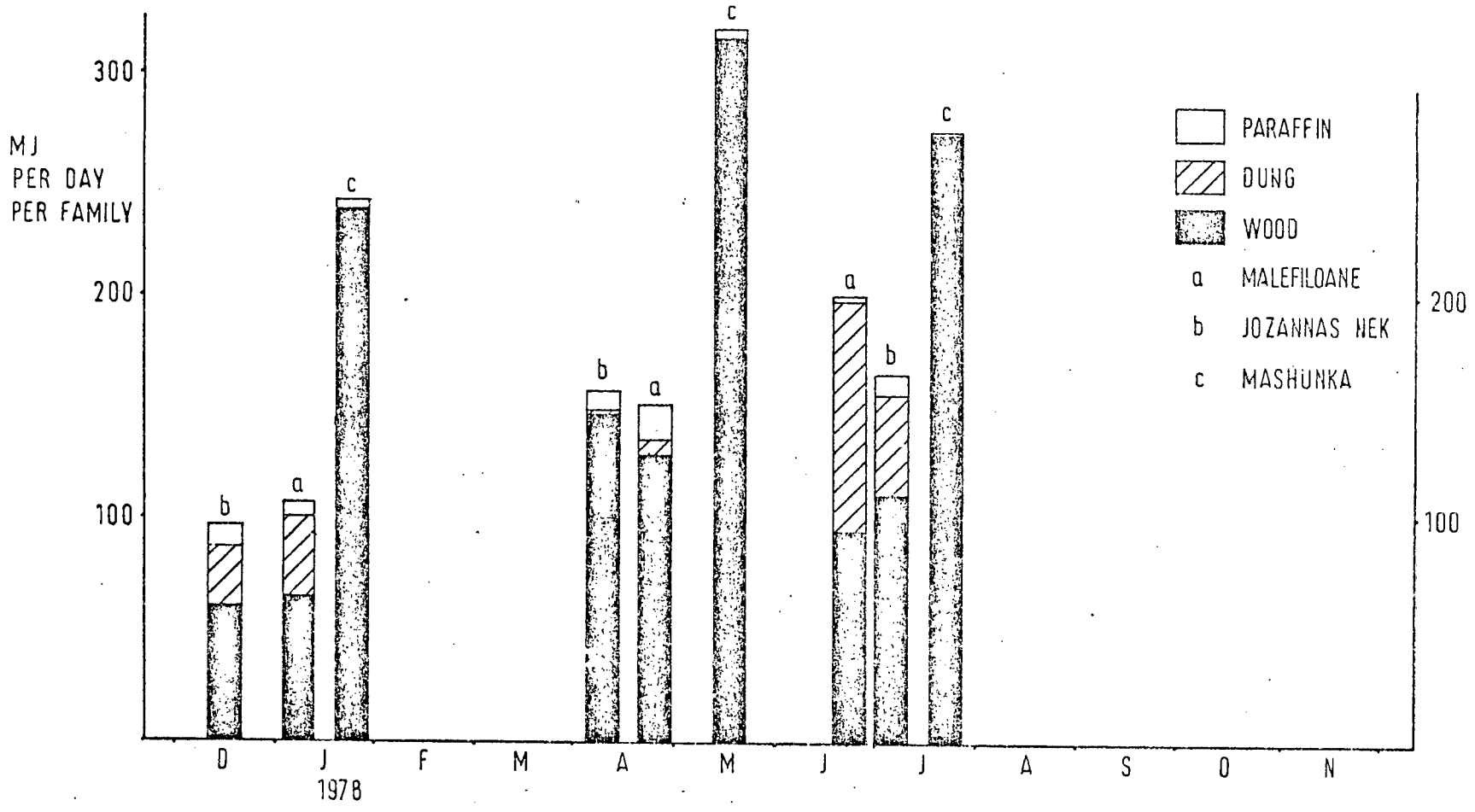


Figure 4.6 : Measured Energy Consumption in Each Village.

The villages show an increase in total energy consumption from summer to winter as might be expected. There is, however, an anomalous drop in consumption in winter in Mashunka. This could be due to faulty estimates of wood consumption because the women refused to take wood off the stockpiles which they were building for winter; and instead made a pile of wood which, they said, would last for one day. Alternatively, this drop could be the result of virtually no temperature difference (see Appendix A). The correlation of wood consumption with mean daily temperature at each village was -1,00 (Malefiloane), -0,959 (Jozanna's Nek) and -0,685 (Mashunka). The availability of wood at Mashunka has freed women from a rigid response to temperature changes. Rainfall is also an important climatic and weather feature influencing energy consumption (see section 5.2.2).

4.4.2 Minor Fuels.

Minor fuels are used sporadically, or by a few people. This made it impossible to measure the quantities of each minor fuel type that are consumed, but the different types can be noted.

The two commercial fuels that have not been mentioned are coal and candles. Coal is not used in Mashunka or Malefiloane. In Jozanna's Nek coal was used by two families, but only during the winter from April to September. The families used a bag of coal in two and six weeks respectively. The coal was obtained from Sterkspruit at a cost of R2.60 per bag. Candles are used for light and are bought in the trading store in Jozanna's Nek. One family used six candles a month.

Crop residues are also burnt for fuel. The stalks of mealies (maize) and the mealie cob are often burnt. Straw chaff and bean pods are used to start a fire. Gay (1978) mentions weeds being collected for burning. The leaves

of sisal plants and aloes are burnt when dry. In KwaZulu the aloes near to the village are 'shaved' clean of the lower dry leaves ('beard') and these leaves are favoured for cooking jwala. The stems of aloes and euphorbias are also burnt if the plant has died. Finally, Guillarmod (1971 : 34) records women burning peat from along marshy rivers in Lesotho.

4.4.3 The Use of Energy for Cooking, Heat and Light.

The proportional quantities of energy consumed for different uses are obtained by applying two assumptions. The consumption of paraffin in Mashunka is only for light (24,3 l per annum per family) and it is assumed that the same quantity is consumed for light in the other two villages. It is then assumed that in summer no energy is used for heating and all additional energy consumed in autumn and winter is only for heating purposes. The final proportions (Table 4.22) are only an indication of the situation. By comparison, in Gambia, 55% of wood fuel is used for cooking, 35% for heating and 10% for ironing (Makhijani and Poole, 1975 : 68), and in rural India the proportional use of domestic energy is : cooking 74%, heating 20% and light 6% (Revelle, 1977 : 138).

	MALEFILOANE	JOZ NEK	MASHUNKA
Cooking	68%	69%	86%
Heating	30%	29%	13%
Light	2%	2%	1%

Table 4.22 : Different Uses of the Energy Consumed.

4.5 CONCLUSION.

The vegetation surrounding each village provides different quantities of wood fuel. Wood was most available at Mashunka, slightly less so at Jozanna's Nek and least at Malefiloane. From literature and the memories of the women, it appears that it has become harder to collect wood with the passage of time. Most women found the collection of wood a serious hardship requiring between 11 and 15 hours of their time each week, and a weekly distance of 28 kilometres. The average weight of wood bundles was 21,3 kg, 15,2 kg and 20,6 kg for Malefiloane, Jozanna's Nek and Mashunka respectively. The heaviest weighed bundle was 39,5 kg (at Mashunka). The quantities of wood, which were burnt in each village, are shown in Table 4.23, and correlate significantly with the availability of wood. The daily quantity burnt increased from summer to winter. In each village there were a few women who collected and sold wood to other members of the community.

		MALEFILOANE	JOZ NEK	MASHUNKA
ENERGY CONSUMPTION (10^3MJ)				
per capita		10,33	7,69	23,86
per family		53,74	48,21	102,28
FUEL TYPE (per family)				
WOOD	10^3kg	1,50	1,70	4,82
	10^3MJ	34,89	38,78	101,36
	%	65%	80%	99%
DUNG	10^3kg	1,35	0,50	
	10^3MJ	17,82	6,99	
	%	33%	15%	
PARAFFIN	l	26,40	64,20	24,33
	10^3MJ	1,03	2,44	0,92
	%	2%	5%	1%
	total	100%	100%	100%

Table 4.23 : Annual Energy Consumption.

In Malefiloane and Jozanna's Nek, where wood is less available than in Mashunka, many women burn dung for warmth and for cooking. Two types of dung are burnt; cow dung is collected from the land once it has dried out to some extent, and dung is dug out of the kraals twice a year. In Malefiloane and Jozanna's Nek respectively 67% and 52% of the dung that is burnt comes from kraals. The seasonal proportions vary considerably since dung is dug out of the kraals only in summer and in winter. The quantities of dung burnt also varies considerably between seasons (see Table 4.23 for the annual totals). The ash from the fires, consisting of over 40% of the original cow dung (27% of field dung) by weight, is not returned to the fields. The consumption of dung was found to relate to the ownership of livestock, even when field dung was included.

Paraffin is obtainable from shops in or near each village. It represents the most important inexpensive item sold by shops (Gay, 1977). In the last eight years the price of paraffin has risen sharply. In each village most women used paraffin for light, some for cooking (no-one in Mashunka), and it was only used in heaters in Jozanna's Nek. Very often women reported that they used paraffin although they had none. The largest quantities of paraffin are used in Jozanna's Nek (see Table 4.23). One important factor affecting the use of paraffin is the strength of the traditional role that women play in collecting wood. This appears to be declining amo ngst some of the younger women.

The largest quantities of energy are consumed annually in Mashunka, where only wood is burnt. In Malefiloane the climate is colder than at Jozanna's Nek and more energy is consumed by burning large quantities of dung. Wood is slightly more available at Jozanna's Nek than at Malefiloane. Crop residues, aloes, mealie cobs and stalks and coal are also burnt sporadically. It was estimated that from

68% to 86% of the energy was for cooking, 13% to 30% for warmth and 1% to 2% for light.

CHAPTER FIVE
STRUCTURAL DETERMINANTS OF FUEL CONSUMPTION.

From the field results it is possible to isolate some of the underlying factors which determine the consumption of fuel. These factors relate specifically to the villages that were studied; they cannot be generalized without a more widespread sampling of villages. Fuel consumption is one component of the village system and is interrelated with income and population, amongst other components. The importance of nutrients within the village system is also discussed. At the household level there is another range of factors which affects either the selection of a fuel type or the quantities of fuel which are consumed. These factors are the availability of wood, rainfall, temperature, tradition and others. The final component that is considered, is the efficiency with which the fuels are burnt. Because these efficiencies are very low, they have a major impact on the quantity of fuel which each woman must collect and burn.

5.1 THE VILLAGE SYSTEM.

A model is a diagramatic representation of a real system, that can be easily understood and accurately portrays the interactions between components. Makhijani and Poole (1975 : 89/90) present models of a traditional Indian village and a developing Indian village. Figure 5.1 presents a model of a village in Southern Africa that is partially subsistent with transition occurring in response to the migration of most of the economically active males for the greatest part of the year to urban industrial centres. The model is most precise in detail in the flows relating to fuel consumption, the nature of this project. A model can portray the flow of energy or of nutrients through any system. With respect to energy consumption, the two sig-

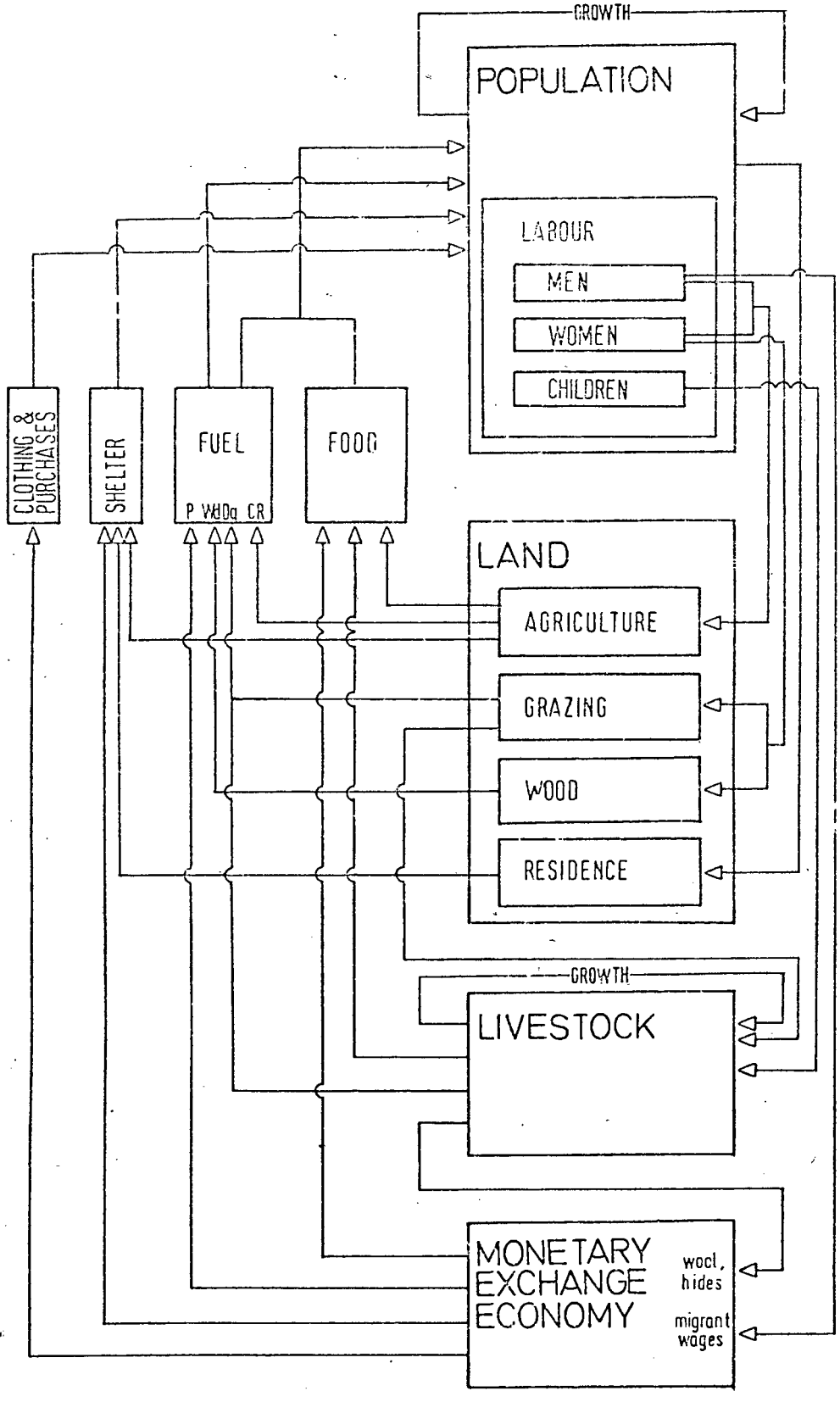


Figure 5.1 : Model of a Village System in Southern Africa.

nificant components are population growth and migrant labour.

5.1.1 Energy Flows.

The model has been constructed to show the flows of energy represented by human activity, money and commodities (food, fuel, clothing, etc.). The values, in each village, for the relevant flows are given in table 5.1.

