

RURAL ENERGY AND DEMAND IN BOTSWANA
AND ITS IMPLICATIONS: THE CASE OF FUEL
WOOD IN NORTH EAST DISTRICT.

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RURAL ENERGY SUPPLY AND DEMAND
AND ITS IMPLICATIONS: THE CASE
IN NORTH EAST DISTRICT

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APPROVAL

This Dissertation has been examined and is approved as meeting the required standards of scholarship for partial fulfilment of the requirements for the degree of Master of Science.

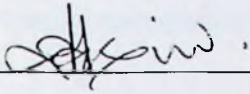
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STATEMENT OF ORIGINALITY

The work contained in this dissertation was completed by the author at the University of Botswana between 25.8.1995 and 18.5.1996. It is original work except where due reference is made. It has not been and will not be submitted for the award of any degree or diploma to any other of higher learning.



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ABBREVIATIONS AND ACRONYMS

ARAP	Accelerated Rainfed Arable Programme
BA	Basal Area
BEMP	Botswana Energy Master Plan
CFDA	Communal First Development Area
CSO	Central Statistics Office
DAO	District Agricultural Office
dBASE	Data base
DRP	Drought Relief Programme
DVO	District Veterinary Office
ERL	Energy Resources Limited
FAB	Forestry Association of Botswana
FAO	Food and Agricultural Organisation
GIS	Geographical Information System
MFDP	Ministry of Finance and Development Planning
MLGL	Ministry of Local Government and Lands
MLGLH	Ministry of Local Government Lands and Housing
MMRWA	Ministry of Mineral Resources and Water Affairs
MOA	Ministry of Agriculture
NAS	National Academy of Science
NCS	National Conservation Strategy
NDP	National Development Plan
NEDC	North East District Council
NEDCS	North East District Conservation Strategy
NEDDC	North East District Development Committee
NEDDP	North East District Development Plan
NIR	National Institute for Development and Research
P	Pula (A unit of Botswana currency)
RES	Rural Energy Study
SADCC	Southern African Development Co-ordinating Conference
SDLB	Secretary to the District Land Board
SPSS	Statistical Package for Social Scientists
UNDP	United Nations Development Programme
UNICEF	United Nations International Children and Educational Fund

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ABSTRACT

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RURAL ENERGY SUPPLY AND DEMAND IN BOTSWANA AND ITS IMPLICATIONS: THE CASE OF FUELWOOD IN NORTH EAST DISTRICT

Supervisor: Dr. C. Vanderpost

The role of fuelwood in rural development has often been overlooked despite its importance to many people. This seems to be true of Botswana and several other developing countries. An attempt is made to address the problem of fuelwood shortage which was identified in North East District of Botswana by analysing the supply and demand of the fuelwood to find the extent, causes, and the effects of the shortage; and also to establish people's perception of the problem. These issues have not been investigated in previous fuelwood surveys carried out in the District. An in-depth study was conducted in Mulambakwena village area which was considered representative of the District in terms of the fuelwood situation. The methods used in the data collection were: questionnaire survey, fuelwood consumption measurements, direct observation, informal interviews and group interviews, aerial photograph interpretation, vegetation sampling, and ground truthing. Although the use of possible indicators of and responses to declining fuelwood availability shows that there is no fuelwood shortage, the people themselves perceive fuelwood shortage as a problem, but not most serious compared to shortage of water and lack of income. The study also revealed that the main causes of the fuelwood shortage are the increase in demand of fuelwood and the decrease in supply of the wood. The demand increases because of the rise in consumption level of fuelwood due to population increase of the village, the increase in household size, and the increase in household income. The supply of fuelwood available to the people decreases because of lack of dead preferred species of trees for fuelwood, moreover the little supply available is less accessible due to distance. The land use and land management through the arable destumping scheme temporarily increases the fuelwood supply, but the ultimate consequences of this is a reduction of the growing stock of the woodland. The fuelwood shortage has a negative impact on some households which suggests that as the shortages increase, more households will become affected by the diversion of labour and income in order to obtain it. However, the fuelwood shortage seems to have very little effect on deforestation. The solutions to the problem of fuelwood shortage suggested include: increasing supply of fuelwood by planting more trees, and increasing the productivity of the existing woodland through its proper management; reducing the demand of fuelwood by introducing fuelwood saving cooking stoves, and by encouraging people to shift to alternative sources of energy such as coal, gas and paraffin. All the above suggested solutions should be based on the peoples' felt needs, on their priorities in dealing with what they perceive as the most important problem.

Approved _____

Signature of supervisor

CHAPTER ONE: INTRODUCTION.

1.1 Background to the problem.

The role of fuelwood in rural development has often been overlooked despite its importance to many people. This seems to be true of Botswana and several other developing countries. One of the main reasons for this is that fuelwood is usually collected free or traded informally and used directly. Unlike "commercial" fuels like electricity, gas or kerosene, little is known about the quantities, qualities and sources and so fuelwood is not included in the official statistics of most governments. One result is that the problem of its growing scarcity remains hidden.

For many rural areas without electricity or reliable gas or kerosene supply, fuelwood may be the only source of energy for cooking, heating and at times even for lighting. According to Crump (1991) and the National Academy of Science (NAS, 1980), more than a third of the world's population depends on wood for cooking and heating and 86 percent of all wood consumed annually in developing countries is used for cooking. About 2 billion people rely on it for all or most of their daily needs making it the world's most widely used fuel (Foley, 1992). In Botswana fuelwood is estimated to account for about 58 percent of national energy consumption and most of it is used by rural households mainly for cooking (Government of Botswana, MMRWA, 1993).

Even if other energy sources like electricity, gas, kerosene, solar energy or biogas were to be available, fuelwood is likely to continue as the most universal fuel for rural areas of developing countries (Bradley, 1991) because it is cheap, accessible and can be consumed using simple techniques and inexpensive equipment. Electricity, gas or kerosene use requires substantial money which most rural people do not have. Other sources such as solar energy or biogas need imported technology and highly qualified man power which most developing countries still lack (Harrison, 1987). These sources are therefore not yet at a stage of development where they can be adapted to adequately serve the needs that fuelwood currently serves in Third World countries (Morgan, 1983; Harrison, 1987).

The living standards in rural areas will be affected negatively unless there remains an adequate supply of fuelwood to meet the increasing demand due to population growth. A number of authors (notably UNICEF and UNDP, 1993; Leach, 1987; Leach and Mearns, 1988; Kuyper and Mellink, 1983; Hall and Rossilo-calle, 1991; Eckholm *et al.*, 1984) indicate that fuelwood is already scarce in many parts of developing countries, Botswana included. The population of Botswana is one of the fastest growing in Africa with the majority (76 percent) living in the rural areas (Government of Botswana, CSO, 1991). According to National Development Plan (NDP) 7 of 1991-96, due to population growth, problems of fuelwood supply already exist around larger settlements and boreholes. Furthermore, the plan notes that fuelwood use is highest in eastern and north-eastern Botswana where the majority of the population lives and agriculture is thus concentrated. This is also emphasised in the North East District Development Plan (NEDDP) 4 of 1989-95 which states that fuelwood is already scarce in the District.

The fuelwood problem affects both the socio-economic well-being of the people as well as the physical environment. For example, if there is shortage of fuelwood, people have to walk longer distances in search for it and others may miss meals and go hungry (Agarwal, 1986). Research has also shown that in Botswana as in other developing countries, the commoditisation of fuelwood is a common phenomenon. This has contributed to denudation of the forest cover and general degradation of the physical environment (Government of Botswana, MLGLH, 1990).

Despite the fact that fuelwood shortage may have a negative effect on the lives of people living in rural areas of many developing countries, there has been a notable neglect in planning for the fuelwood sectors in many of those developing countries (Hall, 1994). Planners and policy makers need to know whether there are fuelwood problems, the extent, causes, characteristics and implications of the problems in order for them to plan and make policies on fuelwood. This information can be and needs to be made available by collecting baseline data on demand and supply of fuelwood (Karenzi, 1994).

However, in Botswana, the relative neglect of fuelwood was realised to some extent. The Government of Botswana has given rural development high priority since independence and

has emphasised the need for a research programme in this area in NDP7 to obtain data for planning and management of the fuelwood sector (Government of Botswana, MFDP, 1991). Because of this interest, since the 1980s a number of fuelwood surveys have been carried out. On the demand side, issues addressed included collection, distribution, marketing and consumption in the rural areas as well as in government institutions. On the supply side issues like estimation of the growing stock and annual increment were done either by remote sensing techniques or by field measurements. Other issues investigated include adaptation to fuelwood scarcity, woody biomass utilisation and deforestation as well as other environmental problems and peoples' perception on the seriousness of the fuelwood shortage (Arntzen, 1983; Kgathi and Mlotshwa, 1994a). In North East District a fuelwood survey was carried out in 1985 by Energy Resources Limited (ERL) which covered only Masunga village (ERL, 1985). No further research has taken place.

1.2 Statement of the problem.

It was felt that it was important to study and analyse the supply and demand of fuelwood in a specific area in order to determine the extent, causes and effects of the reported fuelwood shortage in North East District of Botswana. In addition, it was also necessary to establish people's perception of the problem. Without this, a proper search for a solution can not be embarked upon. However, so far there is no data that documents, for any specific village of the North East District, the extent, causes and consequences of fuelwood shortages over time and people's perception of the problem.

The source of fuelwood is normally the woody biomass of a particular area. Knowing the extent of these resources plus its distribution can give a general picture of what might be available. However, not all wood is necessarily fuelwood. What is available as wood may not be accepted or preferred by the community as fuelwood. Therefore it is necessary to assess the acceptability or preferability of such woody biomass resources for fuelwood. The information on the nature of the woody biomass in terms of availability, distribution and preferability/acceptability will be useful in planning for rural energy. Most previous fuelwood surveys in Botswana have neglected this and have only concentrated on making quantitative assessment of how much biomass is available (see for example Thomas, 1991; ERL, 1985; Tietema *et al.*, 1988).

Even if woody biomass resources in a particular locality are known to exist in the accepted or preferred form it is not a guarantee that all those who need it have sufficient fuel at their disposal. The accepted or preferred types must be accessible to the users. The factors controlling the accessibility to those resources for fuelwood need to be known for any proper analysis of fuelwood problems. There is very little information regarding the issue of accessibility.

Fuelwood consumption is a highly dynamic variable which responds to changing supply levels and to other circumstances quite rapidly (ETC, 1987; De Groot and Hall, 1989). It is important to know why a particular group of people in a given location use the amount of fuel they do for proper interventions to meet the needs of the community, especially the poor. Yet there are little data on these aspects.

Relationships between fuelwood shortage, environmental degradation in the form of deforestation have not been investigated in depth in Botswana (Sekhwela, 1994; Kgathi, 1992). Assumptions are often substituted for facts when describing the effects of fuelwood shortage on the environment. For example it is usually assumed that the fuelwood shortage is the cause of deforestation (Agarwal, 1986; Leach and Mearns, 1988; Sekhwela, 1994; Kgathi and Mlotshwa, 1994a). Meanwhile, Earthscan (1987) notes that it is deforestation which leads to fuelwood shortage. Similarly, very little information is available on the relationship between family well-being and fuelwood shortage. The present research therefore tries to provide data on the impacts of fuelwood scarcity on the environment and the socio-economic situation of the households.

The fuelwood problem is only one amongst many problems experienced by the rural population. Rural people need water, food, and shelter. In planning interventions to relieve the fuelwood crisis an approach that responds to locally perceived needs is essential. It is not possible to know in advance what these needs are for a community. Many projects aimed at solving the fuelwood problem have not done well so far because the form in which the problem was identified and solutions specified did not accord with the local production system (Foley and Barnard, 1984; FAO, 1986; Munslow *et al.*, 1988). Planners of such projects had different perceptions of the problem to those of the local people who were

supposedly being helped (Munslow *et al.*, 1988). Therefore information is needed which will address people's own perception of the problem and needs.

1.3 Research aim and objectives.

1.3.1 Research Aim

The aim of the research is to analyse the supply and demand of fuelwood at village level in order to determine the extent, causes and effects of the reported fuelwood shortage; and also to establish people's perception of the fuelwood problem. Possible solutions to the problem will be suggested.

1.3.2 Research Objectives

The specific objectives of the research are to:

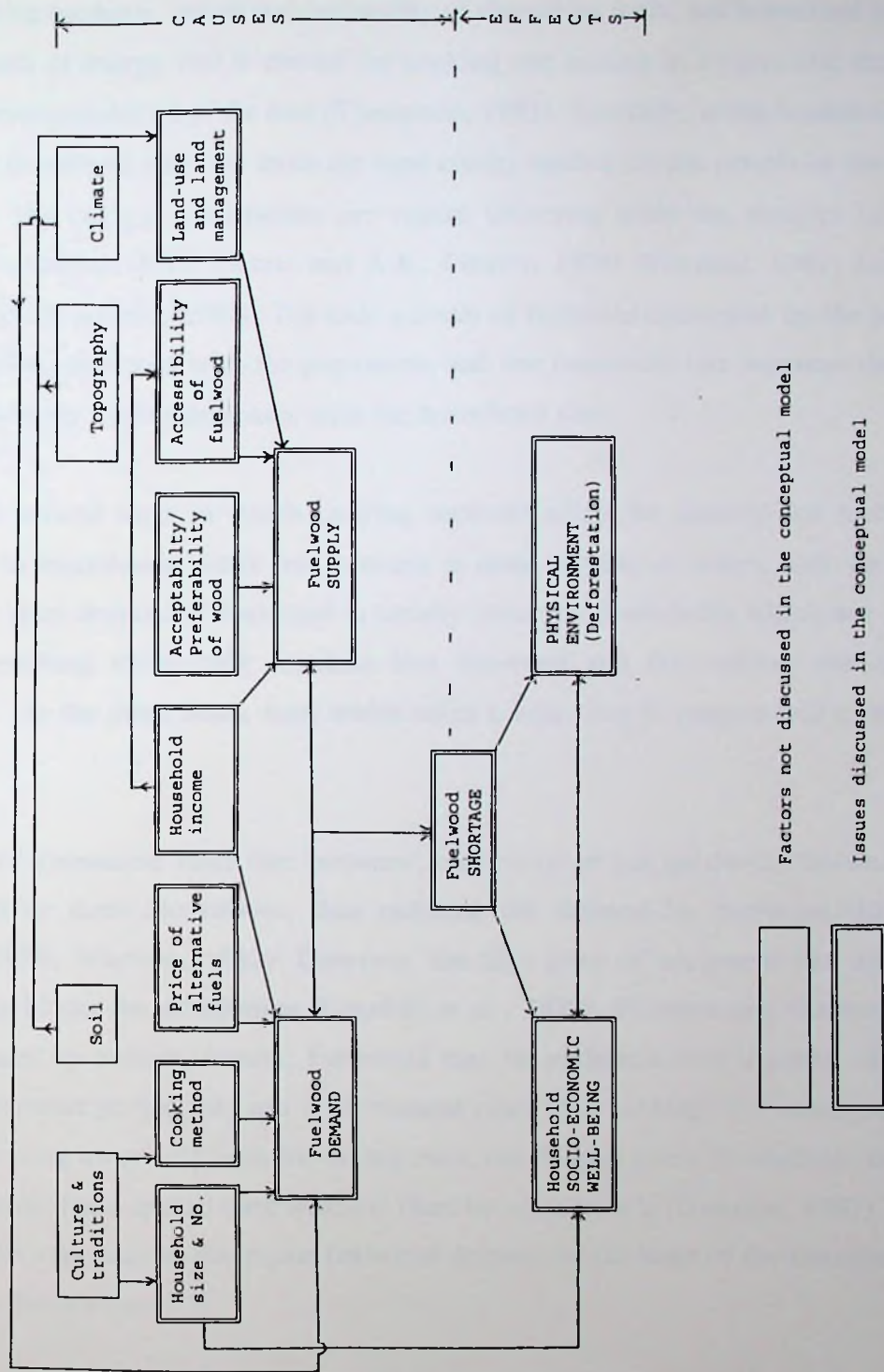
1. determine the nature of the supply of woody biomass resources and factors controlling access to such resources;
2. determine the nature of the demand, specifically to investigate the relationship between the demand for fuelwood and household size, and household income;
3. determine the severity of the reported fuelwood shortage at village level in North East District;
4. establish people's perceptions regarding the fuelwood situation;
5. investigate the effects of the reported fuelwood shortage on the socio-economic well-being of the households; and
6. investigate the effects of the reported fuelwood shortage on the physical environment especially its effects on deforestation.