	MALEFILOANE	JOZ NEK	MASHUNKA
Time Spent Coll			
Field Dung	136 hrs	247 hrs	0
Kraal Dung	12 hrs	12 hrs	0
Wood	719 hrs	767 hrs	585 hrs
Money Spent on			
Paraffin	R6.36	R12.48	R6.60
% tot household inc	2,49%	3,02%	3,59%
Quantity Burnt			
Dung (1000kg)	1,35	0,50	0
Wood (1000kg)	1,50	1,70	4,82
Paraffin (litres)	26,40	64,20	24,33
Energy Used For			
Cooking	68%	69%	86%
Heating	30%	29%	13%
Light	2%	2%	1%
Total Consumption (10^3 MJ)	55,60	51,12	102,06

Table 5.1 : Annual Flows Relating to Energy Consumption for the Average Family in each Village.

The few productive activities (other than agriculture) such as construction, thatching, making beer and jwala, are not shown in the model since they are sporadic and only occupy a few people.

5.1.2 Nutrient Flows.

There is also a nutrient flow within any system. Using the method in Afgan and Ryan (1975) for extracting nutrients from sediments, an analysis of nutrients in the wood and dry dung was attempted. The solution was analysed using a Hach kit and the dilutions of nutrients were too low to be reliably determined. There were not sufficient quantities of each sample to prepare more concentrated solutions (in the method of extracting nutrients, it was necessary to dilute the solution 10 times, that suggested by Afgan and Ryan (1975 : 63), because the quantities of dung were too small). Part of the interest was to see what quantities of nutrients remained in the dried dung (that had been subject to rain for up to six months), but this study had to be abandoned. A large amount of nutrient remains in the ash after combustion. The average ash weight of wood, kraal dung and field dung was found to be 3,0%, 41,4% and 27,1% respectively. The higher value for kraal dung is a result of inorganic soil particles entering the dung as it was stamped into the floor of the kraal. Nowhere was the ash spread on the fields. Generally it was put on a special heap and thus all the nutrients in the combusted fuel are wasted. If manure and ash were applied on the fields, the yields of crops could be increased over threefold (Ashton, 1952 : 126).

5.1.3 Population.

The figures on population are taken from Appendix A. Many of these figures are census results and frequently underestimate the actual population (Schultze,1969). With reference to fuel consumption the important factor is the balance between population growth and vegetation growth. Measurements of growth in the vegetation biomass around each village were not attempted. In section 4.1.1, an estimate of productivity of 1 to 4 metric tons of wood per hectare was taken from Earl (1975). Comparing the biomass

productivity and the consumption of wood by the population theoretically within the same area, (table 5.2), assumes that all of the land is available for woody vegetation growth. Large amounts of land are used for agriculture, settlement and grazing. The actual productivity around each village can only be assumed to be below even the minimum value suggested by Earl (1975). The rate of exploitation of trees in Mashunka appears to be close to the minimum limit suggested by Earl (1975). Although, at present there is an abundance of wood around Mashunka, this seems unlikely to continue for very long.

	MALEFILOANE	JOZ NEK	MASHUNKA
Biomass Productiv. km^{-2}			
Max	400	400	400
Min	100	100	100
Population density km^{-2}	17	45	75
Wood Consumption			
1000kg per family	1,50	1,70	4,27
1000kg p km^2 pop	4,90	12,18	74,65

Table 5.2 : Biomass Productivity and Population Density.

5.1.4 Income.

Migrant labour provides the main source of income in each village (that is 70,4%, 44,4% and 82,4% of total reported household income in Malefiloane, Jozanna's Nek and Mashunka respectively). This means that, in the long term, the changes in remittances by migrant labourers will largely determine the money available to women with which to buy consumer goods including paraffin. In figure 5.2, the retail price of paraffin and the remittances by migrant labourers to Lesotho (van der Wiel, 1977), from 1971 to 1976 are shown. It was suggested in section 4.3.1 that women have no longer been able to buy paraffin because the

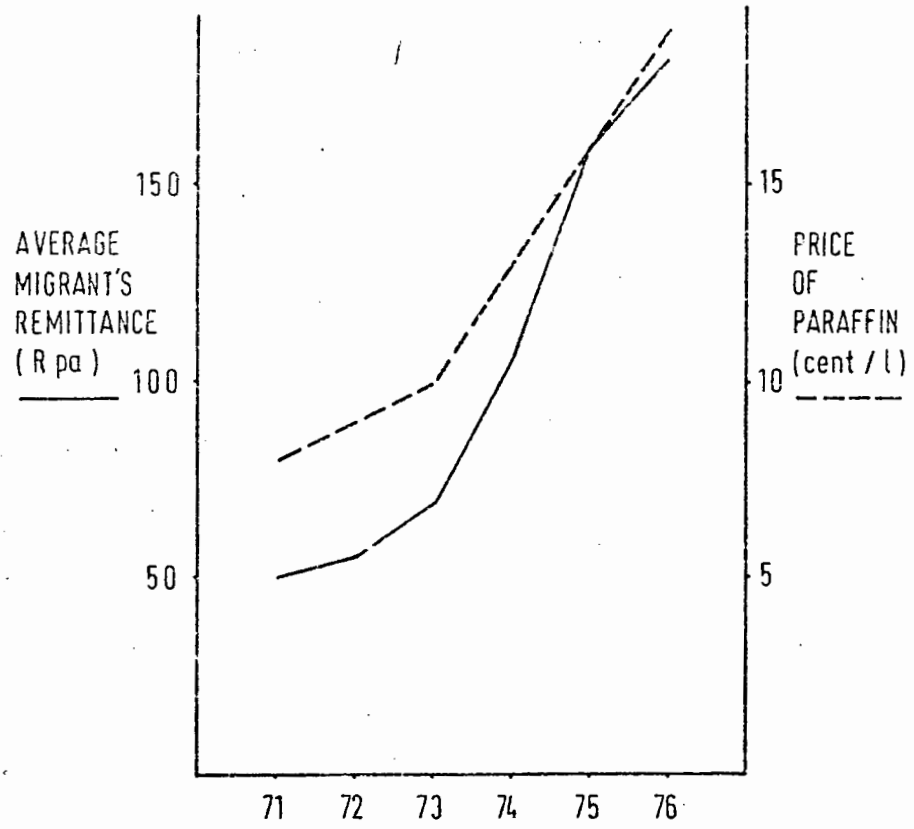


Figure 5.2 : Remittances from Migrant Labourers (van der Wiel, 1977), and the Price of Paraffin.

cost of paraffin has risen faster than the increase in their household incomes. Already the women spend, on average for each village, 2,49%, 3,02% and 3,59% of their household income on paraffin in Malefiloane, Jozanna's Nek and Mashunka respectively. In these villages paraffin, the only important commercial fuel, accounts for 1,65%, 4,01% and 0,92% respectively of the energy consumption. This means that if all the energy was supplied by the main commercial fuel (paraffin), incorporating a tenfold reduction in energy consumption due to the higher efficiency of a paraffin primus stove (30% versus 3% for a traditional wood or dung fire), the cost would be R3.71, R3.52 and R6.42 per month for the average household in Malefiloane, Jozanna's Nek and Mashunka respectively (against R0.53, R1.04 and R0.55 at present). The provision of energy by

the subsistence sector of the village economy (that is the non-commercial collection of wood and dung by women), which is dominated by production by migrant labourers in the urban complexes of Southern Africa, conforms with the 'wage subsidy' theory (Molteno, 1977). This theory maintains that subsistence production in the rural villages subsidises production in industrial centres by permitting the payment of wages below the minimum necessary to support the workers' families in a fully commercial economic structure. The Poverty Datum Line of the Lesotho Department of Statistics estimates an expenditure of R6.95 per month on fuel and lighting, which is 7,2% of the total expenditure of R96.00 per month (van der Weil, 1977 : 89). In 1975, in Lesotho, 75% of rural households had an income below the Poverty Datum Line.

5.2 FUEL SELECTION AND THE QUANTITIES CONSUMED.

In each village women are consuming different quantities of wood, dung, crop residues, paraffin and coal. In part, their selection of the fuel type and the quantity of energy can be explained. The most consistent factors influencing fuel selection and quantities are the weather, the availibility of wood, tradition and the agricultural cycle. Other sporadic events, such as feasts, holidays and men returning from the mines have a temporary impact.

5.2.1 The Selection of a Fuel Type.

Three factors emerged as significant in influencing the choice of fuel type. They are the availability of wood, tradition and rainfall. These are shown in a selection tree in figure 5.3. Initially, it was thought that wealth, old age, and sickness would be important, but the evidence is too weak. Sickness and old age were mentioned by several women as increasing the hardship of wood collection, and a few women who were sick were unable to fetch wood and had to rely on collection by friends or on paraffin.

Household income did not correlate with paraffin use, but it seems likely that many women will use paraffin when they have money (depending on the sporadic remittences of migrant labourers every few months and annual returns from the sale of wool, hides or livestock). Crop residues are discussed in section 5.2.4.

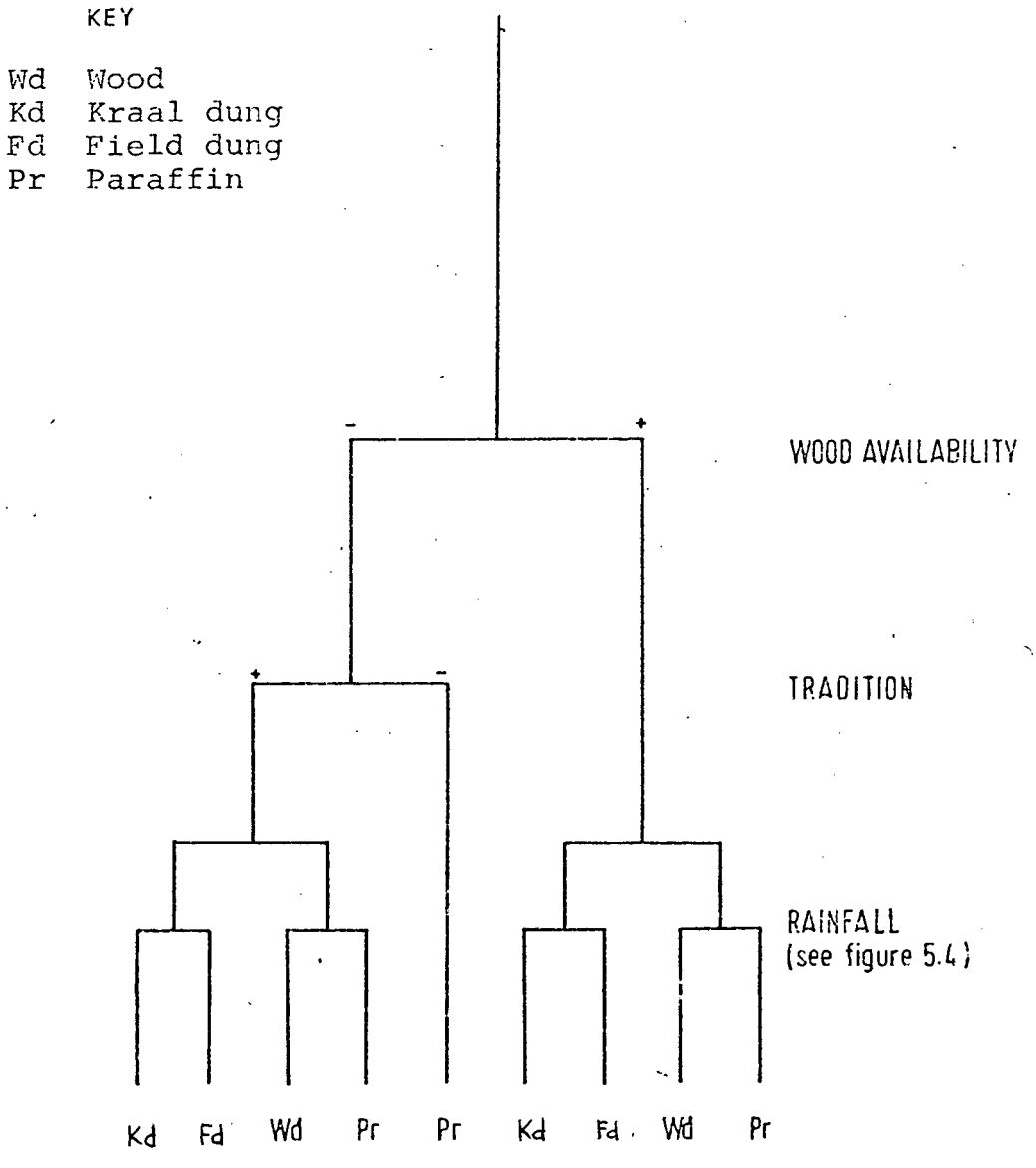


Figure 5.3 : Fuel Selection Tree.

5.2.1.1 The availability of wood.

Where wood was most abundant (at Mashunka), neither dung nor paraffin were used for cooking or warmth. The women in

Mashunka confirmed that they burnt wood because it was so easy to collect and had no need to burn dung. Wood is the most favoured non-commercial fuel being relatively smokeless and easy to burn. Only when wood becomes scarce will women start to burn dung (Agarwal, 1978; Earl 1975 and Hill, 1972). In Mashunka, paraffin was used for light, but some women even used wood for providing light preferring the wild olive (umQuma), which gives a clear smokeless flame.

5.2.1.2 Tradition.

An explanation of the importance of paraffin in Jozanna's Nek (greater than Malefiloane, where even less fuel was available) is the erosion of traditional structures suggested by the lack of 'remoteness' (section 3.1.1). It implies that the replacement of wood by paraffin consumption is part of the change towards a consumer society. This is supported by Gay (1978 : 9), who suggests that:

> "Older women gather (wood) fuel more than younger women, not only because of economic need, but because they are continuing an accepted activity of Basotho women. Younger women, on the other hand, particularly in such lowland villages, want to take advantage of all the modern conveniences which cash income and access to roads and towns make possible, and hence look upon gathering fuel as an old fashioned activity to be avoided if at all possible."

5.2.1.3 Rainfall.

Rainfall is significant in that it prevents the consumption of wood and dung. Some women keep a dry pile of wood inside their cooking hut or place a plastic sheet over their pile of dung, but these stocks of fuel are generally small. Often, partially as a result of collecting wood on a daily basis, there is no attempt to keep dry piles of fuel. After a few days of rain all dry wood and dung will

have been burnt. While it is actually raining, the women will never go out to collect wood. The wood would be wet, the women have no waterproof clothing and there is a very real danger of becoming ill. Thus during periods of rainfall, the women will burn paraffin, if they have the money to pay for it.

Once the rain stops the women will collect wood again. The small herbaceous bushes burnt in Malefiloane and Jozanna's Nek will burn easily, even when green and only take one day to dry in the sun. Dung takes much longer to dry out enough for it to burn and the women will not collect dung from the fields and grazing camps for several days. After four to five days of sunshine, there is an abrupt switch by many women to collecting field dung (instead of wood), which is then dry enough to burn. Dung is in demand in winter because it is quicker to collect, and the coals provide warmth.