1.4 Conceptual framework of fuelwood supply/demand relationship.

Conceptually, the reported fuelwood shortage is either caused by an increase in demand of fuelwood and/or a decrease in the supply of wood (see figure 1.1). The causes and effects of the reported fuelwood problem are discussed at a local level.

Figure 1.1: Conceptual framework of fuelwood supply/demand relationships

Conceptual framework of fuelwood supply/demand relationships.



he demand for fuelwood is determined by such factors as the total population, household size, cooking methods, prices and availability of alternative fuels, and household income. The total amount of energy that is needed for cooking and heating in a particular area increases with the total population of the area (Thompson, 1983). Similarly, at the household level, the larger the household size, the more the total energy needed for the people in the household. However, the energy consumption *per capita* decreases when the number of household members increases (P.C. Fleuret and A.K. Fleuret, 1978; Wiersum, 1982; Leach, 1987; Kamara, 1986; Kgathi, 1992). The total amount of fuelwood consumed by the people in an area therefore increases with the population and the household size whereas the fuelwood consumption *per capita* decreases with the household size.

There are several ways in which cooking methods affect the demand for fuelwood. For example, in households where less cooking is done per day or where bulk cooking takes place, the total demand of fuelwood is usually reduced. Households which use fuelwood-efficient cooking stoves will consume less fuelwood and this reduces the demand for fuelwood. On the other hand, food which takes a long time to prepare will consume more fuelwood.

If prices of alternative fuels like kerosene, electricity or gas go down, fuelwood may be substituted by these alternatives, thus reducing the demand for fuelwood (Ernst, 1978; Hariscoe, 1979; Wiersum, 1982). However, the high price of equipment like the cooker or heater may hinder the substitution (Cecelski *et al.*, 1979). Furthermore, fuelwood use may be influenced by cultural factors. Fuelwood may be preferred even if prices of alternative fuels fall because people may use it for reasons other than cooking. For example, it may be used for driving away wild animals, drying meat and treating seeds. In addition, food cooked with fuelwood has a special taste which is liked by some people (Harrison, 1987). It may not therefore be very easy to determine fuelwood demand on the basis of the changing prices of alternative fuels alone.

According to Kamara (1986) and Leach (1987), in most African societies households with high income tend to have large household size because they usually attract distant relatives who may employ servants and so will consume more fuelwood. Smaller households are often

characterised by young couples, bachelors and elderly people who tend to generate small incomes and so will consume less fuelwood.

The following factors affect the supply of fuelwood: Land use and land management, accessibility to fuelwood resources, acceptability or preferability of wood for fuelwood and income (figure 1.1).

Different land use determines the amount of woody biomass or vegetation and consequently the supply of fuelwood. Areas with dense woody vegetation usually supply more fuelwood compared to areas with less dense woody vegetation. For example, land under arable agriculture contains fewer woody biomass resources. Where land management involves complete clearing of vegetation for farming the ultimate wood supply will be reduced. And where the area is grazed, there is poor regeneration of the trees due to the effect of browsing. This may result in the reduction of the woody biomass density which ultimately reduces the supply of fuelwood. Therefore by studying the spatial distribution of the woodland (dense and less dense woodland and agricultural fields) in a village area, it will be possible to tell which parts of the village area have a relatively better supply of fuelwood.

Accessibility to woody biomass resources will determine the supply of fuelwood which can be obtained from those resources. Accessibility will in turn depend on the location of the resources and land tenure. People who stay close to woody biomass resources usually obtain a good supply of fuelwood compared to people who stay far away from the resources. Land tenure also affects the supply of fuelwood in that in private land or government owned land fuelwood collection may be controlled or prohibited whereas in communal land access may not be controlled (Feeny *et al.*, 1990).

Although the total woody biomass in an area may determine the availability of the supply of fuelwood, it is not enough to say that all those resources are used for fuelwood. This is because some of the woody biomass may not be accepted or preferred by the community. The reasons for this may be that some of the trees are associated with taboos, or spirits and are therefore not used, while others may be known to produce toxic smoke. Local regulations may prohibit the use of some tree species or may not allow the use of live trees for fuelwood

(McGranahan, 1991). An area which has less of the accepted or preferred wood will therefore be supplied with little fuelwood. Therefore by studying the tree species composition in a woodland, it will be possible to know whether the species preferred for fuelwood is plenty or not. Furthermore, if the composition of dead trees in the woodland is estimated, it will be possible to know whether the preferred species is plenty or not plenty in the dead form. When the stand density in terms of basal area per hectare of the different species of trees in the woodland is estimated, it will be possible to tell the contributions of each tree species to the total standing crop or biomass of the woody vegetation (Avery and Burkhardt, 1994; Coe, 1992; Tietema *et al.*, 1988). If the population structure of the woodland is estimated, it will be possible to know which diameter class is abundant and which ones are not. The relative scarcity of a particular diameter class may be linked to its continuous harvesting. Wealthier families tend to have more people in their houses who may contribute labour necessary for fuelwood collection. Also where fuelwood sources are far, wealthier families may afford transport in the form of vehicles to collect fuelwood. It is also the rich families who own more land which is the fuelwood source. All this means that richer families are in a better position to supply themselves with good amounts of fuelwood than the poorer ones.

The effects of the fuelwood shortage considered in the study are those that directly affect the people's well-being and the environment in the form of deforestation. The effects of fuelwood shortage on the socio-economic well-being of the people are many. For example, people may need to walk long distances looking for fuelwood resulting in the reduction of labour and time available for other household activities. Families may eat only once a day because of lack of firewood to cook, thus affecting their health. In places where fuelwood is sold, the increase in price of fuelwood, due to its shortage may mean that some families will have to spend extra money in obtaining it. This money could have been put to other productive uses. According to McGranahan (1991), when people begin to derive income from fuelwood sale it may lead to over-cutting of trees which then results in deforestation. Even where fuelwood is not yet commoditised, but already scarce, an increase in population will cause an increase in demand leading to the over-cutting.

The household socio-economic well-being and the physical environment also interact with each other to form a vicious circle. For example, due to deforestation soil erosion may result, leading to reduced crop yield, and this may affect the amount of food or income available to the people of the area. Poor households who may not afford other types of fuel may be forced to over-cut the remaining trees, leading to deforestation.

1.5 The study area.

The study was carried out in Mulambakwena village in the North East District of Botswana. This District was chosen because it is experiencing a growing demand for fuelwood due to the high population density. It is the second largest populated district in the country and yet it is second smallest district. The high demand for fuelwood has contributed to its scarcity. Another reason for choosing the district is that no previous study on fuelwood has been carried out there, apart from only one done in 1985. The reason for selecting Mulambakwena is discussed in section 3.1. This section describes the climate, the soils and the vegetation of the study area. It also discusses the population, land tenure and land use, the economic activities and the infrastructure of the area. Figure 1.2 is the map of Botswana showing the location of North East District, the insert indicating the position of Botswana in Africa. Figure 1.3 is the map of North East District showing the position of Mulambakwena, other villages and the land tenure. Figure 1.4 is the map of Mulambakwena village and its supporting resource area (subsequently referred to as Mulambakwena village).

1.5.1 Location and physical conditions.

Mulambakwena village is situated about 5 km north of Masunga, the District headquarters, and occupies an area of 34.8 km² (0.7 percent of the total District area). With nine other villages, Mulambakwena falls under the Communal First Development Area (CFDA), an area set up and approved in 1980 as an approach to facilitate rural development in Botswana (Barnhoorn *et al.* 1994). The village boundary follows the rivers Dati to the east and Ntoba to the west. It borders the villages of Zwenshambwe to the north, Mosojane to the east and south east, Masunga to the south and south west and Gambule to the west (see figure 1.4). North East District, with an area of 5232 km², is the second smallest district in Botswana. It is in the north eastern part of the country (figure 1.2) and is bounded by two rivers: Shashe in the west and south; and Ramokgwebana in the east. The Ramokgwebana river is

also the international boundary between Botswana and Zimbabwe. Bordering the district to the west and south west is the Central District of Botswana (figures 1.2 and 1.3).

Figure 1.2: Map of Botswana showing the location of North East District. Source: Government of Botswana, Department of Survey and Lands, Gaborone, 1989.

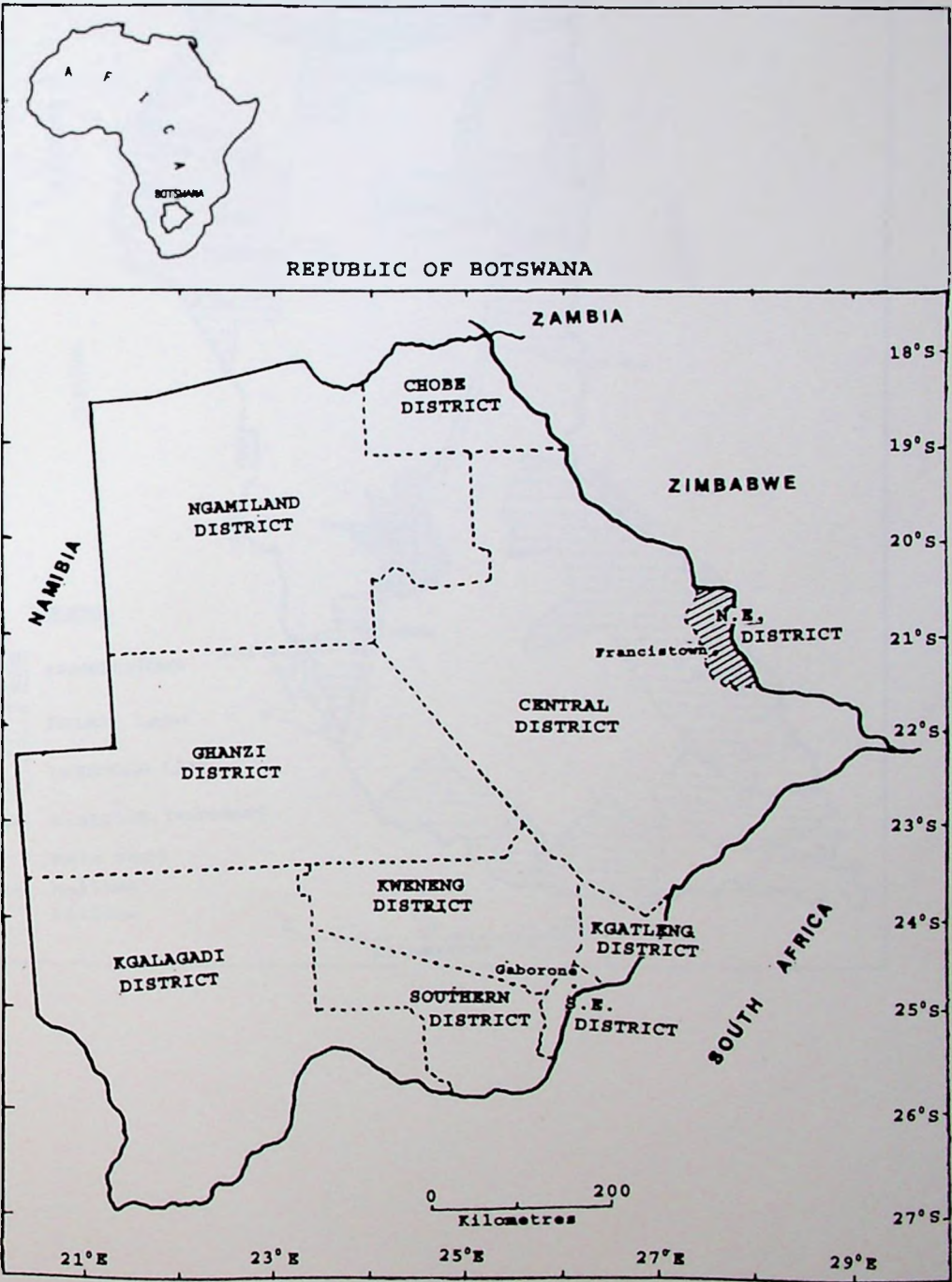


Figure 1.3: Map of North East District showing the location of Mulambakwena village.
Source: Government of Botswana, NEDC/NEDDC, 1989.