Kraal dung can be dug out from the kraals even if it is wet. But the blocks require three to four weeks of dry weather before they will burn. The kraal dung is dug our mainly in summer when it is hot enough to dry the blocks between intermittent rainstorms and in winter, which is the dry season.

A final situation, observed in Jozanna's Nek in April, is when it continues to rain until the increased demand for paraffin exhausts the supply in the shops. In this case new supplies can take several weeks to arrive, and the women are forced to collect wet wood or cope as best they can.

The influence of rainfall on fuel selection is shown diagramatically in figure 5.4. When rainfall does not limit a woman's selection, she is free to choose any fuel type, being influenced by other factors.

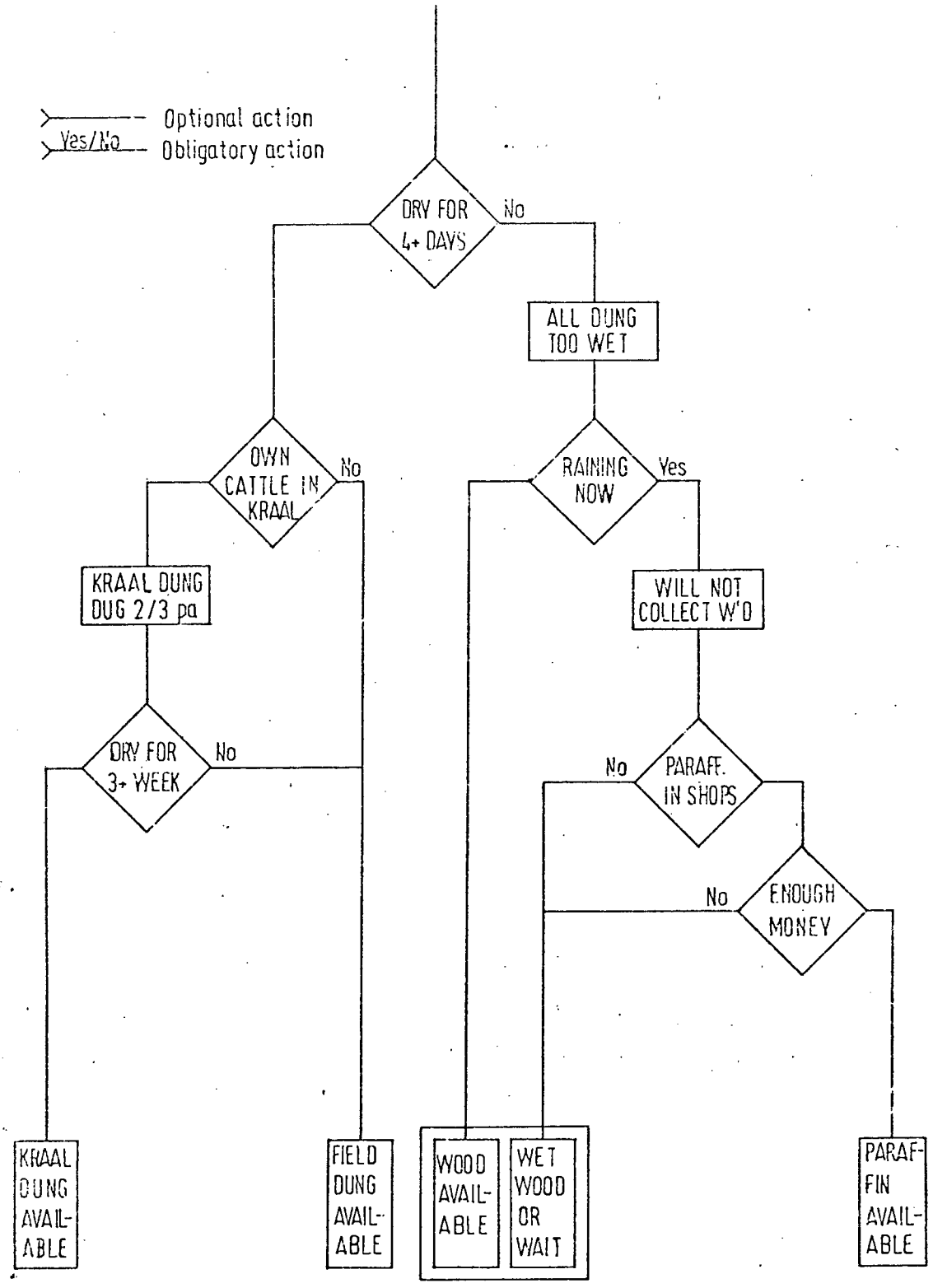


Figure 5.4 : The Impact of Rainfall on Fuel Selection.

5.2.2 Changes in Consumption.

There are significant differences in the total annual energy consumption per family in each village. The total consumption can be seen as a response to climatic differences, as suggested by Makhijani and Poole (1975 : 56), because "more fuel (is) required for heating in colder climates", or responding to the availability of wood as suggested by Earl (1976 : 6), who found "no evidence to show energy consumption is related to climatic conditions."

The rainfall and temperature regimes for each village (or the nearest meteorological station), are shown in Appendix A. The mean annual temperatures for Malefiloane, Jozanna's Nek and Mashunka, are 11,5°C (Mokhotlong), 15,4°C (Aliwal North), and 18,4°C (Weenen) respectively. The annual consumption of energy (table 4.23) shows the opposite trend to what would be expected if energy consumption was determined by temperature. However, there is a slight increase in energy consumption in Malefiloane over consumption in Jozanna's Nek, that could result from a colder climate. Also temperature is found to have an impact on seasonal energy consumption in each village (Section 5.2.4).

In section 2.1.3, there was a correlation coefficient of 0,999 between maximum wood biomass and wood consumption. Correlating the total energy consumption (from table 4.23 in 1000MJ units) with maximum wood biomass, the coefficient is 0,986. The small n(n = 3) does not permit a significance test of these correlation coefficients. These results confirm that, in the three villages that were studied, the availability of wood primarily determines the annual consumption of energy. Where wood availability is relatively similar (Malefiloane and Jozanna's Nek), there is a partial response to the climate (i.e. increased consumption in colder regions). The increased total consumption of energy in Malefiloane over Jozanna's Nek can be broken down into a slight reduction in wood consumption and a

large increase in dung consumption (see table 4.22). This shows that the women in Malefiloane have resorted to burning dung on a far larger scale than women in Jozanna's Nek to counteract a colder climate, and a lower availability of wood. That energy consumption is largely independent of climate, underlines the hardship that people in cold mountain climates, where biomass is generally low, have to endure as a result of insufficient fuel.

5.2.3 Sporadic Events.

Certain sporadic events have a short duration impact on energy collection or consumption. School holidays increase the collection of wood since most of the young girls are sent to collect wood. In most families the schoolgirls only fetch wood on Saturday. But in the poorest families, or if the mother is old or unwell, a young girl might be sent to collect wood every day after school. No-one collects wood on Sundays. Feasts and meetings occur in the village to mark a funeral, a marriage, etc. During the feast, large quantities of meat, bread, beer and samp will be consumed. The collection of wood for cooking the meat is traditionally collected by the men and boys using an ox-drawn sleigh. The women collect wood for brewing beer and making bread and samp. Letsemas are co-operative agricultural parties where the host provides food and beer, in exchange for the labour of the guests in harvesting, or some other task. The woman providing the letsema will have to collect an extra large quantity of wood, but the other women participating in the Letsema will have less time to collect wood, and a lower consumption. In part, the women prepare for the harvesting season by stockpiling wood before hand.

When the men return from working outside the villages as migrant labourers (for periods of eight months or more), and then to some extent throughout their stay in the village, the consumption of fuel in a household will increase.

The men expect beer, more food and warm water (Bond,1977). The consumption of energy by Malerato Mapulla increased over sixfold on the day her husband returned to Malefiloane.

5.2.4 The Seasonal Cycles.

Several factors have a seasonal effect on the selection and consumption of fuel. The rainfall cycle will have an impact on fuel selection by reducing dung and to a lesser degree, wood consumption during the rainy season.

The seasonal labour demands of agriculture, a large portion of which are met by women, will reduce the collection of wood because the women spend all of the day working in the fields. The women collect wood to build up extra large stockpiles in slack agricultural periods. In Jozanna's Nek these periods are early June (before weeding), April and May (before harvesting), from August onwards (before ploughing and planting for the next crop), and before winter (when consumption rises and the women are reluctant to collect wood in the cold). The agricultural seasons for Lesotho are given in Wallman (1969 : 50), but the bushes burnt for fuel in Malefiloane are too small to stockpile over long periods. In Mashunka, ploughing occurs from September to November, weeding from November to January, and harvesting from March to May, but the major stockpiling occurs in April and May before winter. The annual agricultural cycle is also important in the provision of crop residues. These are available for a limited period after harvest. The most important residues which are burnt are maize stalks and maize cobs.

Mean annual temperature does not affect annual energy consumption (section 5.2.2), but there is a strong seasonal change in energy consumption. The correlation coefficients for seasonal fuel consumption and mean daily temperature (measured during each visit to each village) for Malefiloane, Jozanna's Nek and Mashunka, are -1,00, -0,959 and -0,685

respectively. The correlation is lowest in Mashunka, presumably because the abundance of wood reduces the importance of temperature (i.e. the women do not reduce their consumption of wood, to the same extent as other villages, during summer when temperatures rise). It also indicates that in Malefiloane and Jozanna's Nek the women consume energy in direct response to need. In section 4.4.3 it was assumed that seasonal changes in energy consumption are a result of increased fuel consumption for heating. In the villages where dung is burnt, there is a shift towards the consumption of dung in winter because it provides a long burning, warm fire.

5.3 THE EFFICIENCY OF COMBUSTION.

The transformation of the potential heat, in any quantity of fuel, into useful heat to the household can never be 100% efficient. During the transformation, varying proportions of the potential heat are 'lost'. The lost heat goes into converting water within the fuel to vapour, heating the air etc. The extent to which heat is lost or wasted, in terms of human benefit, varies according to how the efficiency is conceptually defined, and according to the method of transforming potential heat into useful heat. The possibility of using more efficient technologies for burning the fuel is one of the solutions to the present shortages of domestic energy.

5.3.1 Efficiency.

The point of transformation at which efficiency is measured must be defined. Thus efficiency can measure the production of heat by the fire, irrespective of what use is made of the heat; or the efficiency can relate to human use and in the case of a fire for heating, the efficiency is zero, if no-one is present in the room. In this project, efficiency is defined at the transfer of potential heat in fuel into heating the water inside a cooking ves-

sel. As far as it is possible, this approximates the efficiency of burning the fuel for domestic cooking.

In order to calculate the efficiency, the following information was recorded:

i. The mass of water inside the vessel (m kg).

ii. The quantity of fuel burnt, later converted to heat units to give potential energy (Ep MJ).

iii. The rise in the water temperature as a result of the fire, generally until boiling ($\Delta T\,^{\circ}C$).

The effective energy (E) can be calculated by:

$E = m.Cp.\Delta T$ KJ specific heat of water : 4,18 KJ/kg°C.

Efficiency = (E/Ep)100%.

Each experiment on efficiency was done in the field and the woman, at whose house the experiment was done, was asked to make and feed the fire. Her usual cooking spot was used as well as her own pots. The fires, especially when dung was burnt, were often allowed to burn for up to 8 minutes before the cooking pot was placed upon the flames. The wood consumed during this period was included in Ep. As a dung fire will burn for a long period, the initial fuel consumed to get the fire burning should be spread over the whole burning period, and not the initial 20 or 30 minutes required for the water to boil in the experiments. Once the water had boiled, the fire was extinguished and the unburnt fuel weighed. Inevitably, this included some semi-burnt fuel and ash (with kraal dung, the ash accounted for up to 30% of the initial weight). Although asking the women to maintain the fire approximated the real situation, they had no fixed quantity of kindling, initial burn time or frequency of feeding the fire. The condition of the ground, whether it was cold, wet or dry, may also have affected the results.

	PLACE	POT SIZE No.	AIR TEMP C	LOCATION	WOOD kg	DUNG kg	TOTAL MJ	MIN	WAT -ER l	T C	FUEL	EFFICIENCY
1	Joz Nek	5	13	Outdoors	0,60	1,88	35,26	34	3	78	DUNG	2,77%
2	Joz Nek	1½	13	Outdoors	0,32	0,82	16,76	22	1	82	DUNG	2,05%
3	Joz Nek	1½	17	Outdoors	1,45		33,07	16	1½	80	WOOD	1,52%
4	Joz Nek	10	17	Outdoors	1,69		38,48	21	3	78	WOOD	2,54%
5	Malefiloane	1	12	Outdoors	0,32	2,01	30,44	23	2	83	DUNG	2,14%+
6	Malefiloane	1	15	Outdoors	0,40	4,10	35,68	30	2	83	DUNG	1,94%
7	Malefiloane	1	14	Outdoors	0,80		18,61	17	2	77	WOOD	3,46%
8	Mashunka	¾	19	Inside	0,45		9,46	19	2	83	WOOD	7,33%
9	Mashunka	¾	19	Inside	0,76		9,83	14	2	77	ALOE	6,55%
10	Malefiloane	1	21	Inside	0,20	1,38	29,33	21	2	85	DUNG	2,42%++
11	Malefiloane	1	21	Outdoors	0,40	3,95	54,61	30	2	83	DUNG	1,27%+
12	Malefiloane	1	21	Inside	0,40	2,98	43,48	42	2	78	DUNG	1,50%+
13	Mashunka	¾	16	Inside	0,79		16,61	10	2	82	WOOD	4,13%
14	Mashunka	¾	16	Outdoors	1,18		24,82	12	2	79	WOOD	2,66%
15	Cape Town			Inside					1	82	PAR.	30,21%

Table 5.3 : Measured Efficiencies.

\+ Using a 'Paolo'.

++ Hand Made Dung Pats.

5.3.2 The Results.

The efficiencies measured in the villages are very low, especially when compared with ~~the~~ modern appliances. The results of the efficiency experiments are shown on table 5.3. The average efficiency of a wood fire is 2,54%, for a kraal dung fire it is 1,85% (excluding experiment 1, where an assumed linear combustion of fuel will overesti- the real efficiency since the combustion rate will be greatest in the middle of the fire's duration; including experiment 1, the average efficiency of a dung fire is 2,03%), and the efficiency of a fire burning hand made dung pats from fresh dung (assumed to be equal to field dung), is 2,42%. This gives the ratio of efficiency of a wood fire to a kraal dung fire of 1:0,73 and wood to field dung of 1:0,95. For a wood fire the ratio of the efficiency of cooking inside to cooking ourside, is 1:1,55, and for a dung fire, this ratio is 1:1,18. Hayes (1977 : 351), estimates that firewood is burnt at less than 9% efficiency in India.

As the initial temperature of the water in each experiment varied, the time taken to boil water has been extrapolated to cover a span of 100°C to make the results comparable. Whether the fire was indoors or outdoors did not appear to affect the time it took to boil water.

	NUMBER OF EXPERIMENTS	MINUTES FOR WATER TO BOIL
WOOD	4	18,09
KRAAL DUNG	4	38,47
FIELD DUNG	1	24,71
ALOE	1	18,18

Table 5.4 : Time Taken to Heat 2 Litres of Water through 100°C.

The speed with which each fuel will boil water (table 5.4) explains the preferences for fuels that the women

mentioned. Jwala (beer) and bread take several hours of cooking to prepare so dung is preferred. Wood is much faster and used for shorter cooking tasks.

A paraffin primus is a modern appliance in widespread use. Using the method described, the efficiency of a paraffin primus was found to be 30,25%. In table 5.5, the efficiencies of a number of modern appliances are listed (taken from Department of Planning and the Environment 1978 : 192). The efficiency of a paraffin stove is listed at 75%, suggesting that, in these figures, the efficiency is that of transforming potential to available heat, but does not include the conversion into used heat (in the case of cooking, this is the transfer of heat from the flame into the water which involves further heat loss.) A precise definition of the listed efficiencies is not made.

ELECTRIC	
Stove	80%
Kettle	99%
COAL AND ANTHRACITE	
Stove	10%
GAS	
Stove	75%
Heater	63%
Light	6%
PARAFFIN	
Light	57%
Stove	75%

Table 5.5 : Efficiencies of Modern Appliances (from Department of Planning and the Environment, 1978 : 192).

In the Third World, on average, 85% of the total energy consumption is of the non-commercial fuels (i.e. food, fodder and wood; Makhijani, 1976 : 6). This makes the efficiencies with which the traditional non-commercial

fuels are burnt, extremely significant. Makhijani and Poole (1975 : 1) state that "the energy characteristic that is typical of poverty is not so much low per capita energy use - although that is part of it - but the relatively small amount of useful work that is obtained from it."

5.3.3 The Possibility of Changing Technologies.

Inevitably, most of the solutions to the inadequacies of Third World fuel supplies propose new technologies. These either raise the efficiency of converting traditional fuels into useful heat (incremental changes) or they suggest a new energy source (alternative changes). In Brauer (1977) some tentative estimates of the savings in 'wasted' heat that result from drying wood (10%), stove design (20%), and the design of the cooking pot (30%), are given. In evaluating the effectiveness of each proposal, it is essential that the social and economic structure of these communities is considered. Proposals that make false assumptions about the needs and resources available to households in each village, are doomed to failure. This section is not an exhaustive or detailed analysis of each proposal.

5.3.3.1 Incremental changes in technology.

These proposals still use traditional fuel sources but decrease the loss of heat in cooking.

i. The hay box:

This is also known as a Wonder Cooker. It is described (by Pearce, 1978 : 12) as "work(ing) on the same principle as a vacuum flask, the hay being a good insulator, so that the heat in a pot of boiling stew could be retained for a whole day." Once the pot is boiling, it is taken off the heat source and placed inside the box, which is packed with straw, nylon or polystyrene, which acts as the insulator.

ii. Mudstoves.

The Lorena mudstove (Evans and Wharton, 1977), is a stove sculpted out of a large block of a mixture of sand and clay to give a firebox, with tunnels leading the flames to the base of each pot. The holes are make to fit each pot, so the women can use their existing pots. The mudstove conserves 90% of the heat and the major expense is the chimney. A few mudstoves have been built in South Africa in order to evaluate their applicability. The main difficulty appears to be the ratio of sand to cement, which can cause cracking if not correct.

iii. Iron stoves.

An iron stove would also concentrate the heat of a fire onto the base of the pot. In many ways this is an extension of the 'paolo' or brazier, frequently used in Lesotho. The main criteria is to keep the cost of the stove down. Conventional iron coal stoves are available at R200 to R300, and are only owned by the most wealthy families in Jozanna's Nek.

5.3.3.2 Alternative changes in technology.

Innovations that increase efficiencies of consuming fuel are only likely to reduce the demand for traditional non-commercial fuels in the short term. Long term demand for energy will increase as a result of increasing consumption of energy and population increase. What is required is some energy source that will not deplete existing resources. The controlled use of woodlots is discussed in section 2.1.4. Two of the other proposals are solar energy, and methane gas.

i. Solar energy.

Trees and bushes convert and store solar energy into a form that can be used by man. A number of proposals have appeared using direct solar energy for cooking. One approach uses parabolic reflectors make from wicker, mud and tin foil to concentrate the sun's rays on a pot (Von Oppen, 1977). Box cookers can trap the sun's rays in a glass walled insulated oven (Hoda, 1977 and Vidyalya, 1976). Direct solar energy

devices are a major step away from traditional methods of cooking. The energy source is new and requires a change in the daily routine towards midday cooking instead of early morning and late afternoon, which occurs now. The sun's energy can be converted to electricity, a clean and versatile energy form, using photoelectric cells. The major drawback at present is the cost, which is "exhorbitantly high because the total world production is so low (Usmani, 1978)." Usmani suggests that if finance (at present used by the Third World for arms and nuclear reactors) was available, the demand for units to electrify the poorest million villages would drop the price to a feasible level. Photoelectric cells, would be used in conjunction with wind and biomass energy sources.

ii. Methane Gas.

Methane gas digestors or biogas plants use animal or human manure (as well as crop residues) which, when fermented anaerobically, give off methane as a result of bacterial action. The manure effluent can still be used as a fertilizer after the production of methane as its nutrient value is enhanced. Initially, larger scale methane plants were proposed (Everett, 1975, Makhijani, 1976 and Makhijani and Poole, 1975), because of the complexities of construction and maintainance. Solly (1977 : 25) concludes that "the major reason for the limited propagation of digestors is economic. Capital costs for the installation of digestors were not justified upon the basis of the visible returns, primarily that from utilization of the gas." A more recent approach is to use simpler small scale units. These are being developed by Neil Alcock (Emdukashani, Churches Agricultural Project, Weenen, Natal), and Moran (1975), using 55 gallon oil drums. The gas is stored either in an inner car tyre tube or trapped in an inverted drum above the manure 'slurry'. The major problem is to maintain the temperature close to 95°F at which the bacteria are most active. Romesberg estimates that one cow can give approximately 12cu ft of methane per day on 12 gals liquified manure mixed with grass, sawdust and leaves, per month (Hayes, 1977 : 352,

supports the estimate). The advantage of the methane digestor is its ability to provide a clean and sustainable energy source as well as free fertilizer. The importance of temperature curtails its usefulness at high altitudes and in winter, where and when it is most needed.

5.3.4 The Social Context Within Which Technology is Changed.

A technological solution to energy shortages is not sufficient. The introduction and acceptance of a new proposal into the village structure is very important. If the innovation is too expensive or cannot be moved outdoors in summer and indoors in winter (using wasted energy to heat the room) or too complex or unreliable, its usefulness to each woman is undermined. Where an innovation is of use to the women, its adoption can be rapid. The widespread ownership of paraffin lamps and primus stoves in the villages indicates the spread of new appliances where their benefit is felt to be real. Whether an innovation is introduced through trading stores, co-operatives or a government structure, will also be important. Any proposal must be within the resources and money available to each family. Although this should be obvious, too often development projects only benefit the richer members of the community. Within each community, there is a large range of income and any innovation should be accessible to the poorest households.

The impact of changes in fuel technology will be to make more time available to the women for non-domestic activities. In part, the benefits of making energy more easily available can be measured in terms of the use to which they can put the extra time. There is also the reduction in the hardship of collecting and carrying the bundles. Nomluyelelo Mtunyana of Jozanna's Nek complained of pains in her back after carrying a bundle home. Another consequence will probably be an increase in demand for energy once it becomes available. The correlation between availability of wood

and consumption of energy rather than climate, indicates that the women have reduced their consumption of energy significantly below a comfort level.

5.4 CONCLUSION.

Within the village system, the availability of wood is a fixed component. The demand for fuel is likely to grow as population grows, and as the household consumption of energy grows. The alternative of consuming paraffin depends on the retail price of paraffin and on household income. At present, the price of paraffin is rising sharply, and household income is largely determined by the remittances by migrant labourers. These remittances rose significantly between 1971 and 1976, but the subsequent economic recession and unemployment probably reversed this trend.

The selection of a fuel type, by a woman, was influenced by the availability of wood, tradition and rainfall. If wood was easily available, neither dung nor paraffin was used for cooking or warmth. The older and more traditional women collected wood, while younger women preferred paraffin as a fuel. Rainfall prevented the women from collecting wood and caused the kraal and field dung to be too wet to burn. The total quantity of energy consumed in a year was primarily determined by the availability of wood. Only where the availability of wood was similar, did the colder climate result in increased energy consumption. This increase was found to be the result of burning large quantities of dung. Significantly, greater quantities of energy were consumed in winter; but this was most marked where wood was least available. The demands of agriculture for labour caused women to intensify the collection of wood before active periods.

Wood and dung are burnt, in cooking, at efficiencies of between 2% and 3%. One short term solution to the shortages of fuel supplies is to introduce stoves which will raise the

efficiency of combustion. The Lorena mudstove is one of the cheapest methods of achieving this objective. In the long term, alternative sources of energy must be exploited. Solar energy, and methane gas are the most feasible alternatives. Small methane digestor plants, that avoid technological complexity, can provide methane gas and manure for fertilizer. Their strongest drawback is the need to maintain temperatures at around 37°C, reducing their efficiency in winter and at higher altitudes.

CHAPTER SIX.
CONCLUSION.

The three villages cover two spectra within Southern Africa. The first spectrum is the environmental transition from a high altitude mountainous area (Malefiloane, Lesotho), through the interior veld (Jozanna's Nek, Transkei), to the semi-tropical East coast river valleys , (Mashunka, KwaZulu). The second spectrum is the social transition from a traditional African culture (Malefiloane and Mashunka) towards the modern industrial consumer culture (significantly stronger in Jozanna's Nek). Both of these components have an impact on fuel consumption.

6.1 THE STATISTICS.

The recorded annual consumption of domestic energy is listed in table 4.23. This gives the consumption of energy by each household, a value that was found to have a lower variability than per capita energy consumption. Since most other studies on rural domestic energy consumption outside Southern Africa record energy consumption per capita, this is shown in Table 6.1. These values are derived from the quantities of individual fuel types consumed annually, converted to a per capita value using the average family size in each village.

	MALEFILOANE		JOZ NEK		MASHUNKA	
	kg l	10^3 MJ	kg l	10^3 MJ	kg l	10^3 MJ
WOOD	288	6,70	271	6,18	1124	23,64
DUNG	260	3,44	80	1,12		
PARAFFIN	5,08	0,19	10,22	0,39	5,67	0,22
Total		10,33		7,69		23,86

Table 6.1 : Annual Fuel Consumption per Capita.

Comparing the consumption of wood in the three villages with other studies, the quantity of wood burnt in Mashunka is similar to the higher values recorded in Thailand, China, Gambia, etc. (see table 2.2). The quantities of wood burnt at Malefiloane and Jozanna's Nek are equal to the lowest values recorded in India, Nepal and Nigeria. Values on dung consumption are comparable with those found elsewhere.

There was an increase in energy consumption in all villages from summer to winter, except that the trend was weakest in Mashunka. Dung was only burnt in Malefiloane and Jozanna's Nek where, in winter, there was a drop in wood consumption and a greater rise in dung consumption. The largest quantity of paraffin was used in Jozanna's Nek, probably as a result of the transition towards a consumer society. It was found that the daily variation in fuel consumption was equivalent to approximately 50% of the average daily consumption of energy.

6.2 IS THERE A PROBLEM?

A central question is, how serious are the shortages in available fuel? The problem can be approached from it's environmental context or it's social context.

A number of aspects suggest that the collection of firewood is having destructive, long term effects upon the vegetation. These must be seen within a well documented, historical trend of vegetational deterioration, resulting from the impact of man. The forces of agriculture, veld burning, overgrazing, settlement, etc., play dominant roles along with firewood collection. It is seldom that firewood collection can be singled out exclusively. Ironically, the presence of the bushes which are collected for fuel at Malefiloane, is indicative of overgrazing. In the memories of the women in each village, except Mashunka, wood has become less available and the trees have become smaller.

Suitable trees and bushes are only found some distance from each village suggesting that nearer sources have been exhausted. The removal of trees and bushes increases the erodability of soils, while the collection of dung deprives the soil (and the vegetation) of important nutrients. No major erosional features, such as rills or gullies, occurred in the areas where wood was most commonly collected.

The women spend a long time collecting wood, averaging up to 15 hours a week. This is a chore that hardly exists for an urban housewife with electricity, paraffin or gas at her disposal. It also severely limits the time available to women for other activities. There is the physical hardship of collecting and carrying the wood for 3 kilometers, which caused pain in the women's backs. The smoke from the dung, especially, strongly irritates their eyes. In Malefiloane and Jozanna's Nek, the women, themselves, considered collecting wood a difficult burden.

The consumption of energy is found to depend upon the availability of fuelwood. This means that, where the vegetation provides very little firewood, even if the demand for energy is high, the consumption of energy is low. Practically, the effect is that food might not be properly cooked in extreme situations and, more generally, there will not be enough fuel for warmth at night, even when the temperature is below freezing. There can then be further repercussions on health, especially with children. Where shortages are severe and temperatures low, the women suppliment firewood with large quantities of dung. No satisfactory level of fuel consumption can be defined, since consumption will always equate supply with demand. The quantities of energy consumed per capita in Malefiloane and Jozanna's Nek are only 47% and 36% of that in Mashunka. It is inevitable that social change will increase the per capita demand for energy.

Shortages of domestic energy is a serious social problem that is affecting a large proportion of the population of

Southern Africa. Because of the escalating cost, it is unlikely that the present commercial fuels of paraffin and coal can satisfy the present, and future demand for energy, and relieve the vegetation from the pressure of fuel collection. There are indications of the effect of firewood collection on the vegetation surrounding each village; but the effect of fuel collection cannot be singled out from amongst the effects of grazing, burning and agriculture.

6.3 SOLUTIONS.

Three solutions can be proposed. The first is to establish woodlots large enough to provide enough wood for each family on a sustainable yield. Although a shortage of land already exists, the poorest agricultural land can be used when the village women feel that the need for wood is greater than the present benefit from that land. Secondly, wood and dung are burnt at efficiencies of below 3%. By introducing stoves, this efficiency can be raised and smaller quantities of fuel will be needed for the same task. The important factor is to minimize cost of any stove that is proposed. Mud ovens can be made at total costs of less than R15. Finally, it may become possible to exploit methane gas from human and animal manure if simple, small scale units can be developed that will allow manure to be used for fuel and fertilizer.

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APPENDIX A.

THE VILLAGES.

This appendix includes information on each village which is not directly relevant to the consumption of fuel or from which values were extracted for previous sections. Information on the villages, which has already been documented, is not repeated.

i. Location.