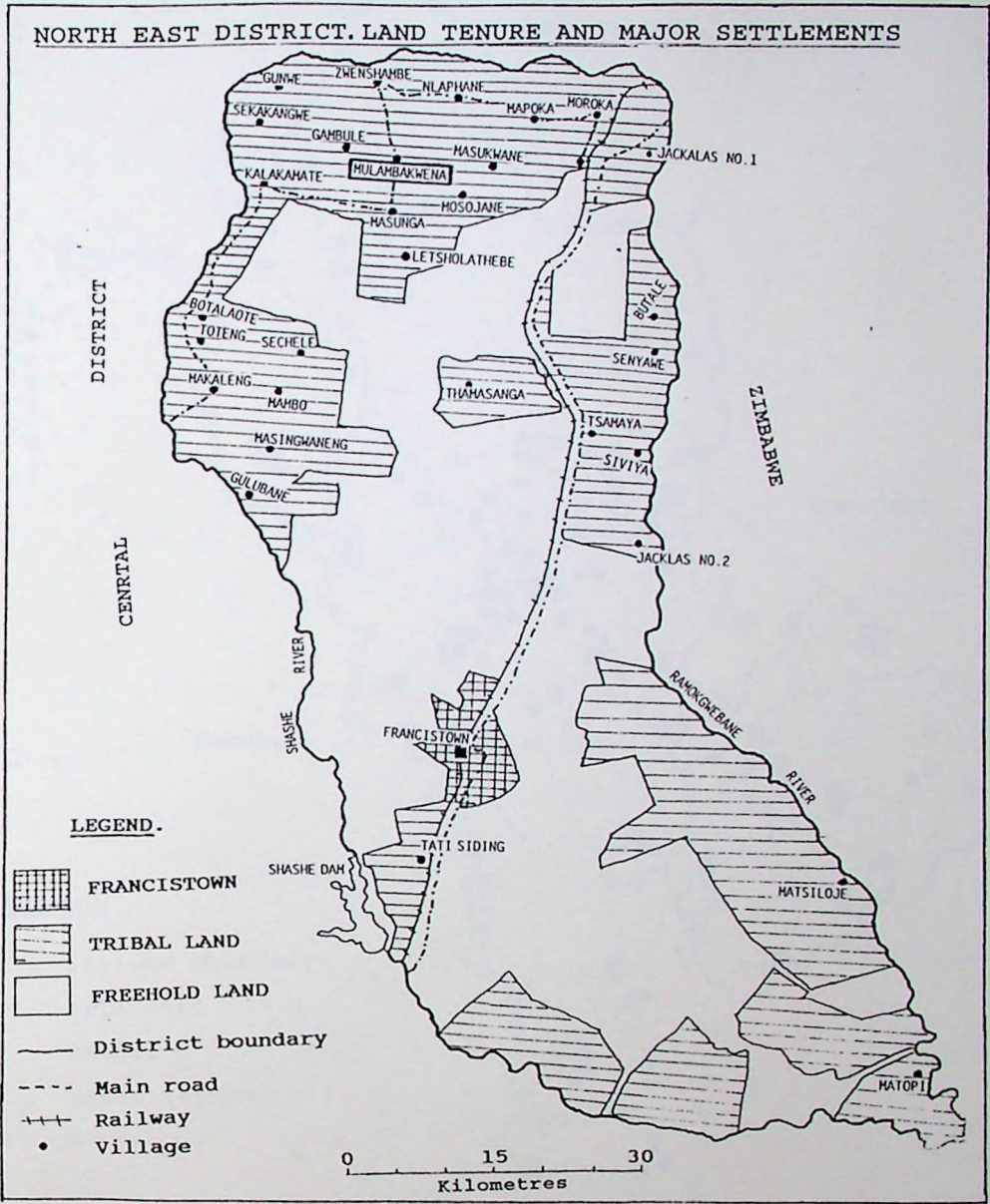
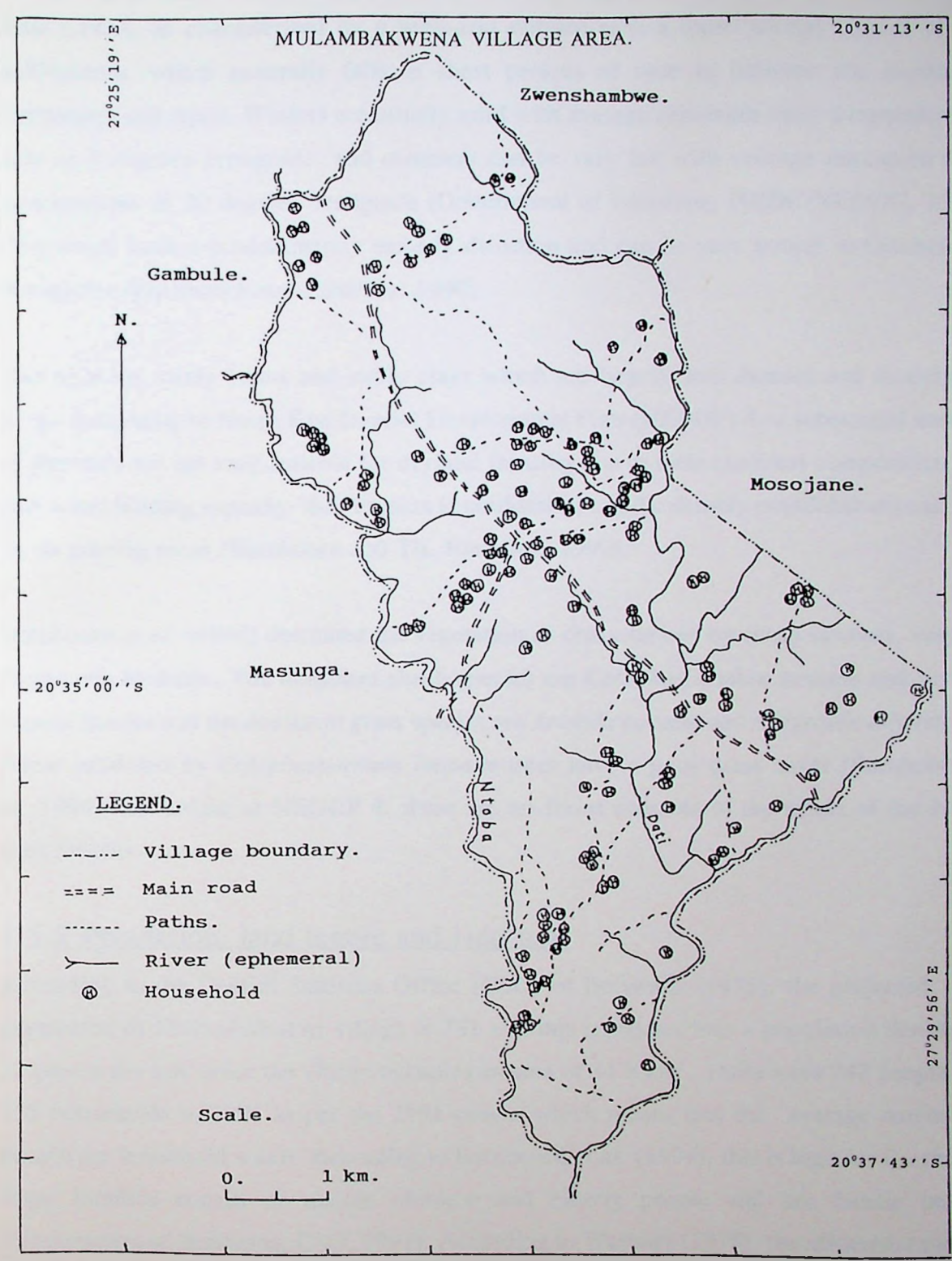


Figure 1.4: Map of Mulambakwena village and its supporting resource area.



According to Barnhoorn and Th. Riezebos (1990), Mulambakwena, as the rest of the North East District, is characterised by a semi-arid climate with a mean annual rainfall of 509 millimetres, which generally falls in short periods of time in between the months of September and April. Winters are usually mild with average minimum daily temperatures as low as 5 degrees centigrade, and summers can be very hot with average maximum daily temperatures of 30 degrees centigrade (Government of Botswana, NEDC/NEDDC, 1989). The winds have a predominantly easterly direction and can be very strong in October and November (Barnhoorn and Riezebos, 1990).

The soils are sandy loams and sandy clays which are largely well drained and moderately deep. According to North East District Development Plan (NEDDP) 4, a substantial amount of the soils are not very suitable for dryland farming due to their chemical composition and low water holding capacity. Soil erosion is predominant in the densely populated area as well as on grazing areas (Barnhoorn and Th. Riezebos, 1990).

Barnhoorn *et al.* (1994) described the vegetation as characterised by shrub savanna, varying from open to dense. The dominant shrub species are *Colophospermum mopane* and several *Acacia* species and the dominant grass species are *Aristida conesta* and *Eragrostis atherstonii*. Areas inhabited by *Colophospermum mopane* trees have a poor grass cover (Barnhoorn *et al.*, 1994). According to NEDDP 4, there are no forest reserves in the whole of the North East District.

5.2 Population, land tenure and land use.

According to the Central Statistics Office (CSO) of Botswana (1995), the projected 1995 population of Mulambakwena village is 781 and this translates into a population density of 22 people per km² since the village occupies an area of 34.8 km². There were 742 people and 132 households in 1991 as per the 1991 census which means that the average number of people per household was 6. According to Barnhoorn *et al.* (1994), this is high for Botswana. Most families consist of mainly children and elderly people and are female headed (Government of Botswana, CSO, 1991). According to Werbner (1975), the settlement pattern differs from the rest of Botswana in that people live in scattered settlements of hamlets and homesteads surrounded by their fields. The distance between the homesteads and the fields

is between three to five kilometres. The majority of the people live in traditional houses which are made of mud and wood and have grass thatched roofs (Barnhoorn and Th. Riezebos, 1990). Only one major ethnic group, the Bakalanga live in the village and according to Tapela (1982), the ancestors of these people have been there for at least 1000 years.

The whole of the North East CFDA falls under the tribal land type of land tenure which is about 45 percent of the total land in the district (Barnhoorn and Th. Riezebos, 1990). Land is communal property and under the Botswana tribal land act of 1968, land may be granted in two main ways. The first is under the customary land rights where a person may be granted the rights to use the land mainly for ploughing and residential purposes. The second one is under the common law in which a lease may be granted to occupy land for business or residential purposes and the occupants are asked to pay rent. Land granted under the above two types of ownership may be inherited or borrowed from the grantee. The rest of the land not granted is normally the common land (Government of Botswana, MLGLH, 1968). Barnhoorn *et al.* (1994) noted that the average land holdings of 8.0 hectares per household is not enough as people generally still complain that there is land shortage in the village.

The present land use in the North East CFDA consists of mixed subsistence farming: arable and pastoral which will be described in the next section. As far as land resource management is concerned, in 1985 the Government of Botswana, after realising that the resource was being mis-managed initiated the National Conservation Strategy (NCS). This was approved later in 1990 and is meant to deal with natural resource management of national concern (Government of Botswana, MLGLH, 1990). In North East District the branch of the NCS is known as North East District Conservation Strategy (NEDCS). The committee of the NEDCS has indicated that people in the North East district and thus CFDA are worried about the future of the resources in their area. Problems identified were, overgrazing, soil erosion, land shortage and improper land allocation, fuelwood shortage, and lack of thatching grass, among others (Government of Botswana, NEDC/NEDDC, 1989). As an attempt to solve the fuelwood problem, a regulation was passed by the NEDCS committee that prohibits the cutting of live trees for fuelwood.

5.3 Infrastructure and economic activities.

The main infrastructure in Mulambakwena village area consists of roads and social services. Within the North East CFDA, Mulambakwena is accessible to Masunga, Zwenshambwe, Lapkhane and Mapoka by a tarred road which also connects it to the Francistown-Bulawayo road. Dirt roads and paths also exist within the North East CFDA. The social services include a primary school, a health post, a few retail shops, a telephone booth and water supply from boreholes. The village and its supporting area is not connected to an electricity supply.

The main economic activities in the village area are arable and livestock farming. These, plus remittances from migrants, government support programmes and income from formal and informal jobs and activities are the main source of household incomes (Barnhoorn *et al.*, 1994). Arable agriculture is still the dominant activity for many people. The main crop grown is sorghum and the minor ones include millet, maize, beans, pumpkins, groundnuts and water melon (Government of Botswana, NEDC/NEDDC, 1989). According to Barnhoorn and Th. Riezebos (1990), under the semi-arid conditions of Mulambakwena village, arable agriculture is a high risk activity. Other problems include lack of inputs and capital especially draught power and labour and a low level of technology for example fertilizer and insecticide use. Many young people have left the North East CFDA to look for work in the urban centres (Barnhoorn *et al.*, 1994). Access to land is another problem affecting arable agriculture, and the other is lack of nutrients and moisture in the soil (Barnhoorn *et al.*, 1994). Because of all these problems there has been low yield of crops. For example, in 1988 the total average harvest was 433 kg per household which is well below the household needs for consumption and only 4 percent of all households had harvested enough to be self sufficient in food (Government of Botswana, DAO, Masunga, 1990; Barnhoorn and Th. Riezebos, 1990). Generally crop sales are negligible and consequently substantial quantities of sorghum and maize are imported into the village area (Barnhoorn and Riezebos, 1990). In 1985, following the years of drought, the Ministry of Agriculture introduced the Accelerated Rainfed Arable Programme (ARAP) as an attempt to reverse the decline in arable production in the traditional farming sector and to enable farmers to increase their production of basic cereals once the drought ended (Eskeli, 1989). To enable them to achieve this aim, one of the packages offered under this ARAP was the Destumping Scheme. Under

is scheme, farmers were encouraged to clear their land of trees and stumps to expand the area under arable production to boost the amount of food produced. In Mulambakwena village area, 12 farmers had destumped a total of 42 hectares since 1986 by uprooting old stumps and felling new trees on new land (Government of Botswana, DAO, Masunga, 1995).

Compared to other parts of Botswana, livestock farming in North East CFDA is of minimal importance (Barnhoorn *et al.*, 1994). This is because of lack of grazing land due to high population density and the fact that large parts of the area are used for arable farming. Also shortage of water is another problem which affects livestock farming. Consequently, the few animals that are grazed do so near homesteads (Barnhoorn *et al.* 1994). Nevertheless, in Mulambakwena village area livestock still contributes to the incomes of the people through the sale of animals. A report from the District Veterinary Office (DVO) indicates that about 50 percent of the households own cattle with an average number of six. There was a total of 272 cattle, 74 sheep, 503 goats and 55 donkeys in the village in 1995 and the mean number of livestock per household owning cattle is 26 (Government of Botswana, DVO, Masunga, 1995). According to the same source, the mean number of livestock per household owning cattle was only 20 in 1989. In contrast to the above statement, this is actually quite high considering it is not primarily a pastoral area.

The other economic activities and sources of income in the village are formal and informal employment. The main formal employment is provided through a Government support programme called the Drought Relief Programme (DRP), which was introduced to compensate people for the loss of income caused by drought (Barnhoorn and Th. Riezebos, 1990). Under the programme people are employed temporarily in construction of government houses and in road construction and maintenance. People of Mulambakwena also generate income through self employment where they do sewing, make handicrafts, brew local beer, operate retail shops, and some sell fuelwood and also grass for thatching. Some families receive remittances from relatives outside the village. A survey carried out by Barnhoorn *et al.* (1994) revealed that the average monthly income per household in the North East CFDA was P145 in 1988/1989. According to Government of Botswana, CSO (1995), the average monthly income for 1993/94 was P200 thus indicating a rise in income.

CHAPTER TWO: LITERATURE REVIEW.

2.1 Introduction.

This section reviews the existing literature on fuelwood in developing countries generally, and in Botswana in particular. It begins by looking at the importance of energy in society and rural development and then discusses the energy situation worldwide, in Africa and in Botswana. Methods used in the study of fuelwood in developing countries plus some of the major findings are also examined.