The location of each village in Southern Africa is shown in figure A.1. The exact location of each village is : Malefiloane 29°21'S 29°11'E; Jozanna's Nek 30°37'S 27°29'E; and Mashunka 28°44'S 30°16'E. The surrounding topography of each village is mapped in figures A.2 to A.4. In figure A.5, the village of Malefiloane, the only village small enough to sample the whole village population, is mapped.

ii. Climate.

Climatic data on mean monthly temperature and rainfall (figure A.6) are shown for the nearest meteorological station. During each visit to each village, a series of temperature readings were made to cover the daily cycle. (figure A.7) using a whirling hygrometer.

iii. Vegetation.

The species which were found to be used as fuelwood are listed in table A.1. The results of the calorific analyses, which were used to convert fuel quantities into heat units, are listed in table A.2. Finally, tables A.3 to A.5 contain the measurements from the vegetation quadrats whose locations are shown on figure A.2 to A.4.

iv. Population.

The population of Malefiloane could be calculated exactly, because it was so small. The population of Jozanna's Nek and Mashunka were calculated from the number of houses, using the average number of people per house from the sampled group. In Mashunka, there is no defined village area as a result of dispersed settlement, grouped on a family basis. For this project, Mashunka was defined as the rough area within which families were sampled. Demographic statistics for each area are given in table A.6. Using ages reported in Malefiloane and Jozanna's Nek, the age pyramids in figure A.8 were constructed. The low pyramid in Male-

filoane can be explained by the short period of settlement. Malefiloane was first settled in 1965 by younger families leaving their parents' villages, which had become too crowded. In Mashunka, the majority of the women were uncertain of the ages of their children or themselves.

v. Income.

Women were asked what their (household) income was (table A.7). This is not a very reliable figure and is likely to exclude income from sporadic activities such as sewing, making beer or vetkoek, making grass mats, beersieves or brooms and constructions (thatching, stone cutting and collecting, building, etc.). The reported incomes came from migrant labourers' remittances, agriculture (the sale of wool, hides and animals), pensions (accounting for the large proportion of locally derived income in Jozanna's Nek) and selling wood. Histograms of household income for each village are shown in figure A.9.

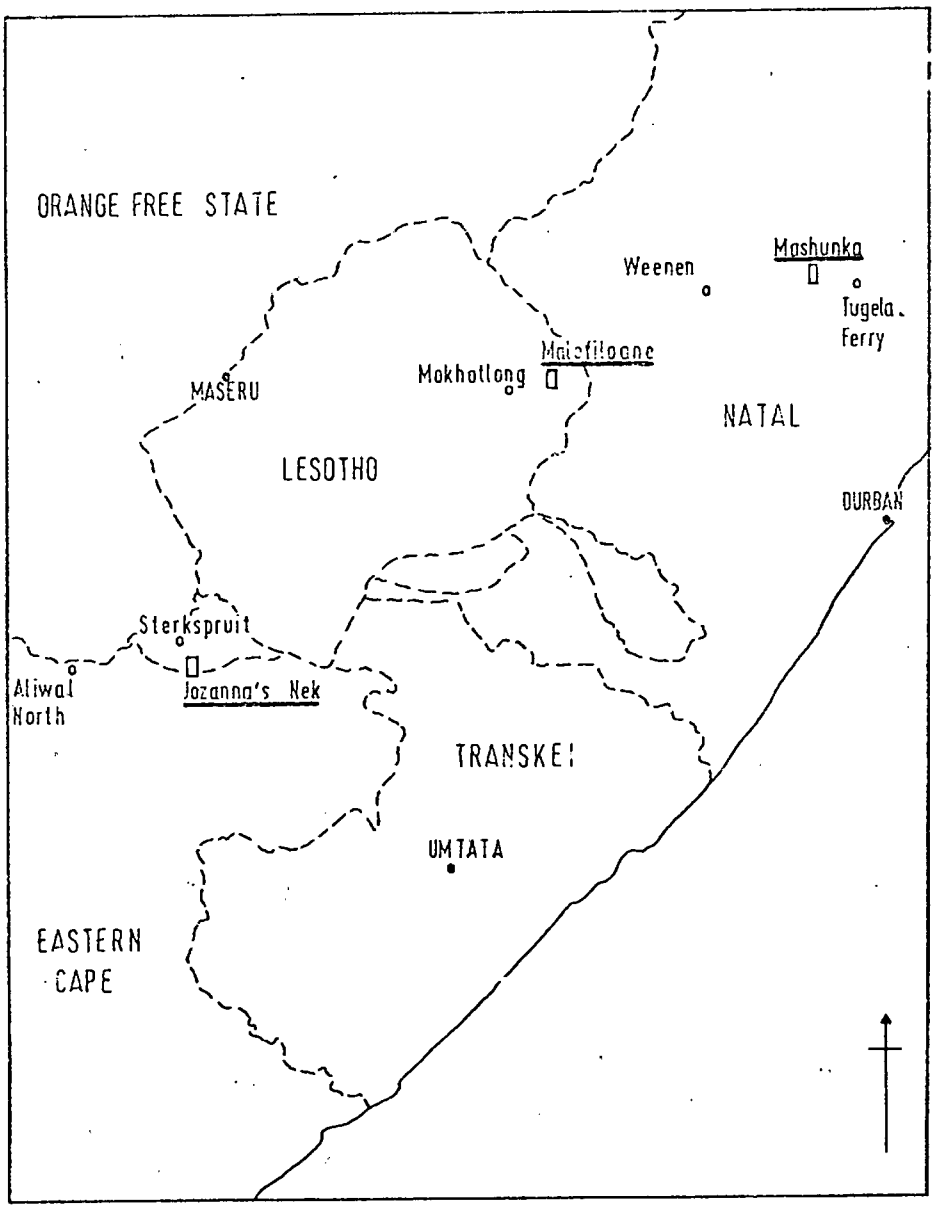

Figure A.1 : Locations of the Three Villages.

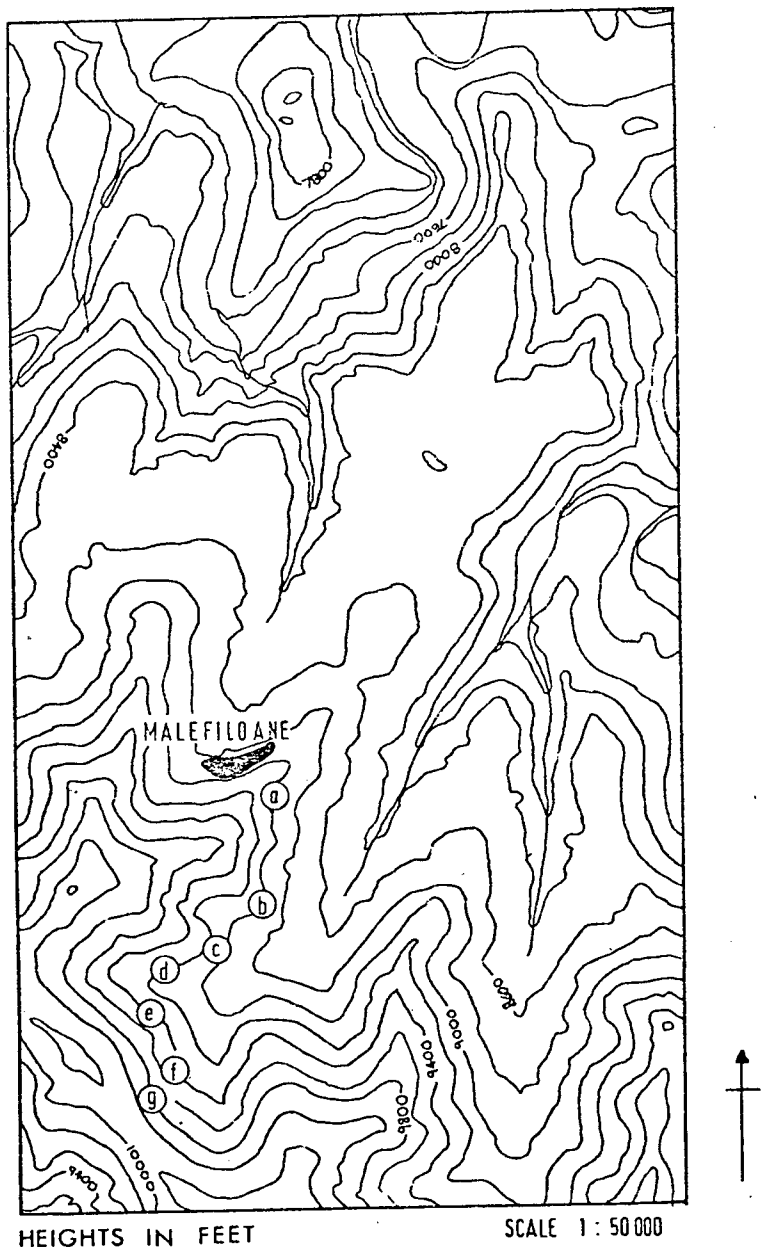

Figure A.2 : Malefiloane, Lesotho.

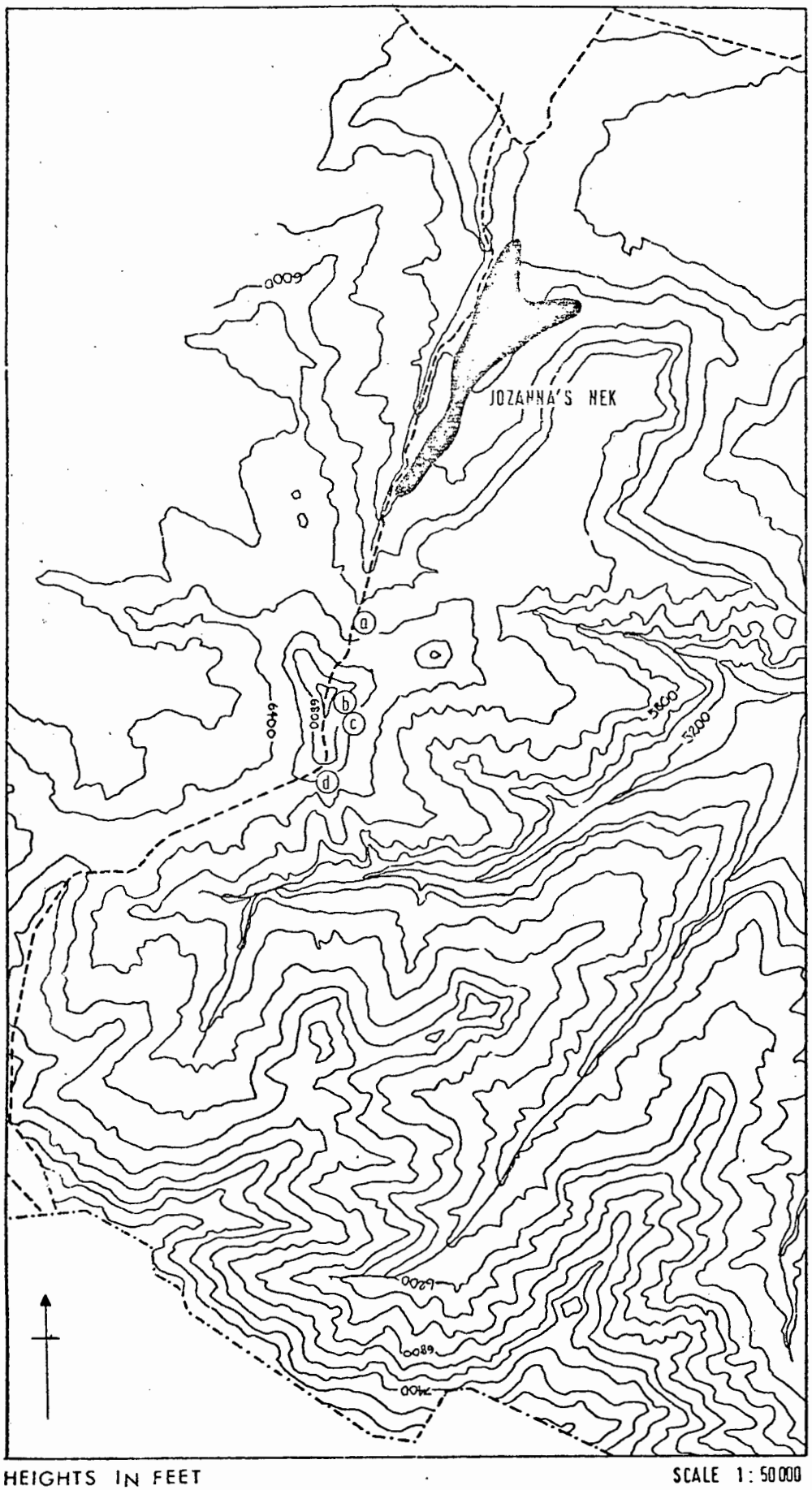

Figure A.3 : Jozanna's Nek, Transkei.

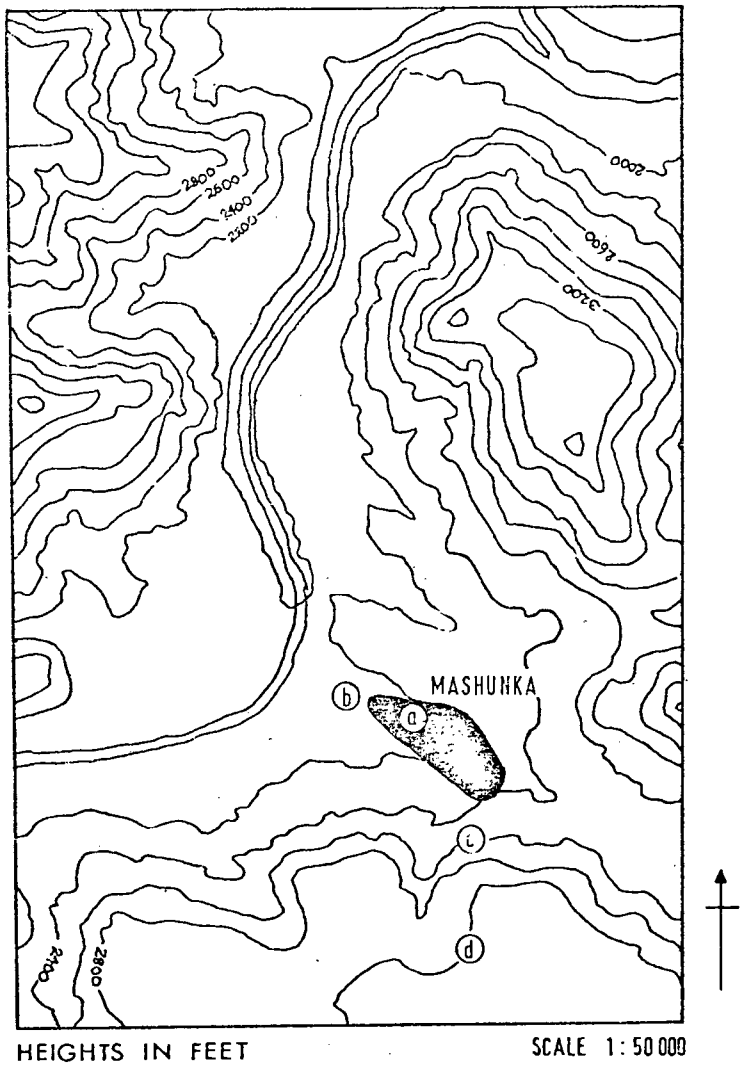

Figure A.4 : Mashunka,
KwaZulu.

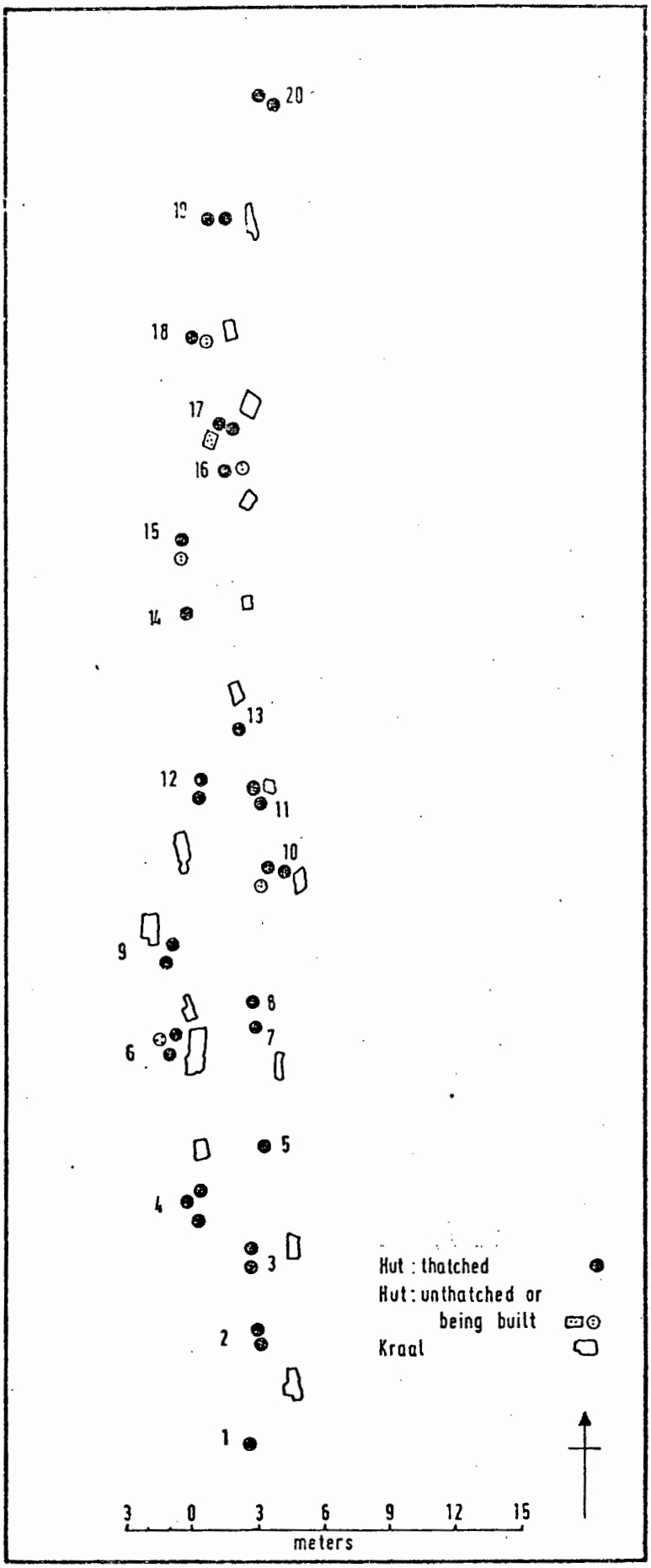

Figure A.5 : Malefiloane Village.
(See Page 131).

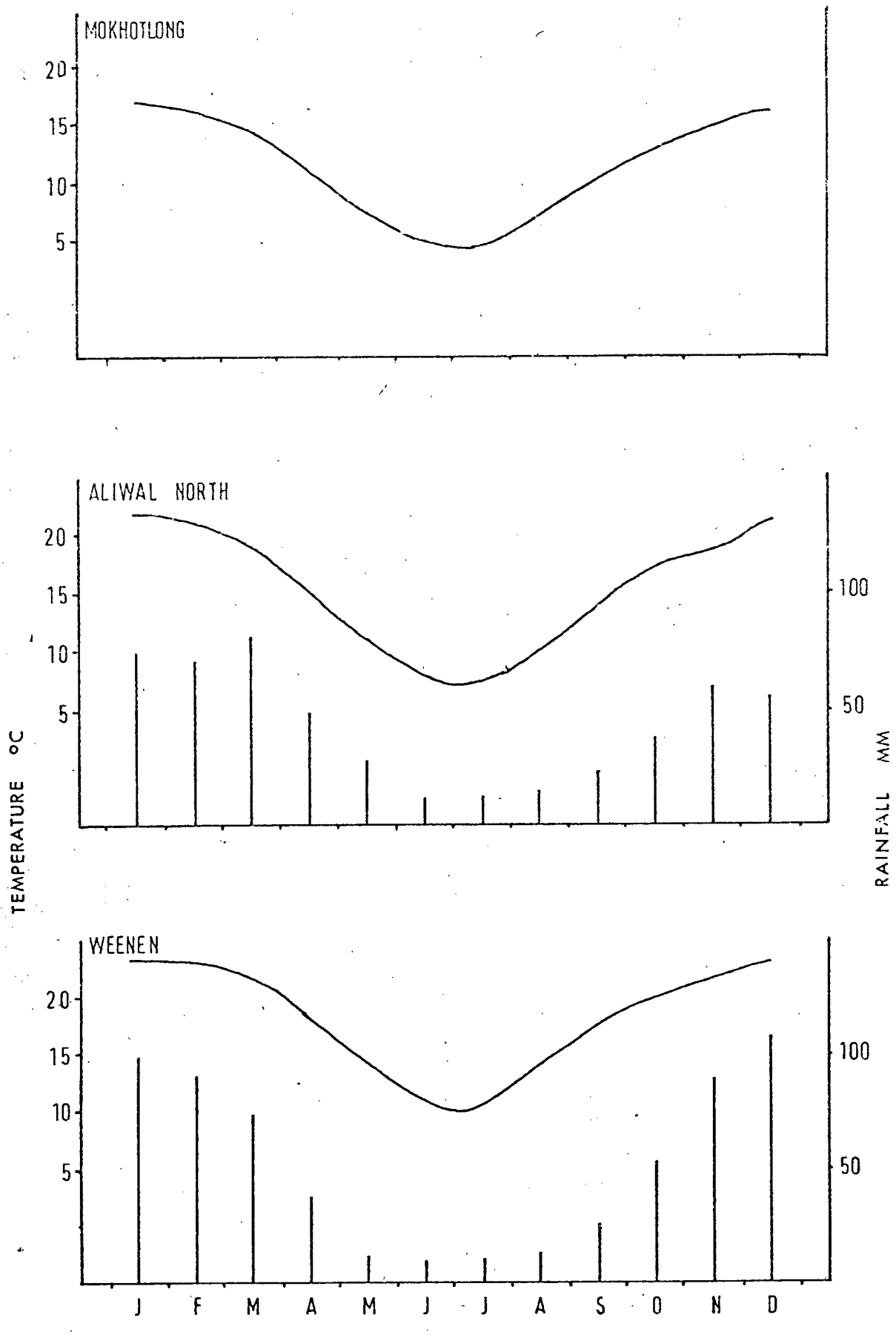

Figure A.6 : Climatic Data (from Weather Bureau, 1968 to 1978); Rainfall (mm) and Mean Monthly Temperatures (°C).

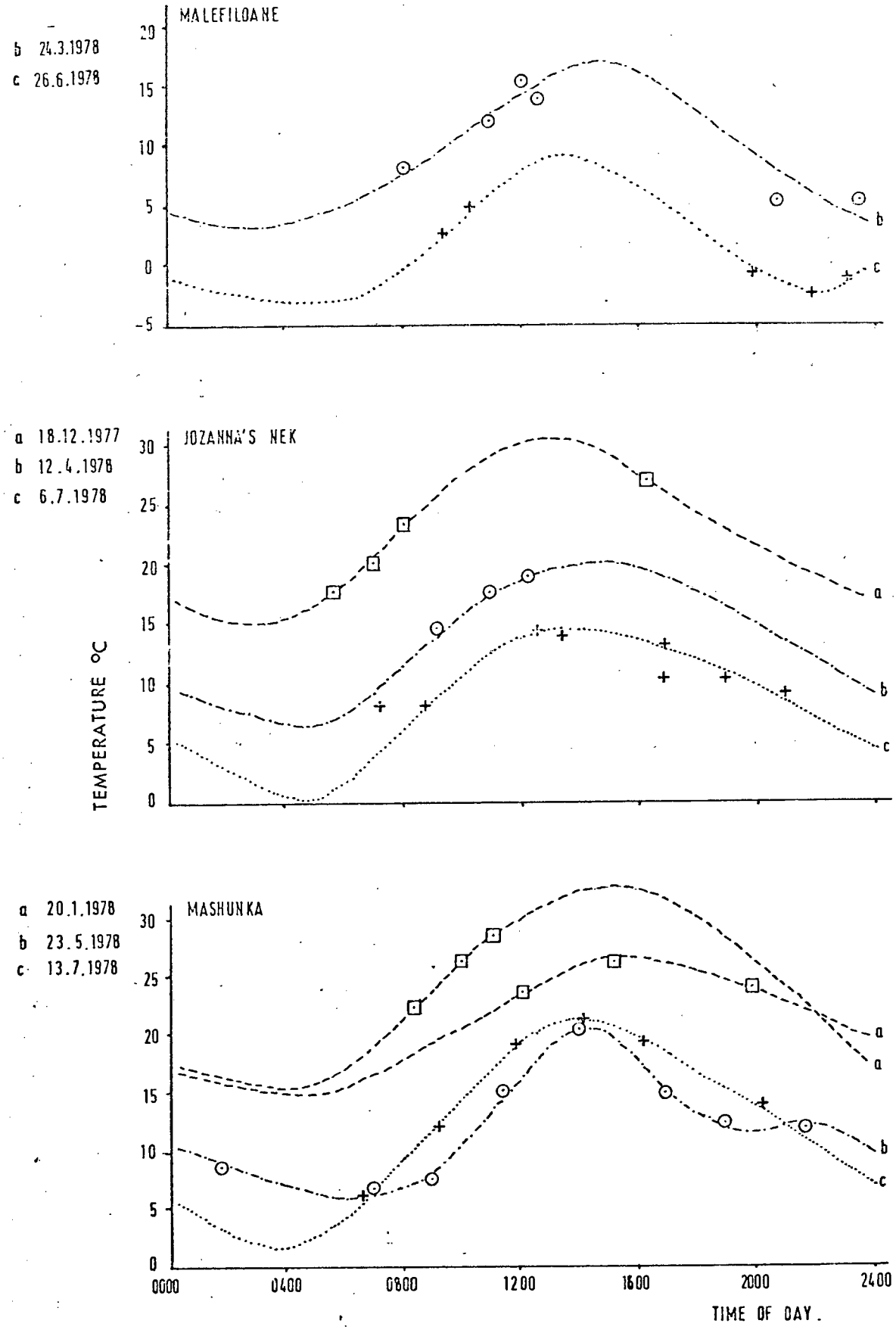

Figure A.7: Measured daily temperature variation.

Table A.1 : Major Firewood Species.

MALEFILOANE

Chrysocoma tenuifolia	(north slopes)
Pentzia cooperi	(north slopes)
Helichrysum trilineatum	(south slopes)

JOZANNA'S NEK

Leucosidea sericea	'intshitshi'
Passerina sp	'rhabhii'
Chrysocoma tenuifolia	'rhalarhala'
Felicia filifolia spp filifolia	'rhalarhala sumadlanga'
Cliffortia sp	'rhalarhala'
Clutia sp	'Qhaphu'
Rhus erosa	'bhosisi'
Rhamnus prinoides	'nyenye'
Buddleia saligna	'rola'
Buddleia salvifolia	'lothwana'

MASHUNKA

Combretum apiculatum	'umBondi'
Acacia tortilis	
Vitrex rehmanii	
Grewia occidentalis	
Dichrostachys cinerea	'um Sasana'
Vepris lanceolata	'umZane'
Grewia flavescens	
Acacia sp	'umNqane'
Maytenus cymosus	
Spirostachys africana	'umThomboti'
Croton sp	
Cassonia spicata	
Euclea sp	
Olea africana	'umQuma'
Brachylaena elliptica	'isiDuli'
Brachylaena ilicifolia	'iGqeba'
Rhus sp	'Hlokoshiyane'
Turraea floribuda	'umVuma'
Maytenus heterophylla	'inGqwangane'

(Table A.1 : continued.)

Aloe sp	'umHlaba'	(valley floor)
Euphorbia tirucalli	'umSululu'	(top valley slopes)
Plectranthus esculentus	'umBondwe'	

Species identified by the Bolus Herbarium, UCT, and using Bews (1921), Palmer and Pitman (1972) and colloquial names.

Table A.2 : Calorie and Ash Samples.

		Moisture Content	Calorie ($kl.g^{-1}$)	Ash %
WOOD				
Malefiloane				
i.	-		23,60	
ii.	Chrysocoma tenuifolia	21,11%	23,00	2,26%
iii.	Chrysocoma tenuifolia		24,13	
iv.	Pentzia cooperi	21,19%	22,33	5,97%
Average			23,26	
Jozanna's Nek				
i.	Leucosidea sericea		24,17	1,61%
ii.	Leucosidea sericea		23,98	
iii.	Leucosidea sericea		22,30	2,23%
iv.	Passerina sp	63,93%+	19,90	
v.	Chrysocoma tenuifolia	39,07%+	23,70	
Average			22,81	
Mashunka				
i.	-		23,93	
ii.	-		21,45	
iii.	Dichrostachys cinerea		19,41	3,92%
iv.	Rhus sp		22,27	
v.			22,07	
vi.	Brachylaena elliptica		19,97	1,72%
vii.	Combretum apiculatum		18,10	
Average			21,03	
			22,14	3,00%

(Table A.2 continued.)

	Moisture	Calories	Ash
DUNG			
Field dung			
i. Jozanna's Nek	7,24%	19,67	20,92%
ii. Malefiloane		14,81	26,13%
iii. Jozanna's Nek	6,76%	15,67	28,02%
		16,72	25,02%
Dung cake (handmade)			
i. Malefiloane	4,90%	17,88	
Kraal dung			
i. Jozanna's Nek		9,07	51,15%
ii. Malefiloane		13,10	
iii. Jozanna's Nek	10,03%	9,65	
iv. Malefiloane		9,88	
v. Jozanna's Nek		14,33	24,18%
vi. Jozanna's Nek	64,45%++	14,67	
vii. Malefiloane	8,23%	9,60	48,37%
Average		11,47	41,40%
		13,48	
OTHER			
Dung ash (Jozanna's Nek)		0,79	
Aloe leaf (Mashunka)		12,93	
Mealie cob (Jozanna's Nek)		15,03	

\+ Freshly sampled vegetation

++ Dung upon which the rain had fallen.