2.2 Importance of energy in society and rural development.

The scientific definition of energy is that it is the capacity to do work (Walker, 1992). It can also be described as resources such as petroleum, coal, gas, wind, nuclear fuel, and sunlight, from which energy in the form of electricity or heat can be produced (Abbott, 1972). Other energy sources include human and animal labour and energy from wood. Wood energy is in fact sunlight energy which was captured and transformed into chemical energy in the leaf by the photosynthetic process with subsequent chemical and transport processes responsible for the formation of wood (De Gier, 1989).

Everyone is dependent on nature for the continuous supply of energy in one or other of its many forms. According to Foley (1992), energy is important not only in science, but in industry, politics and the whole of human welfare. Energy grows food and keeps people alive. It transports them, fuels machines and sustains economic systems (Foley, 1992). According to the same author when supplies of energy are ample, there is prosperity, expansion and development. When energy supplies are in question, all that depends on them is also in question, not only the way of life but life itself.

In most rural communities of developing nations the major energy source is biomass, although petroleum may also be available (Chirarattananon, 1984). Earthscan (1987) supports the above statement when it points out that wood is by far the most widely used domestic fuel in the developing world. Since in many countries virtually every rural family relies on wood for all or part of its cooking and heating, rural energy can be taken to mean predominantly

woodfuel. Woodfuel here will refer to fuelwood (firewood) and charcoal. Fuelwood refers to wood which is burnt directly as fuel. In some cases wood is first converted into charcoal by incomplete combustion of wood and then used.

Around three quarters of the population of developing countries live in rural areas, where to attain even the minimum condition of well-being will require significant increase in the access of energy in the form of food (since population also continues to increase). This in its basic form means an increase in fuelwood for cooking. As Morse *et al.* (1984) point out, national energy supply and rural development need to be integrated. According to the same source (and also Katerere, 1991), in setting up national development objectives, rural development policy should be combined with other policy areas like food, trade, environment and energy policy to form an integrated energy policy which would be essential for rural development.

2.3 Energy situation worldwide.

According to FAO (1987) and Crump (1991), the whole world is experiencing, in different degrees, an energy crisis as available supplies of energy are dwindling and alternative sources cannot rapidly be built up. In developing countries there are two major inter-related aspects. Firstly, increases in the price of imported petroleum products has put great strains on the balance of payments, with many countries spending more than half of their foreign exchange on fossil fuel (FAO, 1987). Secondly, woodfuels and other traditional biomass forms of energy (crop residues, dung) upon which three quarters of the population of developing countries depend for energy for cooking and heating are getting scarce. During the last two centuries wood has gradually ceased to be the fuel most used throughout the world. The replacement of woodfuel by fossil fuels, which have higher energy content and are easier to use played an important role in the energy supplies of the industrial countries. But this is not the case in developing countries, where the vast majority of the people continue to depend on woodfuel to which they traditionally have access (FAO, 1987; Crump, 1991).

The total consumption of the traditional fuels worldwide is probably in the range of 1.5-2.0 billion tonnes, ranking them fourth in the world hierarchy of fuel consumption (Foley, 1992). Dependence on traditional fuels is greatest in rural areas of developing countries. According

to Agarwal (1986) in most countries of the developing world, virtually the whole rural population relies exclusively on these fuels for cooking, heating water and keeping warm. Foley (1992) and Timberlake (1988) note that for many families who are unable to obtain or afford kerosene or bottled gas, the open fire is the only source of light available to them for the evenings and nights. Other uses for fuelwood include brick-making, beer-brewing, processing of tea, coffee and other commercial crops. According to Crump (1991), more than a third of world's population depend on wood for cooking and heating. Eighty six percent of all wood consumed annually in developing countries is used for fuel and of this total at least half is used for cooking. About 2 billion people rely on it for all, or most part of their daily energy needs, making it the world's most widely used fuel (Foley, 1992).

2.4 Energy situation in Africa.

Africa south of the Sahara is the region in which dependence on fuelwood is the most marked: between 90 and 98 percent of energy needs in the rural areas are met by fuelwood which may also account for 75 percent of national energy supplies (Davidson and Karenkezi 1993). In oil rich Nigeria fuelwood accounts for over 80 percent of the total national energy consumption (Hall and Rosillo-calle, 1991) and it is rapidly getting scarce (Cline-cole *et al.*, 1990). Other countries where fuelwood consumption is also high include Uganda where it accounts for 92 percent of the total energy consumption (Bachou, 1990) and Burundi and Rwanda where wood consumption accounts for over 90 percent of total energy consumption (Karenzi, 1994). Hall and Rosillo-calle (1991) reported that in Malawi, Tanzania, Ethiopia, Somalia, Mali, and Chad wood provides over 90 percent of the total national energy consumption of all kinds. In the Southern Africa region (SADCC), as a whole biomass was found to account for over 70 percent of total energy consumption (Tebicke, 1990).

2.5 Energy situation in Botswana.

In Botswana, fuelwood accounts for about 58 percent of the national energy consumption (Government of Botswana, MMRWA, 1993). According to Sekhwela (1994), the high consumption of fuelwood is due to the fact that the majority of the people in rural areas, use fuelwood. Fuelwood is also used in urban areas, government institutions and rural industries (Tietema *et al.*, 1988). The estimated national fuelwood consumption by sector indicates that rural households account for 50.9 percent, followed by institutions which account for 20.9

percent, then urban households and industries which account for 18.9 percent and 1.2 percent, respectively (Sekhwela, 1994). Compared to other African countries like Nigeria, Uganda, Rwanda, Burundi, Malawi and Somalia, fuelwood accounts for a lower percentage of the total energy consumption in Botswana.

2.6 Fuelwood survey methodologies.

A number of methods have so far been used in the studies of the supply and demand of fuelwood in developing countries. This section reviews some of the methods and these are: sampling, the use of questionnaire, the use of informal and group interviews, direct observations, physical measurements, and the use of aerial photographs, remote sensing and GIS. This section will also examine some of the methods used in the analysis of the data.

2.6.1 Sampling.

Most of the areas of the study were large, hence sampling rather than using the whole population in an area had to be done. For instance, in Kenya, Kinyanjui (1984) and Hosier (1985), first divided the area to be surveyed into different ecological zones from which random samples were chosen. The rural energy survey carried out in Malawi used the sampling frame designed for the previous national agricultural surveys (French, 1986). In Botswana, Kgathi (1992) and Kgathi and Mlotshwa (1994a) used the existing population census sampling framework from which random samples were taken. Kgathi (1989) points out that in most fuelwood surveys in Botswana, samples were large enough and therefore representative of the population being surveyed. The same report did not indicate what proportions these samples were.

2.6.2 Questionnaire.

Structured closed questionnaires have often been used to collect factual information on fuelwood. For example, collection, use, consumption, income level, preference, household size. The advantage of this method is that it is quick, economical and the data may be collected by enumerators even when the researcher is not there (Howes, 1985). For example, Soussan *et al.* (1991) used enumerators in Nepal to study the fuelwood situation in that country. In Botswana questionnaire interviewing was used to collect data on distances

travelled to points of fuelwood collection (Arntzen, 1983; ERL, 1985; Tietema *et al.*, 1988). Some of the disadvantages of questionnaire interviewing is that sensitive issues like illegal fuelwood collection may not be asked (Howes, 1985). Also, issues which are difficult to recall as the amount of fuelwood consumed some years back may not be revealed accurately by this method (Soussan *et al.*, 1991). For these reasons questionnaire interviewing is normally used in combination with informal interviews.

2.6.3 Informal interviews.

In informal interviews only check-lists of questions to be asked are used and the questions are open-ended. Key informants who are people knowledgeable of the issues being investigated are involved in informal discussion (Castro and Brokensha, 1983; Howes, 1985). Informal interviews are usually carried out to cross check the reliability of information collected using questionnaires as well as the information which has been directly observed and needs clarification. These interviews are therefore undertaken in order to improve the quality of the data (Howes, 1985). By using informal interviews, data have been collected on some issues such as past events, social relationships and asset distribution as indicator of wealth. Some of the people who used this informal interviewing method include Kamara (1986) in Sierra Leone and Opiro *et al.* (1994) in Thailand to study fuelwood situation in those areas. In Botswana, this method was used by Kgathi (1992). The only disadvantage with this method is that some key informants may be biased on some issues and yet others may not be willing to give some information (Opiro *et al.*, 1994).

2.6.4 Group interviews.

Group interviews are usually done to cover broad issues in the same range of questions as informal interviews, the only difference is that it is administered to groups of people who may be in a village meeting. It is particularly useful when listings of activities are required such that the knowledge of individuals operating in isolation may be either insufficient or unreliable (Howes, 1985). According to the same source, the disadvantage with this method is that some interest groups feel inhibited either from attending or from making their opinions heard. Opiro *et al.* (1994) used this method in eliciting problems concerning fuelwood supply in Thailand where participants in a village meeting were divided into smaller groups for discussions, the results of which were discussed in a plenary session for consensus.

2.6.5 Direct observations.

Direct observations are carried out by a researcher in order to understand the significance of what is going on in particular area, such as labour allocation or fire management during cooking (Howes, 1985). It may also be used to confirm information gathered during interviewing when respondents are asked to estimate for example time and distance in fuelwood collection (Howes, 1985). It is also useful in studying characteristics of the environment (Opiro *et al.*, 1994), especially those connected with fuelwood supply. Clarification on whatever is observed can be obtained through discussion with key informants. Opiro *et al.* (1994) used this method in studying woody biomass configuration in Thailand. In Botswana, one researcher accompanied women to fuelwood collection centres to collect data on fuelwood collection (Jelenic and Van Vegten, 1981) and to assess various uses of fuelwood and labour allocation (Oki and Mahaja-Jartby, 1983). The main problem with this method is that it is time consuming and may be costly as it requires the observer to stay for a longer period of time in a particular place (Howes, 1985; Floro, 1995). Also, in using direct observation only a few sections of the population being studied may be observed (Howes, 1985). Floro (1995) also notes that using a direct observation method on a set of activities may tend to alter the nature of the activities themselves since an observer can be perceived as an "intruder".

2.6.6 Direct measurement.

Direct measurement involves physical measurement (or enumeration) carried out in order to estimate fuelwood consumption or estimate the stocking or composition of fuelwood sources. In the measurement of fuel consumption, P.C. Fleuret and A.K. Fleuret (1978) asked households to lay out fuelwood for measurement, equivalent to that used in the previous day for the morning and afternoon/evening fires. This method is quick and simple but relies so much on memory which may be far from perfect, although probably superior to purely verbal recall (Howes, 1985).

Best (1979) weighed a pile of fuelwood at the households at the beginning and returned at the end of a period to see how much had been used up. The period may be from one day to a week. According to Howes (1985) and ETC (1987), this method is potentially very accurate but time consuming. Also wood might be borrowed by neighbours, and often other

fuels like twigs, leaves, or scraps are used and will not be included in the measurement.

The method that Ernst (1978) employed has been commonly used in fuelwood surveys. Here, a bundle of fuel is set aside each day and weighed. Household members are instructed to use only fuel from that source. The bundle is then reweighed at the end of each day to determine consumption. This method is also fairly accurate but there is danger that other fuels may be used or others may use fuel from selected household's bundle (Howes, 1985; ETC, 1987).

All the above methods have been used in most surveys carried out in developing countries to estimate fuelwood consumption. In Botswana, Tietema *et al.* (1988) used the method employed by Ernst implying that figures obtained were crude estimates.

In estimating the growing stock in Botswana, Thomas (1991) carried out the whole-tree weighing of selected trees and also measured the heights and diameters of the trees at knee heights. Small pieces of the trees were cut, weighed in a laboratory, dried for two months, and re-weighed in order to find the volume without moisture. He later carried out regression analysis to find the relationship between the tree heights and diameters in order to estimate volume of trees. Tietema and Geche (1987) also used a similar method but did not weigh all the parts of the trees.

By counting the number of trees of different species, Sekhwela (1994) and Tietema *et al.* (1988) estimated the species composition of the woody vegetation. Further, by measuring heights of those very trees, population structure and basal areas of the woody vegetation were obtained. Coe (1992) also used basal area to get the stocking of woody biomass. The number of trees per diameter class gives the population structure of a forest. Tree-stem diameter measurements are often converted to cross-sectional areas. According to Avery and Burkhart (1994), the cross-sectional area at breast height is called basal area (BA). BA is normally computed per tree and then the total obtained for all the trees. This can then be expressed on a per hectare basis as BA per hectare. According to the same source, BA per hectare is a logical expression of stand density and is highly correlated with the volume and growth of forest stands. It is therefore a measure for the standing crop or biomass of a stand.

The common measurements of fuelwood are in volume in cubic meters and weight in kilograms. According to ETC (1987), Thompson (1983) and Bird and Shepherd (1989), measurement by weight may be easier in the field but must be converted to take into account the varying moisture content of wood. This is usually done by taking small samples in sealed plastic bags to a laboratory where they are weighed, air dried for two months and re-weighed to determine the proportion of water in the original sample. Volume measurement of fuelwood is done by multiplying length by diameter of wood. De Lucia (1983) and Kuyper and Mellink (1983) noted that this is only suitable for straight and big parts of stems and may not give accurate results for twigs and crooked branches. However, when some correction factors are applied it can be used to produce a reasonable estimate of volume of fuelwood. The fuelwood volume can be converted to weight measurement. For example, 1 cubic metre of fuelwood is equivalent to 700 kg of the fuelwood (Cline-cole *et al.*, (1994) whereas according to Hall and Mao (1994), the same volume of fuelwood weighs 667 kg.

2.6.7 Other methods of fuelwood surveys.

Other methods of fuelwood surveys used in Botswana include biomass assessment for fuelwood based on the analysis of remotely sensed data. This was combined with data from secondary sources and ground truth verification. The above method was used by ERL (1985) and ETC-Foundation (1987) to assess the fuelwood situation for most parts of the country. Miriam Van Heist (1989) used another method in the fuelwood survey in Botswana. She carried out evaluation of fuelwood availability using Geographical Information System (GIS) for south eastern Botswana.

According to a number of authors (notably Barnett, 1982; Castro and Brokensha 1983; Howes, 1985; Kuyper and Mellink, 1983) it is better to use a combination of different methods in a single fuelwood survey as this may increase the reliability of the data collected.

2.6.8 Data analysis.

The methods of data analysis in various studies include descriptive statistical techniques such as measures of central tendency, measures of dispersion, bar charts and tables (Kgathi, 1989). Simple regression analysis was used by Tietema *et al.* (1988) and Thomas (1991).

Kgathi (1992) carried out multiple regression in the analysis of fuelwood consumption. Qualitative descriptions were used most frequently.

2.7 Major findings of the energy surveys.

The major findings of the fuelwood surveys reviewed in this section are on fuelwood demand and supply. The indicators of fuelwood scarcity and the effects of the scarcity on the people's well-being and on deforestation will also be discussed. Lastly findings on the people's perception of fuelwood problem will be examined.

2.7.1 Fuelwood demand.

The major findings on fuelwood demand indicate that fuelwood consumption varies from one locality to another and is influenced by a number of factors. These factors could help in explaining fuelwood shortages in those localities. According to Morgan and Moss (1981), fuelwood consumption is influenced by environmental factors and socio-economic factors. The environmental factors are the availability of fuelwood resources, altitude and temperature. Where fuelwood is plenty, fuelwood consumption tends to be higher and vice versa (FAO, 1987). People at high altitudes are usually subjected to lower temperatures and studies reveal that they tend to consume more fuelwood as compared to those at lower altitudes where the temperature is higher (Chirarattananon, 1984). Studies carried out by ERL (1985) in Botswana also found that households consume more fuelwood during winter because more fuelwood is needed for space heating during cold weather.

The socio-economic factors are population density, household size and household income. Much more fuelwood tends to be consumed in areas where more people live (FAO, 1987). Most studies carried out in developing countries to find out the relationship between fuelwood consumption, household size and household income tend to report on the fuelwood consumption *per capita*. A number of authors (notably Hoisier, 1984; Kamara, 1986; Leach, 1987; Islam, 1984; Tietema and Geche, 1987 and Kgathi, 1992) indicate that the larger the household size the less the fuelwood consumption *per capita*. This may be explained by the fact that large families use large cooking pots for cooking which are more energy efficient (Islam, 1984; Kamara, 1986).

The relationship between household income and fuelwood consumption show different results. Wiersum (1979) found that as income increases less fuelwood is consumed. The above relationship is attributed to the fact that as income increases fuelwood is replaced by other fuels like gas and electricity in urban areas (Arnold, 1978). But in rural areas (Ernst, 1978; Wiersum, 1982; Briscoe, 1979) report that this is not the case because when income decreases for the low-income groups the landless will use crop residues, grass, leaves, twigs and cow dung, thus reducing the fuelwood consumption. In Botswana, studies done by Kgathi (1992) and Kgathi with Mlotshwa (1994b) found that in the rural areas as income increases more fuelwood is consumed.

The variations of the estimated fuelwood consumption *per capita* was found in Botswana. For example, ERL (1985) estimated fuelwood consumption *per capita* in rural Botswana to be 0.57 m³ a year. Tietema *et al.* (1988) recorded a figure of 0.84 m³ in Dukwe settlement, in the north-western part of Botswana. The figure for Gaborone was estimated at 0.25 m³ per year and Selibe-Pikwe at 0.49 m³ per year. Despite these variations, ERL (1985) notes that generally the biomass resources are more than sufficient to meet the demand for fuelwood and poles in most parts of Botswana. The same report, however, points out that for villages in the north eastern part of the country, there is a prospect of severe fuelwood shortages on account of the increasing fuelwood demand.

2.7.2 Fuelwood supply.

According to Thompson (1983), the main aim of an inventory of fuelwood supply is to provide planners with a database for decisions on energy and land use and their inter-relationship with the local people. Available literature on fuelwood supply show the following results in Botswana. Findings by ETC-Foundation (1987) revealed that woody biomass resources on a national scale are still high compared to the total population, and so the standing biomass may fulfil the fuelwood requirements. However, the same report added that the ability of the vegetation to recover from large scale exploitation or to produce sustained annual fuelwood is more restricted. For example, the biomass growing stock is highest in the far north while in the eastern part where most people live the growing stock is less (ETC-Foundation, 1987). This means that there is uneven distribution of the woody biomass with respect to the population. Even in the eastern part of Botswana where most fuelwood

inventories have been carried out there are still variations on the figures obtained for the growing stock and annual increment of the woody biomass. For example, a survey carried out by ERL (1985) revealed that there were still substantial fuelwood resources in the eastern part of Botswana amounting to almost 237 tonnes. The same report estimated the total increment to be about 13 million tonnes a year of which 7.5 million tonnes are of the preferred tree species. According to Government of Botswana, Energy Master Plan of (MMRWA) (1987), previous studies gave an estimate of total growing stock of biomass in eastern Botswana as 227.9 million tonnes (oven dried) and annual increment of fuelwood of 7.343 million tonnes (oven dried). Also data from a survey done by Rural Energy Study (RES) in 1986 indicate that actual growing biomass stock lies between 135 and 324 million tonnes (Government of Botswana, MMRWA, 1987).

Analysis of species composition of the woody vegetation in Dukwe area of Botswana by Tietema *et al.* (1988) revealed that the *Colophospermum mopane* was the dominant species accounting for over 65 percent of the total vegetation cover. Population structure of the same area showed an abundance of smaller stem diameter class of 0-5 cm. Sekhwela (1994) also found similar results for the areas around Molepolole and Khakhea of Botswana. In estimating the standing crop, Tietema *et al.* (1988) used basal area measurement and again found the highest percentage to be *Colophospermum mopane*.

The preference of fuelwood species has also been investigated in Botswana. In a study carried out in Kgatleng District, Jelenic and Van Vegten (1981) found that the most preferred fuelwood species were *Combretum apiculatum* and *Combretum imberbe* which later disappeared and households had to switch to *Dichrostichys cinerea* and *Acacia erubescens* species which were again becoming scarce. Kgathi (1984) found out that a similar species of *Combretum* was preferred in Kweneng District. *Colophospermum mopane* was found to be the most preferred species in Masunga village area of North East District (ERL, 1985) and *Terminalia* species in Mosomane (Moganane and Walker, 1995). The above results indicate that tree preference for fuelwood differs considerably from area to area and depends on the availability.

2.7.3 Indicators of scarcity of fuelwood and the effects of the scarcity on the households.

A number of indicators have been used to find out whether fuelwood scarcity exists in some areas and the effects of the problem on the people. Soussan *et al.* (1991) point out that increased fuelwood collection time, switching to residues, over-exploitation of the fuelwood resources and fuelwood commodification were the most widely found indicators of fuelwood stress in Dhanusha district of Nepal. A few of those indicators have been used in Botswana. As far as the amount of labour time spent on fuelwood collection is concerned, there was an indication that it was increasing over time in areas near large settlements and urban centres (Kgathi, 1989). Opschoor (1981) in his study in the village area of Mochudi found that the distances for fuelwood collection increased from 1.3 km in 1969 to 3.6 km in 1979. Women and children are the ones who collect fuelwood and the distances travelled are becoming greater over time (ERL, 1985). Kgathi (1984) found out that it was the poor households who were traders in fuelwood, in Kweneng District, because they could not get alternative employment. According to ERL (1985), fuelwood was becoming commoditised in Goodhope in south eastern Botswana. This is a place where commercial agriculture has taken over much of the woodlands, and as a consequence, cow-dung is used as fuel (ERL, 1985). Studies by ERL (1985) revealed that, in the northern half of the country demand for fuelwood exceeded the supply. Around the towns of Mahalapye, Serowe, and Borolong depletion of fuelwood was about to occur within the 50 km radius. Although the indicators of fuelwood scarcity have been employed from time to time in rural energy surveys, in some cases they have been unsatisfactory in portraying the real fuelwood situation (Howes, 1985).

2.7.4 Fuelwood shortage and deforestation.

The phrase "fuelwood shortage" and the term "deforestation" are discussed first before examining the links existing between them. According to Earthscan (1987), there is a fuelwood shortage when people experience problems in obtaining reliable supplies of wood for cooking. This situation imposes strain on the well-fare of rural people when they scramble to find fuelwood they need and may use as little as possible or may switch to other alternative "inferior" type of fuels like crop residues or dung. Agarwal (1986) reaches a similar view on the fuelwood shortage, but adds that it may also be taken to mean unequal distribution of available fuelwood.

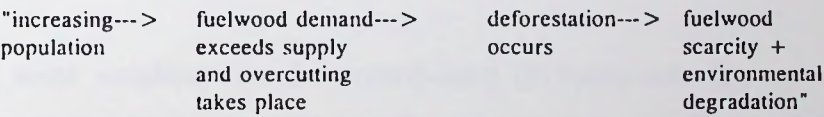
Allanby (1992, p.119) defines deforestation as: "The permanent clear-felling of an area of forest or woodland". Links between fuelwood use and deforestation are usually discussed from two perspectives (Deweese, 1989, p.1165):

"First, woodfuel consumption is often identified as an underlying cause of deforestation; and second, in areas which have been deforested, woodfuels are thought to have become increasingly scarce".

Eckholm *et al.* (1984, p.25) seems to support the above statement when he notes that:

"Fuelwood scarcity is as much a consequence as a cause of deforestation. First, the widespread clearing of lands for agriculture severely reduces the available forest area. At that point, the gathering of fuel from the remaining woodland may well begin to exceed the sustainable harvest".

Available literature shows that the effects of fuelwood shortage on deforestation have not been studied well. This is true for many developing countries including Botswana. It is assumed that fuelwood cutting, deforestation and fuelwood scarcity may be linked in the following manner (Earthscan, 1987, p.17):



Fuelwood problems do not exist everywhere. When local population density remains low, demand for fuelwood can usually be met without damaging the local standing stock of trees. By travelling short distance from their homes people are able to gather sufficient wood (Earthscan, 1987).

Fuelwood cutting is rarely the underlying cause of large-scale deforestation. But as the woody vegetation recedes, demands on the remaining trees grows (Digernes, 1977; Earthscan, 1987). Over time fuelwood scarcities can develop, and fuelwood cutting can become a significant factor in the later stages of deforestation process. The exact way in which fuelwood cutting affects the tree cover has rarely been studied (Earthscan, 1987).

Usually only dead wood is collected where fuelwood is plentiful. Though branches may be lopped off, the whole tree is rarely felled merely to provide fuel (Agarwal, 1986; Leach and Mearns, 1988). But if population begins to grow, the increase in fuelwood demand will most

likely be met by extending the collection area and the process. People will have to search longer and travel further to obtain good quality fuel (Leach, 1987; Bogach, 1985; Van den Beldt, 1984). But provided there is enough wood in this wider area supply and demand can remain roughly in balance (Earthscan, 1987). With further increases in population, eventually people who lack other means of transport will not be able to find new sources of wood within walking distance. Fuelwood collection then becomes concentrated in a fixed area. It is then that firewood cutting starts to cause deforestation, as fuelwood demands begins to eat into the remaining standing stocks of trees (Nyirendra *et al.*, 1994). At the same time the cutting of live branches becomes common, and too much of this kills trees (Earthscan, 1987). Kaale (1989, p.3) agrees with the argument that fuelwood shortage causes deforestation when he notes that: "The consequence of biomass fuel scarcity includes: ...loss of permanent vegetation and tree cover in farms and woodlands, from woodfuel collection and charcoal production". Slessor (1988) also points out that deforestation often occurs because of over-dependence on wood as a source of energy, particularly in developing countries. Dick (1980), however, states that it is largely the urban and industrial demand for fuelwood that is responsible for deforestation.

Despite some emphasis on the contribution of fuelwood shortage to deforestation, it is becoming increasingly accepted that the primary causes of deforestation are land clearance for agriculture (Deweese, 1989; Agarwal, 1986; Leach and Mearns, 1988). Studies carried out in Nepal revealed that it was land clearance for cultivation, and not wood use which was responsible for deforestation (see for instance Bajracharya, 1983; Hrabovszky and Miyan, 1987; Sattaur, 1987). Munslow *et al.* (1988) also reports that in Gutu, Masvingo Province of Zimbabwe, the woody biomass resources continues to diminish because of deforestation due to cultivation.

According to Sekhwela (1994), there is no evaluation of the contribution of fuelwood harvesting to deforestation in Botswana. It is linked with the observed thinning of natural woodlands around settlements. Fuelwood collection occurs all year round in the settlements, other uses of wood such as for construction curving and fencing are only occasional and are not daily requirements like fuelwood. Because of these, Sekhwela (1994) argues that linking fuelwood harvesting to deforestation is founded, but lacks adequate evidence. A report by

Government of Botswana, BEMP (1996) states that fuelwood harvesting may not be the major cause of deforestation in Botswana. The major causes are possibly agriculture and wood cutting for construction.

It is also necessary to obtain the local people's perception of deforestation. According to Whyte (1977), a research on environmental degradation should include people's perception of the situation because this can provide a better understanding of the causes and consequences of the problem. This bottom-up approach does not replace the more traditional scientific approaches, but rather, complements it.

2.7.5 People's perceptions of the fuelwood problem.

According to Kgathi (1989), the approach of using people's perceptions as indicator of fuelwood scarcity is very important as it reveals the views of the local people who are the ones affected by the problem. According to Leach and Mearns (1988), the approach introduces a human dimension to the analysis of the fuelwood problem. Researchers need not only be concerned with the fuelwood problem facing households, but also with the fuelwood problem as a whole relating to other development problems (Munslow *et al.*, 1988). Studies conducted by Eberhard (1986) in South Africa found out that generally water supply was perceived as the most serious problem in seven villages followed by lack of money and employment while fuelwood ranked between third to fourth position. In Botswana studies undertaken in the villages of Mosomane (Arntzen, 1983) and in Kgatleng District (Jelenic and Van Vegten (1981), revealed that the majority of the households perceived fuelwood scarcity as a major problem.

From the above review of the literature, it can be summarised that generally most of the fuelwood survey techniques used in other countries have also been used in Botswana. Although woody biomass on the national scale appears to be adequate to meet the fuelwood needs of the population, some parts of the country are locally experiencing fuelwood problems.

CHAPTER THREE: MATERIALS AND METHODS.

3.1 Introduction.

The supply and demand of the fuelwood survey was carried out in only one village - Mulambakwena, where an in-depth study was done. This village, which was finally selected after a reconnaissance survey, was considered to be representative of 32 villages in the District in terms of the fuelwood situation. It was selected from five villages namely: Mulambakwena, Nlaphane, Mapoka, Musokwane and Gulubane (see figure 1.3) which were pre-selected using the following criteria: villages with high to moderate population; villages with greater percentages of households using wood for cooking and lighting; villages with diverse land-uses; villages which lack woody vegetation cover; villages which had accessibility in terms of the terrain; villages where it was easy to get public transport and villages which were more rural in nature. The in-depth study involved household questionnaire survey, informal and group interviews, aerial photograph interpretation, vegetation sampling and ground truthing.

3.2 Household questionnaire survey.

A household questionnaire survey was carried out through the use of an interpreter. The interview strategies were discussed together with the interpreter a head of time. This was to make sure that they understood the questionnaire well before the interviews. The questions were tested on a small group of respondents to get a general impression about the kind of answers that could be expected and the reliability of the respondents. It was possible to identify questions which were difficult to answer, which attracted biased answers or which put off respondents. Adjustments to the questionnaire were made by adding more questions which arose during the trial; deleting irrelevant ones; and correcting some mistakes. The information obtained from secondary data, the reconnaissance survey, and testing of the questionnaire was used in guiding the selection of households. Data obtained from CSO indicated that all the households in the village were given numbers from 1-132. Out of this, using a scientific calculator, 100 households were randomly selected (76 percent sample) for interviewing. Most interviewing took place outside the houses which was the place most

relevant as it revealed the local conditions being investigated. The questions were asked as specified in the questionnaire and in the order presented. Questions which were misunderstood or misinterpreted were repeated or clarified. Probing was used to motivate the interviewee and to focus discussion on the specific content of the interview. All the probes were recorded. Information that was provided in advance was recorded to avoid repetition of the same questions. During the household questionnaire survey data on the following were obtained: household size, household income, household fuelwood consumption, accessibility to the woody biomass resources for fuelwood, and some data on the socio-economic well-being of households and deforestation (see Appendix I).