Table A.3 : Malefiloane Vegetation Quadrats.

MALEFILOANE	A	B	C	D	E	F	G
Dist from Vill	0,9	1,7	2,3	2,6	3,1	3,6	3,8
10x10m Quadrat (cm)							
0-5	40	68	25	47	25	5	10
5-10	30	10	10	40	15	10	15
10-25	15	15	12	5	35	42	35
25-50	4	2	18	6	15	28	25
50-1m	-	-	-	-	-	-	3
1m+	-	-	-	-	-	-	-
bare ground	4	2	15	2	8	15	12
bare rock	7	3	10	-	2	-	-
Average bush area (cm)	20x20	20x15	70x30	40x40	40x30	50x50	70x60
weight (gm)[+1]	320	250	850	700	750	1,95kg	2,70kg
weight 1x1m area (kg)	8,00	8,33	4,05	4,37	6,25	7,80	6,43
Fuel estimate[+2] (kg) per 10x10m	152,0	141,6	121,5	48,1	312,5	546,0	405,9
Damaged and destroyed plants	nil	15%	12%	nil	4%	40%	
% bare ground from extraction of bushes	nil	nil	nil	nil	8%	10%	18%
Slope	2:3	1:4	3:4	1:3	1:2	2:7	2:5

+1 Average bush weight 1,07 kg (i.e. 22 bushes per average bundle).

+2 Only vegetation over 10cm is included in fuelwood estimate.

Table A.4 : Jozanna's Nek Vegetation Quadrats.

JOZANNA'S NEK	A	B	C	D
Dist from Vill	2,3	3,0	3,1	3,7
10x10m Quadrat (cm)				
0-10	42	25	20	6
10-25	3	20	7	10
25-50	5	-	2	10
50-1m	25	-	10	40
1-2,5m	5	-	40	5
2,5m+	-	-	4	-
bare ground	20	-	13	12
rock	-	-	-	17
dead plants	-	20	-	-
Wood in 50x50 cm (kg)	2,45		3,05	1,60
Trunk diameter (cm)				
Average	2		4	0,5
Maximum	3		6	1
Total fuel content (kg)	294.0		658,8	288,0
Damage to plants (%)	20-30%	100%	8%	5%
Total loss				
(%)	10%	100%	2%	2%
(kg)	29,40	658,8[+2]	13,18	5,76
Slope	1:6	1:5	1:4	1:7

+1 Area which had been burnt over.

+2 Assuming same characteristics as quadrat C.

Table A.5 : Mashunka Vegetation Quadrats.

MASHUNKA	A	B	C	D
Dist from Vill	0	250m	1,5km	1,9km
10x10m Quadrat (cm)				
0-5	40	20	-	-
5-10	19	20	4	-
10-25	9	30	20	-
25-50	2	10	60	-
50-1m	-	-	10	-
1m-2,5m	5	4	29	90
2,5m-5m	-	-	46	31
5m+	-	34	-	13
bare ground	0	6	4	-
Rock	30	12	2	10
No of trees 2m+	2	2	8	10
Trunk diam max	7	35	19	18
average	7	24	8	8
Fuel content				
alive (kg)	213,3[+1]	6369,5[+2]	5205,9[+3]	7284,2
dead (kg)	0	7,0	106,7	2666,3
Total potential (kg)	213,3	6376,5	5312,6	9950,5
Damage				
% trees lost limbs	100	100	0	0
ave. no.lost limbs	2	3,5	-	-
Stumps				
Number	7	1	0	3
Ave. diam	7	4	-	17
% total trees	77,8	33,3	0	23,1
Aloes				
Number	2	10	5	0
shaved (no)	1	2	0	0
(%)	50	20	0	-
Slope	Flat	1:20	1:2	Flat

(Table A.5 continued).

+1 left out Aloes ($1{,}22 \times 10^6$ cm^3).
+2 left out Aloes ($3{,}687 \times 10^6$ cm^3).
+3 left out Euphorbias ($5{,}88 \times 10^5$ cm^3).

Village	Malefiloane	Joz Nek	Mashunka
Village population	104	1269[+1]	248[+1]
Persons absent	19	162	43
% absent	18,27%	12,77%	17,39%
Number of families	20	202	58
Persons per family	5,2	6,28	4,29
Huts per family	1,65	2,00	2,40
Persons per hut	3,15	3,13	1,86
District	Mokhotlong	Herschel	Msinga
Clan	Mokoena	Hlubi	Thembu
Population	78 370	78 821[+2]	94 619[+2]
Density (km^{-2})	17,71	44,58	50-100[+3]
Area	Lesotho	Transkei	KwaZulu
Tribe	Basotho	AmaXhosa	Zulu
Population	1 271 000[+4]		3 079 300[+3]
Density (km^{-2})	41,88		92,86
Growth rate	2,29%[+4]		2,99%[+3]

Table A.6 : Demographic Data.

+1 Estimated by counting the huts (Mashunka, using enlarged aerial photographs).

+2 Dept of Statistics (1976).

+3 From KwaZulu Government (1978).

+4 From Monyake (1973).

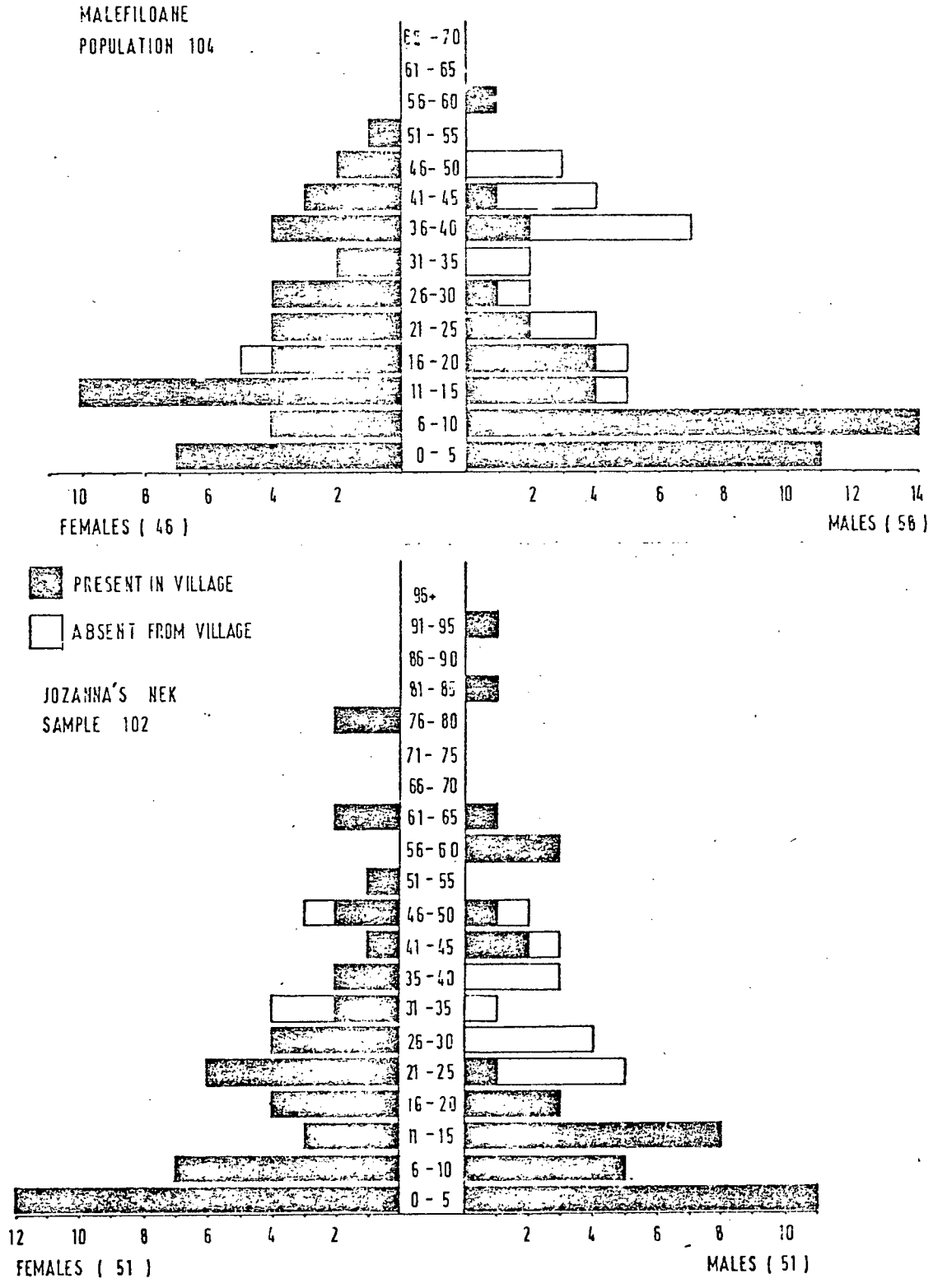

Figure A.8 : Population Pyramids.

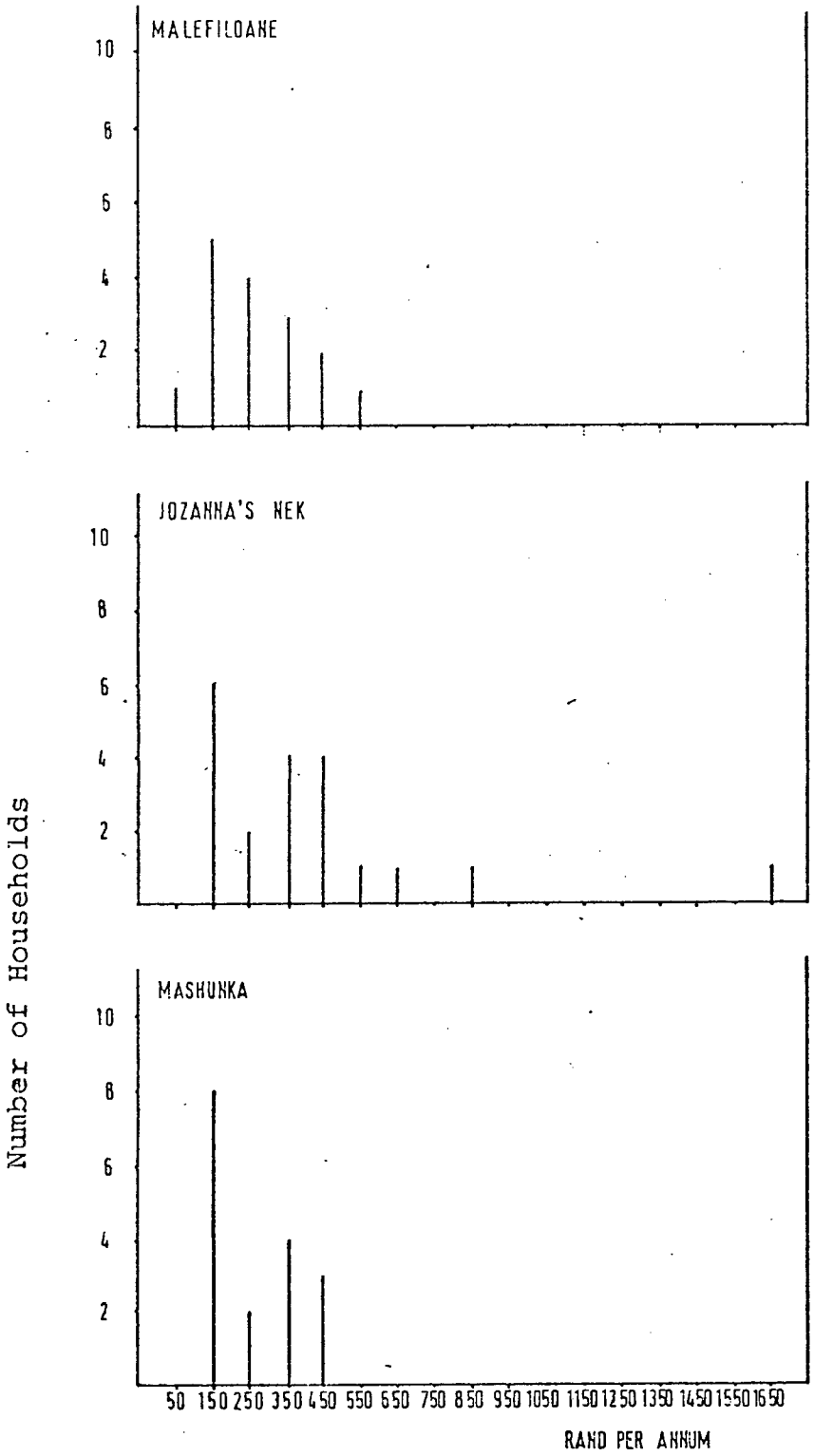

Figure A.9 : Reported Annual Household Income (midpoints of clan interval).

	MALEFILOANE	JOZ NEK	MASHUNKA
Average annually	R255.50	R413.40	R183.60
Average monthly	R21.29	R34.45	R15.30
% from migrant labour	71%	44%	86%
Average monthly migrant labour	R21.44	R23.53	R20.77
% from internal sources	29%	56%	14%
Average monthly internal sources	R11.04	R31.92	R18.05
% from both above	39%	29%	0%
Average monthly both above	R33.08	R40.60	-

Table A.7 : Reported Household Income.

APPENDIX B.

THE QUESTIONNAIRE.

Place		Dates		Times			
No.							
Name							
Home							
Family	Male			Away			
	Female						
Income Source							
Livestock	c	s	g	h	d		
Fields							
Parafin Est				Price			
Meas				Size			
2				Freq.			
3							
Wood Est				Coll time			
Meas				Frequency			
2				Weight			
3				Stockpile			
Dung Est				kraal size			
Meas				Frequency			
2				Stockpile			
3							

Notes:

Figure B.1 : The First Questionnaire.

QUESTIONAIRE

PLACE _____ NAME _____

No _____ HOME _____

MALE _____ AWAY _____ CHILD _____

FEMALE _____ DIED _____

INCOME _____

C S G H D

LIVESTOCK _____

WOOD: EST _____ FREQ _____

TIME _____ WT. _____

ST/PILE _____ BUN-DLES _____

DUNG: EST _____ ST/PILE _____

SOURCE _____ KRAAL _____

PARAFIN: EST _____ PRICE _____

COAL: EST _____ PRICE _____

DAY/TIME				
WOOD				
DUNG				
PARAFIN				
COAL				
COOKED				

_____

Figure B.2 : The Second Questiomaire.

APPENDIX C.

THE BASIC DATA.

MALEFILOANE.
HOUSEHOLDS.