3.3 Fuelwood measurements.

Fuelwood measurements were done in 60 households selected randomly (using a scientific calculator) from the 100 households previously selected. Direct measurement was carried out on fuelwood after getting permission from the interviewee. In determining the amount of fuelwood consumed, the direct measurement, the direct observation, and questionnaire methods were used. All measured fuelwood was found in the compounds stacked as brought from collecting trips. To determine how many trips were made, and how long the fuelwood lasted relevant questions were asked (see Appendix I). The length of the stack was measured. The diameter of each piece from the bundle was measured at both ends. The volume of such fuelwood was calculated using the following formula (Kuyper and Mellink, 1983).

$$V = \frac{\pi \cdot L \{ (\Sigma D_1^2) + (\Sigma D_2^2) \}}{8}$$

Where:

V	=	volume
L	=	length of bundle
D ₁	=	diameter at side 1
D ₂	=	diameter at side 2
π	=	a constant

An average of 45 to 60 minutes was used for each household survey. An average of 7 households were visited per day, 4 in the morning and 3 in the afternoon. Whenever the household selected was not at home attempts were made to come back. If the same household was not found again then the next random number was chosen.

3.4 Direct observations.

Direct observation was carried out on some aspects of the fuelwood situation, for example, how fuelwood was collected and from where, how fuelwood was stored, methods of cooking and food cooked. Also ten households were accompanied to fuelwood collection areas in order to confirm the distance and time taken for fuelwood collection and also to assess the possible effects of fuelwood harvesting. Whenever any information observed needed clarification it was obtained through in-depth interviews with the interviewee, key informants and group discussion with different categories of the villagers.

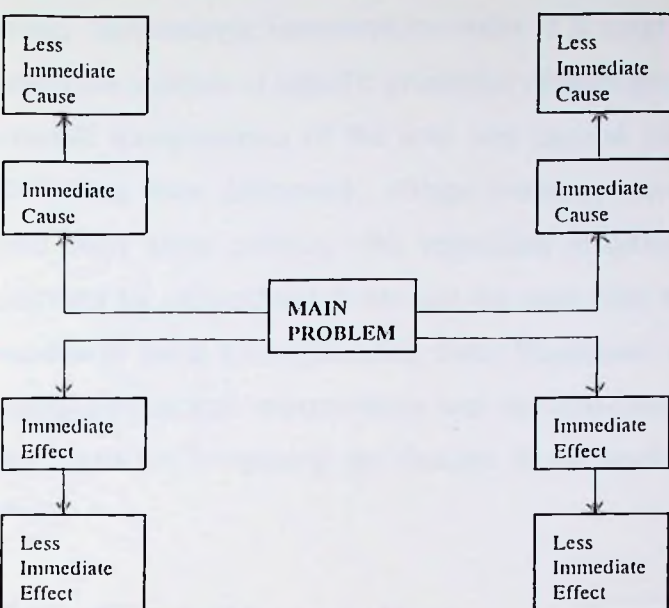
3.5 Informal interviews and group interviews.

Informal and group interviews were carried out through discussion with key informants and also during a village meeting. The key informants were knowledgeable people in the village who were ready to give some information about the village and these included retired village headmen, elderly women, shopkeepers, members of the village development committee, a nurse and school teachers. Informal discussions with them not only revealed more information, but also helped in cross-checking or "triangulating" some of the information collected through the questionnaire, or information obtained from direct observation. The village meeting was specifically organised in order to get people's perception of the problems.

During the meeting each villager was asked to write down only one problem that he or she considered was most important on pieces of paper. A few who could not write were assisted. This could have brought a bias since it reduced the secrecy of the process. Also some villagers who could not write and did not want to be assisted never participated in the voting. The papers were collected and counted in front of them and the results announced.

In order to examine how all the problems identified by the villagers were possibly linked to one another, the villagers constructed a problem tree (Figure 3.1).

Fig.3.1: Problem tree construction



During the process, the problem which scored the highest votes was written on a small piece of paper and placed at the centre of a large manila folder. Through brain storming and by consensus, problems which were thought to be the immediate cause of the main problem were listed on top of the main problem. Other minor causes or less immediate causes were also listed on top of the immediate causes in that order. Similarly, the immediate effects of the main problem were listed below the main problem and other minor or less immediate ones below that. Arrows were drawn to connect the main problem to the causes and effects. Lastly the villagers were asked to suggest possible solutions to the problems.

Forty one people were present in the meeting which was a representative. However, the problem tree construction was tedious since reaching consensus was not easy, even if it was useful.

1.6 Aerial photograph interpretation.

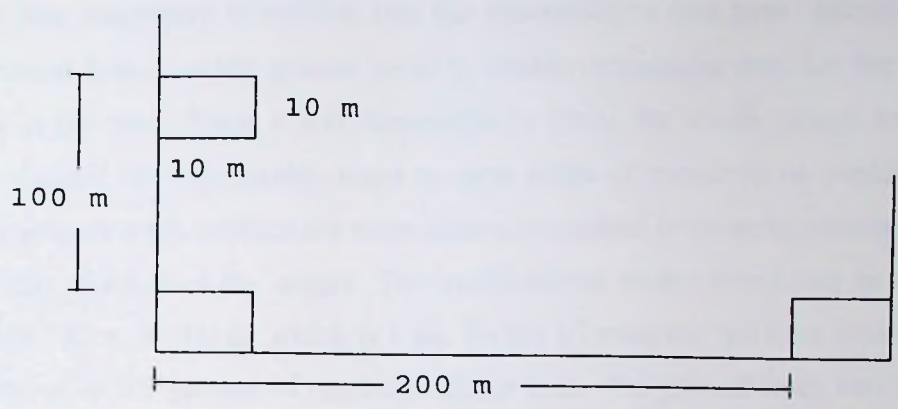
Aerial photograph interpretation was carried out for Mulambakwena village in order to obtain information on the land-use changes. Black and white panchromatic air photography for the years 1981 and 1988 were obtained at a scale of 1:50000 covering the study area. The 1981 photography was carried out in May and that of 1988 carried out in August. It was not possible to get one photo covering the whole village so two photos were placed overlapping

in a mosaic form. The aerial photographs were covered with transparent film (interpretation film). Stereoscopic interpretation under 5 X magnification of the air photographs was based upon the analysis of specific properties of photographs like shape, size, tone and texture. The overall interpretation of the area was carried out methodically one topic at a time. The following were delineated: village boundary, roads, rivers, settlements, agricultural fields and other areas covered with vegetation in different densities. The village area, the area covered by agricultural fields and the area with dense and less dense woodland were later measured using a compensating Polar Planimeter with zero setting device. The result of the aerial photograph interpretation was the land-use maps for the years 1981 and 1988 which was used for comparing the changes in the land-use (see section 7.4.1 and figures 7.1 & 7.2).

3.7 Vegetation sampling.

The main aim of the vegetation sampling was to study the nature of the woody biomass resources and its distribution. Two sample units which were accessible and covered the densely wooded area were chosen (see figure 4.1 for the location of the sampling points). Each unit was systematically sampled as shown in figure 3.2 with each sample plot measuring 10 m X 10 m spaced at 100 m throughout the tract of land. The diameter of all trees falling in the sample plots were measured at knee height and not breast height because of the general shortness of the trees in the area. The tree species were also recorded. The number and species of dead trees were recorded separately and this was later used to produce an estimate of dead trees per hectare. Key informants especially the women and the elderly were able to identify the dead trees. After each tree was measured, a small chalk mark was made on the stem close to the ground level. This mark was used as a check whenever there was any doubt as to whether the tree had been measured or not. The conditions of each plot, for instance, the extent of regeneration, effects of tree cutting and signs of any other human activities, were also recorded (see Appendix II).

Figure 3.2: A unit of a systematic sample lay out.



The following formula was used in designing the systematic line sampling (after Bukhart *et al.*, 1984 quoted in Avery and Burkhart, 1994). A 5 percent cruise was used.

$$\begin{aligned}
 A_p &= AP \\
 n &= A_p / a \\
 P &= a(10)/BL \\
 B &= a(10)/LP \\
 L &= a(10)/BP
 \end{aligned}$$

where:

$$\begin{aligned}
 A &= \text{total tract area} \\
 A_p &= \text{area of all plots} \\
 P &= \text{intensity of cruise as a decimal} \\
 a &= \text{area of one plot} \\
 n &= \text{number of plots} \\
 L &= \text{distance between lines} \\
 B &= \text{distance between plots on a line}
 \end{aligned}$$

For the study area, $A = 3600 \text{ m}^2$, $A_p = 1800 \text{ m}^2$, $P = 0.05$, $a = 100 \text{ m}^2$, $n = 18$, $L = 200 \text{ m}$, $B = 100 \text{ m}$.

3.8 Ground truth verification.

The ground truth verification was carried out to cross-check the validity of the aerial photograph interpretation of the year 1988 in order to produce the land-use map for the year 1995. It was necessary to confirm that the interpretation data gave accurate representation of vegetation found on the ground so as to obtain meaningful data for the vegetation types growing in the area. Since it was impossible to cover the whole village area samples were chosen. Guided by topographic maps to note areas of restricted or prohibited access, the areas for ground truth verification were chosen at random from aerial photographs (see figure 4.1 for the location of the areas). The verifications were carried out in 10 samples each measuring 100 m X 100 m which is 1 ha. So for 10 samples, the total area was 10 ha which is 0.1 km² or is 0.3 percent of the total village area. The ground truth verification was done after the vegetation sampling and did not involve tree measurements.

The fieldwork took eight weeks. One week for reconnaissance survey and collection of additional secondary data; four weeks for household survey and three weeks on vegetation sampling and ground truth verification.

3.9 Methods of data analysis.

Data collected in the field was entered in a dBASE 4 computer programme then exported to SPSS/PC and MICROSOFT EXCEL programmes. The SPSS/PC programme, was used to estimate descriptive statistics like frequencies, means, standard errors, variances, and standard deviations. Multiple regression was also used to analyse some of the data. The MICROSOFT EXCEL programme was used to produce graphs, bar charts and histograms. Apart from the above mentioned computer programmes, the data were also analysed qualitatively.

CHAPTER FOUR: FUELWOOD SUPPLY FACTORS

4.1 Introduction.

It has already been stated that there is a fuelwood shortage in the North East District (NEDDP 4). This section examines fuelwood supply in Mulambakwena village area by looking at the nature of the woody biomass resources and its accessibility for fuelwood in order to try and explain the causes of the reported shortage.

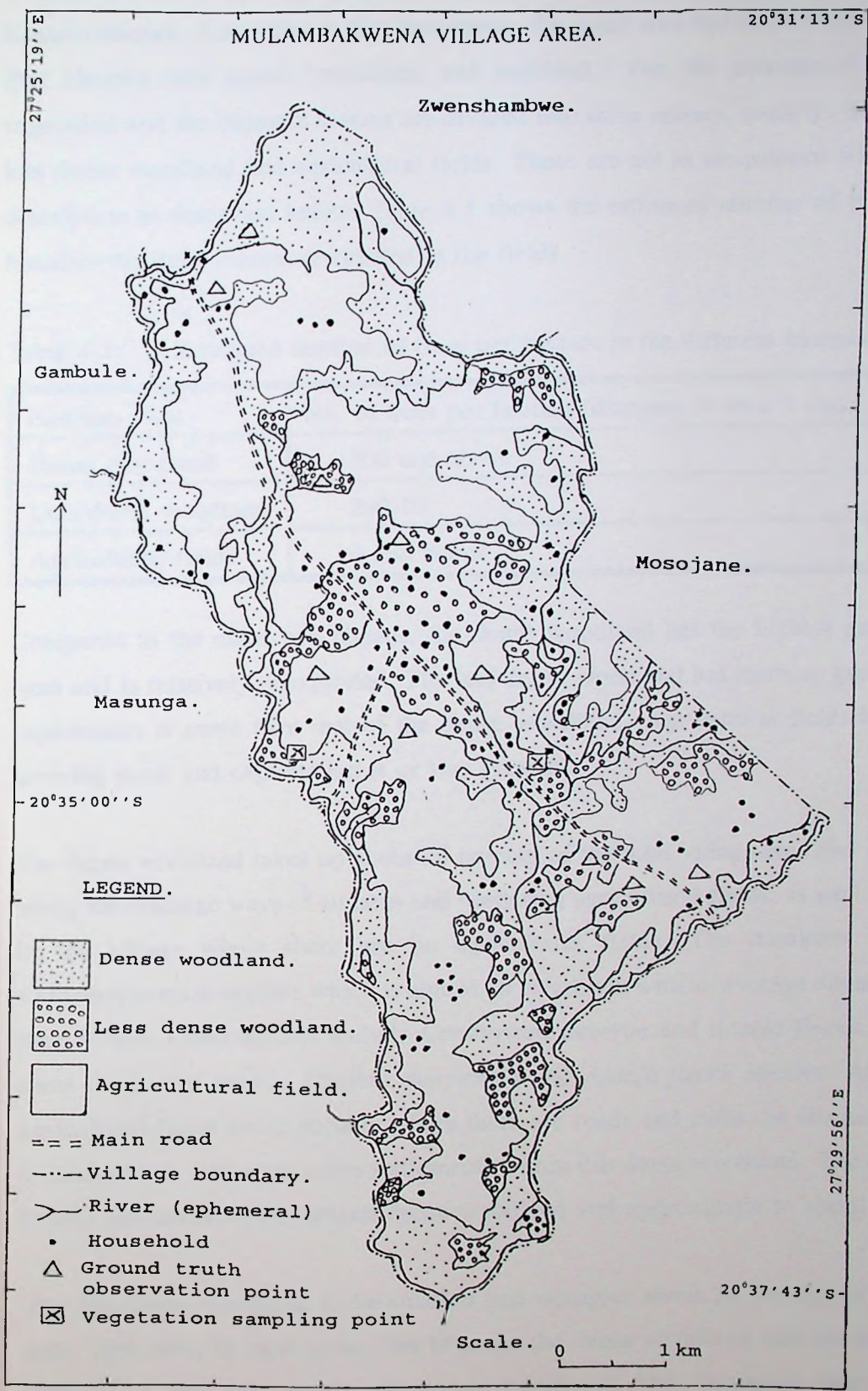
4.2 Nature of the woody biomass resources.

Fuelwood is obtained from the woody biomass resources in the village. These biomass resources are in the form of trees and shrubs and are found in communal land and granted land. Not all woody biomass resources available in a particular area may be accepted or preferred by the community as fuelwood. Furthermore, the ones accepted or preferred may not be well distributed among the population. It was hypothesised that the woody biomass resources are not available in the accepted or preferred form and are not well distributed. It is therefore important to find out first, how the woodland is spatially distributed, then secondly within the woodland, examine the tree species distribution and preference for fuelwood, the size class distribution of the trees and the stand density.

4.2.1 Spatial distribution of the woodland.

The land use map (figure 4.1), produced as a result of aerial photograph interpretation and ground truth observation, shows the current spatial distribution of the woodland in the village.

Figure 4.1: Land use map of Mulambakwena village area.



In the description of Botswana vegetation, Millington and Townsend (1989) gave nine biomass classes. According to this description, the study area and indeed the whole of North East District falls under "woodland and bushland." For the purpose of this study the vegetation and the biomass classes are divided into three classes, namely: dense woodland, less dense woodland and agricultural fields. These are not in accordance with Millington's description as described below. Table 4.1 shows the estimated number of trees per hectare found in the three classes (estimated in the field).

Table 4.1: Estimated number of trees per hectare in the different biomass classes.

Biomass class	No. of trees per hectare (diameter at least 5 cm).
Dense woodland	300 and above
Less dense woodland	299-10
Agricultural fields	9 and below

Compared to the other two classes, the dense woodland has the highest growing stock of trees and is relatively unexploited. The less dense woodland has medium growing stock and exploitation is more than that of the dense woodland. Agricultural fields have the lowest growing stock and exploitation is or was greatest.

The dense woodland takes up about 26 percent of the total village area and is mainly found along the drainage ways of streams and bordering agricultural fields, as well as in most parts of the village where there are no agricultural fields. The dominant tree species is *Colophospermum mopane* which is almost all re-growth with an average diameter of not more than 15 cm. Other species include *Combretum imberbe* and *Acacia fleckii*. There are also some dead trees mainly *Ziziphus mucronata* and *Acacia fleckii* species. At the borders of agricultural fields and especially where there are roads and paths the stocking of these dead trees diminish. There are a few settlements within this dense woodland. The greatest distance from a settlement to the nearest dense woodland was approximate to about 0.5 km .

The less dense woodland is the smallest and occupies about 22 percent of the total village area. This area, in most cases, lies between the dense woodland and the agricultural fields although a few are within the dense woodland. The dominant tree species include

Colophospermum mopane, *Kirkia acuminata*, *Dichrostachys cinerea*, *Ximenia americana* and *Cassia abbreviata*. The less common ones are *Combretum imberbe* and *Acacia fleckii*. Compared to the dense woodland this class contains only a few dead trees. The less dense woodland occurs mostly in the central and southern parts of the village. Most settlements are within this category of woodland.

The agricultural field occupies about 51 percent of the total village area and therefore the largest of all woody biomass classes. The dominant tree species are *Ziziphus mucronata*, *Acacia mellifera* and *Kirkia acuminata* and are generally bigger with diameter of between 30 to 50 cm. Discussion with the key informants revealed that these trees were either too big to be uprooted during the destumping exercise or some were left purposely for shade. No dead standing trees were observed. However, dead trees which were cut, including branches and twigs, were found piled at the borders of individual agricultural fields. The agricultural fields are found all over the village area. There are also settlements within the agricultural fields, the number of which are in between those found in the dense woodland and less dense woodland.

From the above discussion, it can be said that generally, the dense and the less dense woodland, and the agricultural fields are evenly distributed in the village. Further, from table 4.2 it can be said that the dense woodland and the agricultural fields are the main supplier of dead wood in the village.

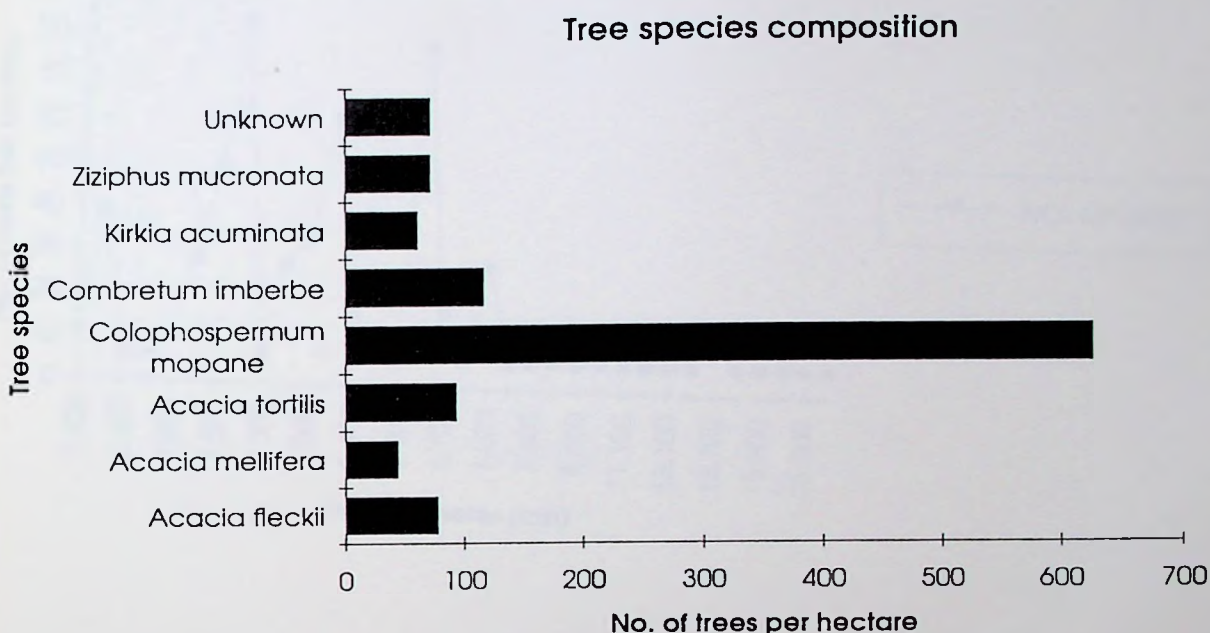
Table 4.2: Summary of the distribution of dead trees in the three woodland classes.

Woodland class	Area (km ²)	%	Proportion of settlements	Distribution of dead standing trees	Distribution of dead trees on ground
Dense woodland	9.2	26.4	Lowest	Highest	Lowest
Less dense woodland	7.8	22.4	Highest	Medium	Medium
Agricultural fields	17.8	51.2	Medium	Lowest	Highest
TOTAL	34.8	100.0			

4.2.2 Tree species composition of the woodland.

Tree species composition of the woody biomass in the village was obtained as a result of the vegetation sampling. In total there were 18 plots each measuring 10 m x 10 m. This means the size of each plot was 0.01 ha. and the size of 18 plots was 0.18 ha. The total number of each tree species in all the 18 plots was divided by 0.18 in order to get the estimated number of trees per hectare (see Appendix III (a)).

Figure 4.2: Tree species composition of the woody biomass in Mulambakwena village area.



From figure 4.2, it can be seen that the most dominant species is *Colophospermum mopane* followed by *Combretum imberbe* then *Acacia tortilis*. Among the less dominant tree species are *Ziziphus mucronata* and *Acacia mellifera*. The dominance of *Colophospermum mopane* may be caused by its intensive regrowth after harvesting. This is because very many stumps of this tree species were coppicing.

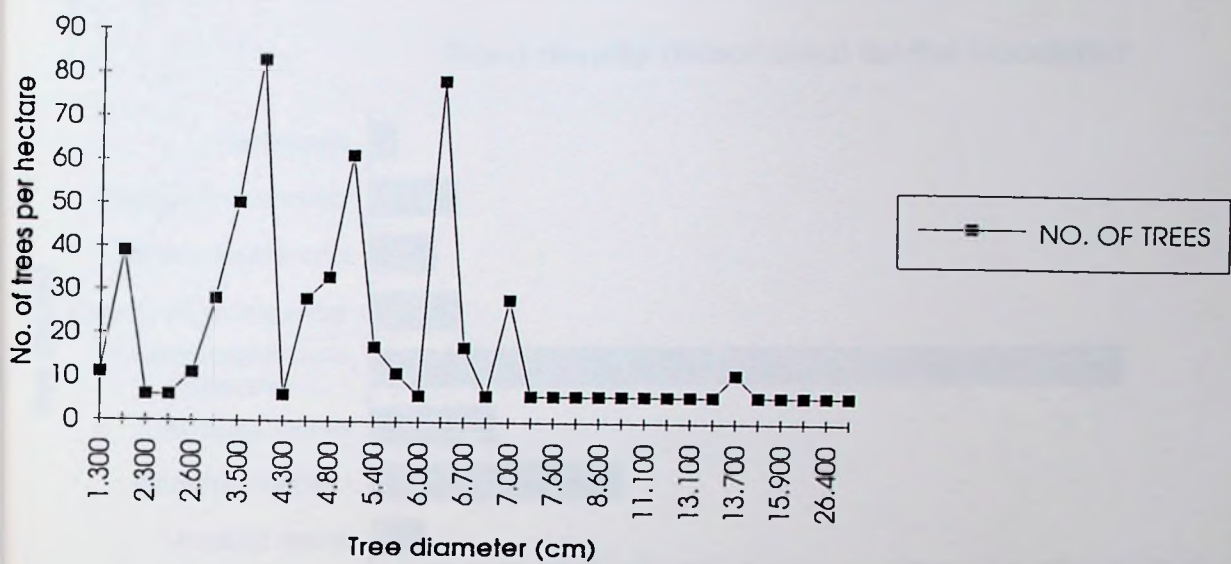
4.2.3 Size class distribution of trees in the woodland.

The size class distribution of the trees was obtained by plotting the number of trees against the diameter (see Appendix III (b)). As can be seen from figure 4.3, generally a relatively large number of trees occur in the smaller diameter class of 1.3-7.0 cm and fewer trees are present as the size (diameter) increases. From the discussions held with the key informants,

and from observations the low number of trees in the higher diameter class of 7.5-26.4 cm may be explained by the fact that trees in this diameter class are usually removed for poles for house construction and for fencing.

Figure 4.3: Size class distribution of the trees in the woodland in Mulambakwena village area.

Size class distribution of trees in the woodland



4.2.4 Stand density in terms of basal area of the woodland.

Stand density was calculated in terms of the basal area (BA) which gave an indication of the volume of trees growing in the area. The BA per tree was calculated from measurement of the tree diameter at knee height using the following formula (Avery and Burkhart, 1994):

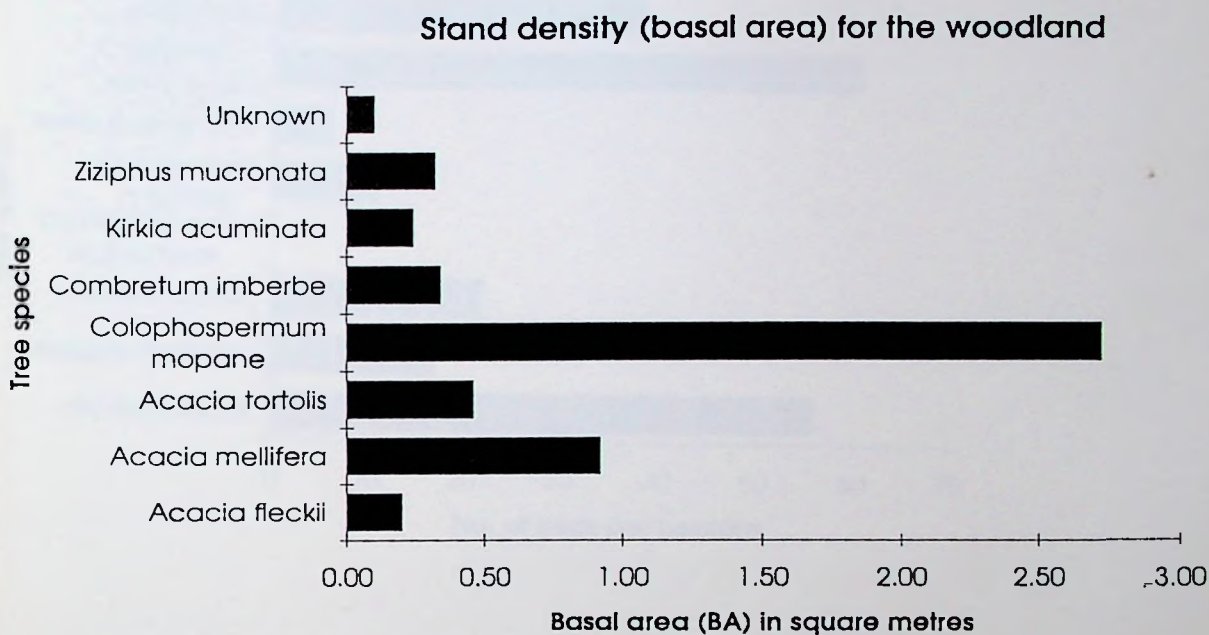
$$\text{Basal area (BA)} = \frac{(\text{diameter})^2 \times \pi}{4}$$

Where: π = constant (3.14)

The total BA in the 18 plots is the sum of the individual BA per tree in the plots, and this is divided by 0.18 in order to obtain the BA per hectare (the size of 18 plots is 0.18 ha.).

Figure 4.4 shows the basal area per hectare for different species found in the village. It can be seen that *Colophospermum mopane* has the highest BA per hectare followed by *Acacia mellifera*. *Acacia tortilis* ranks third followed by *Combretum imberbe* and *Ziziphus mucronata*. Species with a smaller BA per hectare are *Acacia fleckii* and *Kirkia acuminata*. *Colophospermum mopane* is therefore the most dominant biomass source since it has the highest growing stock in terms of the BA per hectare (see Appendix III (d)).