1. Mamusiya Ntsheweu.
2. Mamotswane Ntshweu.
3. Malerato Mapulla.
4. Mateboho Moketse.
5. Manthabiseng Lekhahlela.
6. Mabatho Lepheana.
7. Malehlohonolo Mokwena.
8. Mampho Phtole.
9. Mamaputte Ramolete.
10. Matsepo Mokena.
11. Mathabo Mathethe.
12. Mapuseletso Pakaqane.
13. Matete Makata.
14. Mamakere Matoetoe.
15. Nokalote Mafeka.
16. Mamosiya Mohape.
17. Matebalo Modlatsi.
18. Ketjeketje Pono.
19. Maplaelo Mokede.
20. Mahlopheo Matoetoe.

Malefiloane a (27-16th January 1976);

Fam	Size of Fam	WOOD e kg	WOOD m kg	DUNG	DUNG e kg	DUNG m kg	PARAFFIN e MJ	PARAFFIN m ml	TOTALS Family MJ	TOTALS Person MJ
1	3			Kd		3,5		71	42,50	14,17
2	9			Kd		9,3	169	28	107,73	11,97
3	2		+5,8				190	+206	142,27	71,13
4	4	1,2	+1,2	Kd	5,8	+5,8	107	+107	98,51	24,63
5	1			Fd	2,8	+2,8			46,82	46,82
6										
7										
8	3	3,9	+5,3				529	+ 68	125,86	41,95
9	5	2,1	+2,1				357	+357	62,42	12,48
10	7		9,6						224,46	32,07
11	5		+2,2	Fd		3,5			109,69	21,94
12	7	4,4	+4,4						102,93	14,70
13	5			Fd		6,3			105,34	21,07
14										
15										
16										
17										
18										
19										
20										
n									11	11
x̄									106,23	28,45
s									50,26	18,40
T			30,6			31,2		837	1168,53	312,93

KEY TO TABLES
IN APPENDIX C.

e estimate.

r repeat measurement.

m measurement.

n number of measurements.

x̄ average.

s standard deviation.

T total in column.

MJ 10^6 Joules.

Kd kraal dung.

Fd field dung.

\+ measured value assumed from the verbal estimate.

Malefiloans b (21-2nd April 1978);

Fam	Size of Fam	WOOD e kg	WOOD r kg	WOOD m kg	DUNG	DUNG r kg	DUNG m kg	PARAFFIN e ml	PARAFFIN r ml	PARAFFIN m ml
1	4		10,0	6,5	Kd	4,7	4,1	268	263	238
			3,0		Kd	3,5			208	
2	4		9,0	7,0				100		
			5,1							
3	3	6,7	7,7	5,6				25	635	423
			3,5						212	
4	6		5,9	6,1				126	.	319
			3,3						.	
			9,3						958	
5										
6	4	10,1	3,7	1,8	Kd	4,0	5,3	54	.	183
			0,8			5,3			550	
			0,8			6,6			.	
7	4	3,9	1,2	3,0	Fd	.	3,0	25		
			3,7			.				
			4,0		Fd	9,0				
8	3	3,4	5,7	4,5				54		
			3,2							
9	5		2,5	5,2				54	125	125
			7,4						.	
			5,6						250	
10	7			9,8				125		
11	5	3,4	3,5	3,6				38		
			3,7							
12	6	3,4	3,0	4,4	Fd	.	6,5	56		
			5,8		Fd	13,0				
13										
14										
15	2	3,4	7,0	4,8				107		
			2,7							
16	6	3,4	5,7	6,7				54		
			7,7							
17	6	5,1	7,5	9,3				538	423	169
			15,8						.	
			4,5						85	
18										
19	3	3,4	1,7	5,5				25	.	37
			4,8						.	
			10,0						110	
20	5	6,7	4,2	4,6	Fd	6,2	3,1	25		
			5,0			.				
n										
X										
s										
T				88,4			22,0			1491

Malefiloane b (21-2nd April 1978) continued;

Fam	TOTALS		
	Family		Person
	st dev	used MJ	used MJ
1	125,28	207,41	51,85
2	64,97	163,29	40,82
3	81,26	146,81	48,94
4	90.38	155,18	25,86
5			
6	42,06	109,39	27,35
7	111,67	119,24	29,81
8	39,80	103,74	34,58
9	59,23	125,00	25,00
10		226,78	32,40
11	3,29	83,74	16,75
12	198,92	210,33	35,05
13			
14			
15	71,22	112,35	56,17
16	32,89	157,00	26,17
17	131,99	221,58	36,93
18			
19	99,38	129,34	43,11
20	61,55	159,63	31,93
n	15	16	16
x̄	80,93	151,93	35,17
s		44,59	10,73
T		2430,81	562,72

Malefiloane c (21-27th June 1978);

Fam	Size of Fam	WOOD e kg	WOOD m kg	DUNG	DUNG e kg	DUNG m kg	PARAFFIN e ml	PARAFFIN m ml	TOTALS Family MJ	TOTALS Person MJ
1	4		4,5	Kd		10,0		85	222,60	55,65
2	6	0,9	1,3	Kd	29,5	22,5	107		288,31	48,05
3	3	3,6	6,0						139,56	46,52
4	4		2,5	Kd		31,0			413,72	103,43
5										
6										
7										
8										
9	5		1,3	Kd		2,5			58,91	11,78
10										
11	5		8,0						186,06	37,21
12	9	2,0	11,5						267,49	29,72
13	5	1,4					107	169	6,42	1,28
14										
15	3		4,0	Fd	3,5	7,0	54		210,08	70,03
16										
17										
18										
19	3	2,6	1,0	Kd	25,0	15,0	25		195,31	65,10
20										
n									10	10
$\bar{x}$									198,85	46,88
s									115,40	29,52
T			40,1			88,0		251	1988,48	468,77

JOZANNA'S NEK.
HOUSEHOLDS.

1. Emily Beginsel.
2. Janet Mdleleni.
3. Gaysana Swelonkomo.
4. Maxhego Quoboshiyana (Julia).
5. Elsie Mdleleni.
6. Herbert Mangwana (Nkunene).
7. Mabel Mangwana.
8. Dam Mdidimpa (Nosinda).
9. Ntloko Maloyi.
10. Gladis Monakali.
11. Mboneleni Matroos.
12. Lina Selani.
13. Esther Silwana.
14. Bafom Nbatyozwa.
15. Nowaka Swelonkomo (Hazel).
16. Noxolile Swelonkomo.
17. Agnes Mampho.
18. Vivienne Mangwana.
19. Nosapho Mangwana.
20. Jane Mtunyana (Nomlambo Awuwelwa).
21. Dlisa Swelonkomo.
22. David Mtunyana (Nombuyeleli Mtunyana).
23. Nombuthamaswaswazi Mangwana.
24. Hilda Nodata.
25. Nosandi Ngulube.
26. Helen Mdidimpa.

Jozanna's Nek a (18-19th December 1977);

Fam	Size of Fam	WOOD e kg	WOOD m kg	DUNG	DUNG e kg	DUNG m kg	PARAFFIN e ml	PARAFFIN m ml	TOTALS Family MJ	TOTALS Person MJ
1										
2										
3	7	9,6	5,5	Fd	3,9	1,4	375	37	149,42	21,35
4										
5	8						179	635	24,13	3,02
6	5		6,5				107	203	155,97	31,19
7	5		0,8					946	54,88	10,98
8	5	3,4	2,5					487	76,68	15,34
9										
10	8		4,4					250	109,18	13,65
11	6	4,1	3,2				333		72,31	12,04
12										
13	8		0,2				333	318	16,64	2,08
14	9			Kd		7,0			80,52	8,95
15	2	3,5					321	275	10,45	5,22
16	4	5,2	3,0				83		68,43	17,11
17	5	2,7	1,5	Fd		1,1	714		53,75	10,75
18	5		4,3				500	275	107,85	21,57
19	10		8,0	Kd		23,7	667	466	471,68	47,17
20	5		1,2						26,69	5,34
21										
22										
23										
24										
25										
26										
n									15	15
X									98,57	15,05
s									112,38	11,85
T			41,1			33,2		3892	1478,58	225,76

Jozanna's Nek b (7-15th March 1978)

Fam	Size of Fam	WOOD e kg	WOOD r kg	WOOD m kg	DUNG	DUNG r kg	DUNG m kg	PARAFFIN e ml	PARAFFIN r ml	PARAFFIN m ml	COAL r kg	COAL m kg
1												
2												
3	4		6,7	3,6					180	352		
			0,5						525			
4	8		2,4	2,3			3,5	500				
			2,2		Kd	7,0						
5												
6	10		2,3	3,6				107	150	75		
			5,0									
7												
8	6		12,0	10,0				142				
			8,0									
9												
10	6			6,0								
11	5	7,6	3,7	6,1								
			8,5									
12												
13												
14	5	3,8	8,8	8,2								
			7,5									
15	2	5,1	1,7	3,5				214	119	215		0,7
			1,2						225			
			7,5						300		2,0	
16	4	7,6	11,5	10,0				25				
			8,5									
			10,0									
17												
18												
19												
20	5	7,6		7,5								
21												
22	10		4,5	3,9					180	90		
			3,3									
23	3			10,5				221				
24	10							1429				
25	3			15,0								
26												
T				90,2			3,5			732		0,7

Jozanna's Nek b (7-15th March 1978) continued;

Fam	TOTALS			
	Family			Person
	st dev	used MJ		used MJ
1				
2				
3	90,25	95,04		23,76
4	54,36	93,06		11,63
5				
6	39,52	84,97		8,50
7				
8	64,52	228,10		38,02
9				
10		136,86		22,81
11	79,92	138,68		27,74
12				
13				
14	21,45	186,13		37,23
15	117,02	107,42		53,71
16	34,27	228,10		57,02
17				
18				
19				
20		171,07		34,21
21				
22	25,00	91.69		9,17
23		239,50		79,83
24		54,30		5,43
25		342,15		114,05
26				
n	9	14		14
X	58,47	156,93		37,36
s		80,09		30,58
T		2197,07		523,11

Jozanna's Nek c (29-9th July 1978);

Fam	Size of Fam	WOOD e kg	WOOD m kg	DUNG	DUNG e kg	DUNG m kg	PARAFFIN e ml	PARAFFIN m ml	COAL m kg	TOTALS Family MJ	TOTALS Person MJ
1											
2											
3	3	5,1	5,0		6,7		375			114,05	38,02
4											
5											
6	11	5,1	4,0	Fd		8,0	250			225,00	20,45
7	4		2,0	Fd		1,0			2,0	122,34	30,58
8	4	5,1	4,5		5,0		500	375		116,89	29,22
9											
10	7	0,5	3,3	Kd		2,2	107	675		127,42	18,20
11	6	5,1	8,5				375			193,88	32,31
12											
13	8	5,2	3,5	Fd		7,0	238	300		208,27	26,03
14											
15	2	5,1	7,0		5,0		375	75		162,52	81,26
16	5	7,6	8,0		6,7		25			182,48	36,50
17											
18											
19											
20	6	5,1		Fd	10,0	11,5	375			192,28	32,05
21											
22	11	10,1	12,0		20,0					273,72	24,88
23	3	6,1	3,5		6,7		107			79,83	29,94
24											
25											
26	6	5,1	1,5	Fd	10,0	6,2	375	75		141,56	23,59
										13	13
A										164,63	32,54
S										54,12	15,75
T			62,8			35,9		1500	2,0	2140,24	423,03

MASHUNKA.

HOUSEHOLDS.

1. Hlekelaphi Dladla.
2. Nombuso Mbatha.
3. Mamvelase Mbatha.
4. Mabenya Mbatha.
5. Mzayifani Dladla.
6. Khonzeni Dladla.
7. Nozi Dladla.
8. Mandimandi Dladla.
9. Mbango Dladla.
10. Ndala Mbatha.
11. Tezane Mbatha.
12. Marundla Dladla.
13. Nene Mbatha.
14. Ngubane Dladla.
15. Masoka Dladla.
16. Mamvelase Dladla.
17. Mthezuka Mbatha.
18. Makhize Mbatha.
19. Mandlela Dladla.
20. Madladla Mbatha.
21. Mamtshani Mbatha.

Mashunka a (18-25th January);

Fam	Size of Fam	WOOD e kg	WOOD r kg	WOOD m kg	PARAFFIN e ml	PARAFFIN m ml	TOTALS Family st dev	TOTALS Family MJ	TOTALS Person MJ
1									
2	9	9,2		11,2	0			234,91	26,10
3	6		7,7 11,7	9,7	0		60,67	204,20	34,03
4									
5	5	9,3		7,5	108	+108		161,82	32,36
6	4			15,5	108	+108		330,06	82,51
7	1		9,7 2,7	6,2	27	+27	105,28	131,63	131,63
8	3	3,9	8,8 12,2	10,5	107	+107	52,05	224,88	74,96
9	7	8,2		10,5	108	+108		224,91	32,13
10	4			12,9	108	+108		276,44	69,11
11	7			19,0	107	+107		403,64	57,66
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
n							3	9	9
x̄							72,67	243,61	60,05
s								83,46	34,16
T				63,0		673		2192,49	540,49

Mashunka b (15-25th April 1978);

Fam	Size of Fam	WOOD e kg	WOOD r kg	WOOD m kg	PARAFFIN e ml	PARAFFIN m ml	TOTALS Family st dev	TOTALS Family MJ	TOTALS Person MJ
1									
2	6	9,2		+9,2	0			192,85	32,14
3	2	16,0		+16,0	0			336,48	168,24
4									
5									
6									
7									
8	7	26,0		+26,0	107	+107		550,85	78,69
9									
10									
11	6	17,0		+17,0	107	+107		361,58	60,26
12	3	15,0	12,5 3,5	8,0	187	+187	133,83	175,35	58,46
13	5			8,7	54	+54		186,06	37,21
14	6	10,0		4,3	167	+167		97,41	16,23
15	3	30,0 24,0		+27,0	54	+54		569,86	189,95
16	3	14,0		+14,0	107	+107		298,49	99,50
17	3	28,0		+28,0	54	+54		590,89	196,96
18	6	9,7		+9,7	54	+54		207,09	34,51
19	5	15,0		+15,0	107	+107		319,52	63,90
20	6	12,5		13,0	188	+188		280,53	46,75
21									
n							1	13	13
x̄							133,83	320,54	83,29
s								160,83	62,10
T				195,9		1186		4166,96	1082,79

Mashunka c (11-16th July 1978);

Fam	Size of Fam	WOOD e kg	WOOD m kg	PARAFFIN e ml	PARAFFIN m ml	TOTALS Family MJ	TOTALS Person MJ
1							
2	6	20,6	25,0	0		525,75	87,62
3	5	6,9	4,5	0		94,63	18,93
4							
5							
6							
7	1	6,9	6,5	27	±27	137,72	137,72
8							
9							
10							
11	3	10,3	12,0	107	±107	256,43	85,48
12	3	6,9	17,0	36	±36	358,88	119,63
13							
14							
15							
16							
17							
18							
19							
20							
21							
n						5	5
x̄						274,68	89,88
s						174,38	45,36
T			65,0		170	1373,41	449,38