Figure 4.4: Stand density in basal area (BA) for the woodland in Mulambakwena village

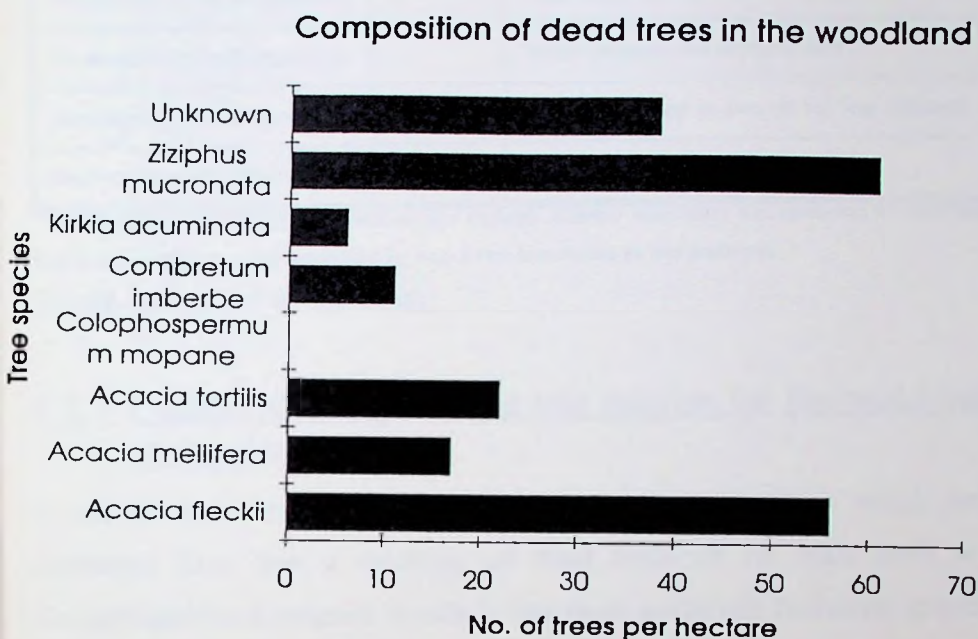


4.2.5 Composition of dead trees in the woodland.

It was mentioned in section 1.5.2 that, by a regulation formulated by the NEDCS committee, only dead trees should be harvested for fuelwood. Due to this regulation and the fact that people in Mulambakwena actually adhere to it, it was necessary to study the distribution of dead trees. Key informants, especially the elderly and the women were able to identify the dead trees. The number of dead trees per hectare was calculated in a similar way explained in section 4.2.2. From Figure 4.5 it can be seen that from the 7 tree species identified, *Ziziphus mucronata* has the highest number of dead trees per hectare (29 percent) followed

by *Acacia fleckii* (26 percent). *Acacia tortilis* ranks third with 10 percent followed by *Acacia mellifera* with 8 percent. Those with lower percentage of dead trees include *Combretum imberbe* (5 percent) and *Kirkia acuminata* (2 percent). *Colophospermum mopane* did not have a proportion of dead trees (see Appendix III (c)).

Figure 4.5: Composition of dead trees in the woodland in Mulambakwena village area.



4.2.6 Tree species preferred for fuelwood.

Not all the tree species found in Mulambakwena village are used or preferred as fuelwood. All the households that were interviewed and were using fuelwood indicated that the tree species that they preferred most for fuelwood is *Colophospermum mopane*. The second most preferred was *Combretum imberbe*. The reasons given for preferring these species were that they burn slowly and give out much heat. Table 4.3 shows the ranking of tree species according to their preference for fuelwood and the reasons as to why they are not preferred or not used at all. It can be seen from the figure that the less preferred ones are *Acacia fleckii* and *Dichrostchys cinerea* whereas the tree species not used at all for fuelwood were *Ziziphus mucronata*.

Table 4.3: Trees not used or less preferred for fuelwood.

Name	Ranking *	Reasons
<i>Ziziphus mucronata</i> (Mokgalo)	1	Associated with dead spirits. Not used for fuelwood.
<i>Acacia fleckii</i> (Mhahu)	2	Associated with dead spirits, but used for fuelwood.
<i>Dichrostchys cinera</i> (Moselesele)	3	Produces plenty of smoke with bad smell, but used
<i>Terminalia cinera</i> (Mogonnono)	4	Smoke produces bad smell, but used
<i>Peltophorum african</i> (Moseltha)	5	Burns too fast and so does not last long, but used.
<i>Sclerocarya caffra</i> (Murula)	6	Preferred for making traditional beer.

* Ranking based on frequency of mention. For example *Ziziphus mucronata* was mentioned by most households as not used whereas *Sclerocarya caffra* was only mentioned by only a few households as less preferred.

(Local names are in brackets).

4.2.7 Comparison of preferred tree species for fuelwood and the distribution of dead trees.

It can be seen from figure 4.5 and table 4.3 that species which are more preferred as fuelwood have low a stocking of dead trees or no dead trees at all. For example, *Colophospermum mopane* which is the most preferred fuelwood species had no dead trees and *Combretum imberbe*, the second most preferred is the third last in the stocking of dead trees. Similarly, species which are not used or least preferred have more stocking of dead trees. For example, *Ziziphus mucronata* which is not used for fuelwood has the highest stocking density of dead trees and *Acacia fleckii* which was least preferred for fuelwood also has the second highest percent of dead stock of trees.

Generally there is an even distribution of woody biomass in the village area. However, there are more dead trees in the dense woodland and agricultural fields. The dominant tree species is *Colophospermum mopane* which also has the highest growing stock. There are more trees in the smaller diameter class and very few in the larger diameter class. It was also found out that there are few or no dead trees of the preferred type and there were more dead trees of the less preferred species or species not used for fuelwood. Therefore it may be said that the total woody biomass is well distributed, it is available mainly in the type preferred for fuelwood (*Colophospermum mopane*), but not in the accepted form (dead trees). A possible

cause of the reported fuelwood shortage in Mulambakwena is the lack of dead *Colophospermum mopane*. The appearance of dead trees, observed from the "main road" may be misleading in portraying the fuelwood situation.

4.3 Accessibility to woody biomass resources for fuelwood.

The previous section discussed the availability, distribution, preferability, and acceptability of the woody biomass resources for fuelwood in the village area. But it is also necessary to find out how these resources are accessible to the community. On this basis it was also hypothesised that accessibility to the biomass resources for fuelwood is influenced by its location in relation to households, land tenure and land management practices in the village.

4.3.1 Location of households in relation to the woody biomass resources.

Table 4.4 shows the number of households that use fuelwood and stay in the different land uses and the average distance they travel for fuelwood collection. It can be seen that less dense woodland had the highest number of households followed by agricultural field and dense woodland has the least.

Table 4.4: Household location in the different land uses.

Land use	No. of households	Average distance travelled to collect fuelwood (km)
Agricultural fields	33	3.5
Less dense woodland	43	5.0
Near dense woodland	18	1.5
Total	94	

Households in the less dense woodland travel furthest to collect fuelwood followed by households surrounded by agricultural fields and households near the dense woodland travel the shortest distance. This might be explained by the fact that there are more dead trees in the dense woodland and on the agricultural field boundaries. Therefore in terms of distance and availability of the accepted fuelwood, location of the households in relation to the woody biomass resources may influence accessibility to those resources.

4.3.2 Land tenure.

The whole area of study falls under tribal land in the district as mentioned in section 1.5.2. In summary, land holding consists of granted land (without lease), granted land (with lease), borrowed land and ungranted land (common land). Eighty three percent of the households were granted land, 16 per cent had borrowed land and only 1 percent was landless.

Table 4.5: Sources of fuelwood.

Sources of fuelwood	No. of households	%
Buying	7	7.4
Collecting from communal land only	16	17.0
Collecting from granted land only	26	27.7
Collecting from both communal and granted land	45	47.9
Total	94	100.0

From table 4.5 it can be seen that the majority of the households collect fuelwood from both communal and granted land. This is followed by households who collect from granted land only. Out of 54 households who said they get enough fuelwood, 30 (55 percent) collect the fuelwood from both granted and communal land and 14 households (26 percent) collect from granted land only whereas only 10 (19 percent) collect the fuelwood from communal land only. Discussions with the key informants revealed that access to the common land for fuelwood is not restricted but once land has been granted or leased, then the grantee and the lessee usually have control over the resources and have the right to exclude others from using the resources.

It can therefore be said that because those who are granted land have access to fuelwood from both the land granted to them and the communal land, they are the ones who appear to be getting enough fuelwood. Land tenure therefore seems to be affecting accessibility to the woody biomass resources for fuelwood in Mulambakwena village area.

4.3.3 Land management practices.

The land use in the village can be broadly described in two ways: subsistence mixed farming which is both arable and grazing and infrastructure construction.

In section 1.5.3 it was mentioned that ARAP was introduced by MOA to attempt to reverse the decline in arable production in the traditional farming sector which was caused by drought and to enable farmers to increase production of basic cereals. To enable them to achieve this aim, farmers were encouraged to clear their land of trees and stumps (destumping scheme) to expand the area under arable production to boost the amount of food produced. In Mulambakwena village, since 1986, twelve households had destumped a total of 42 ha. When asked what type of material they destumped from their fields, the majority of the households (70 percent) indicated that they removed both trees and stumps in their fields and 20 percent removed stumps only whereas 10 percent removed only trees. The same households were asked what they did with the parts of the trees that they removed from their fields. Nine of them said that they used it for fuelwood and fencing and the rest indicated that they burned it in the fields. When the households were asked how they do the destumping, 9 households said they hire contractors and the rest use the family labour. In an area where no live tree cutting is allowed for fuelwood, the destumping exercise has the effect of increasing the fuelwood supply. The ultimate result in future may, however, be a decline in the fuelwood supply. Therefore land-use (arable farming) and land management (destumping scheme) seems to have some influence on the accessibility to woody biomass resources for fuelwood.

The aim of this section (chapter 4) is to study the fuelwood supply in order to try and find out the causes of the reported fuelwood shortage in Mulambakwena village area. One possible cause of the fuelwood problem is the shortage of supply of dead *Colophospermum mopane*. Households which are not near the dense woodland or those which are far from agricultural fields may be supplied with a relatively less fuelwood. As a result of the destumping exercise the fuelwood supply seems to increase temporarily. However, the ultimate result will be a reduced growing stock. In fact this seems to have a considerable contribution to the reported fuelwood shortage in Mulambakwena village area.

CHAPTER FIVE: FUELWOOD DEMAND FACTORS

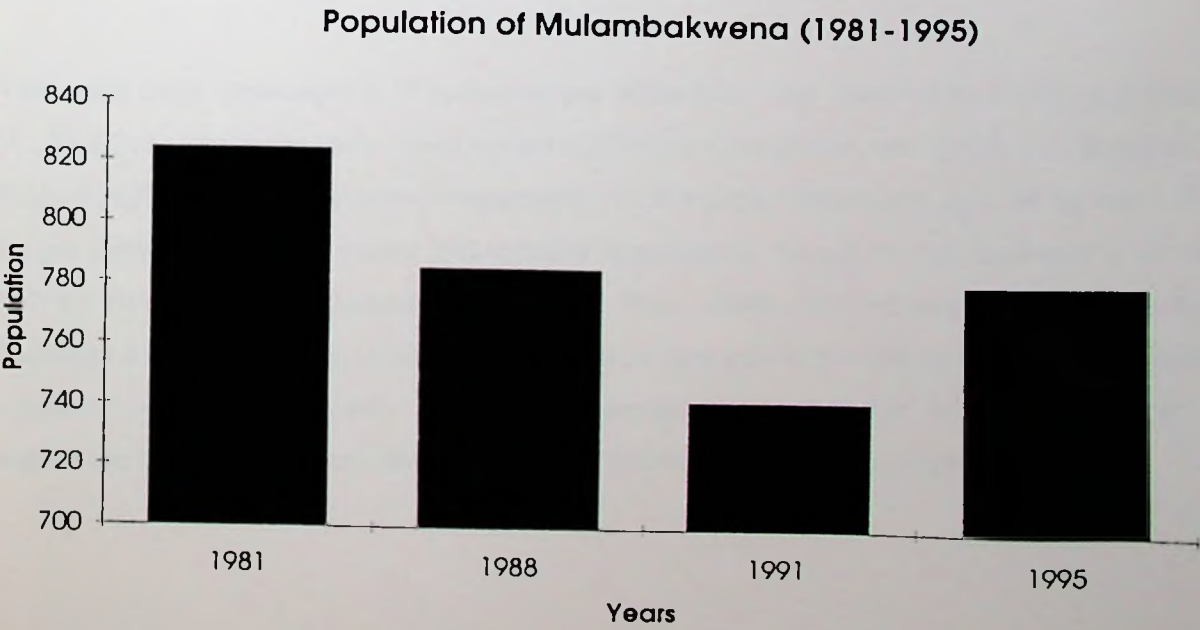
5.1 Introduction.

In this work fuelwood demand is taken to mean the minimum amount of fuelwood necessary in view of the minimum energy estimated to be indispensable for household consumption. It is a reflection of energy needs from fuelwood mainly for cooking and other domestic uses. When this demand increases more fuelwood is consumed. There are a number of factors that influence the demand for fuelwood. This section discusses three of these factors: the total village population, household size and household income in order to try and explain the causes of the reported fuelwood shortage. The hypothesis postulated in this regard is that there exists a significant relationship between fuelwood consumption, household size and household income.

5.2 The total village population.

Figure 5.1 shows the changes in the population of Mulambakwena village area between 1981 and 1995.

Figure 5.1: Population of Mulambakwena village (1981-1995). Source: Government of Botswana, CSO, 1981 to 1995).



The population show a decrease between 1981 and 1991. One possible reason for this may be the fact that many young people left the area to look for work in urban areas, as earlier mentioned in section 1.5.3. In theory the fuelwood demand is expected to have decreased as well during the same time. Due to the increase in population between 1991 and 1995 it is also expected that more fuelwood could have been demanded during the period since there was no proportional increase in the alternative fuels like gas or electricity. In fact 94 percent of the households use fuelwood for cooking. The other 6 percent either use gas or paraffin.

5.3 Fuelwood consumption.

It is in the household that fuelwood is mainly consumed. The only non-household fuelwood consumption in Mulambakwena is a primary school. In this school, pupils are asked to take fuelwood to the school from their homes for cooking lunch. Almost all households rely on fuelwood for domestic activities with cooking as the predominant end-use. Additional household activities that use fuelwood include heating water, space heating in winter, ironing and beer brewing. Fuelwood consumption was measured in volume (cubic metre) in 60 households. The daily fuelwood consumption per household was calculated by dividing the volume of fuelwood collected by each household by the number of days the stock lasted. Daily fuelwood consumption per person was obtained by dividing the daily fuelwood consumption per household by the household size (the number of people for whom cooking is done).

The mean daily consumption of fuelwood per household was found to be $0.032 \pm 0.0039 \text{ m}^3$. Similarly, the mean daily consumption of fuelwood per person was $0.005 \pm 0.00196 \text{ m}^3$. ERL (1985) estimated fuelwood consumption in Masunga village area as 2.54 kg and 1.93 kg per person per day in winter and summer respectively. Using the conversion of $1 \text{ m}^3 = 667 \text{ kg}$ for fuelwood measurement (Hall and Mao, 1994), the fuelwood consumption for Masunga was equivalent to 0.004 m^3 and 0.003 m^3 per person per day in winter and summer respectively. The *per capita* fuelwood consumption per day for Mulambakwena is a somewhat higher indicating that probably the fuelwood situation is slightly better.

5.4 Household size.

This refers to the number of people in the household for whom cooking is usually done per day and not the total number of people living in the house. This is because some household members may not eat at home always, and not all those who eat in the same house are necessarily those household members. Also babies who do not eat cooked food were excluded in this household size definition. For the 60 households where fuelwood measurement was carried out, there were 381 people with an average household size of 6 ± 0.39 . In section 1.4 it was mentioned that household size is usually correlated to household income. As will be seen in the next section, the average household income in the village has increased. It is most probable that household size also increased.

5.5 Household income.

Income here is assumed to be closely related to the stock of wealth. Household income is usually difficult to measure as people are unable or unwilling to give precise figures of their income. Because of this, number of animals and hectares of land owned and bags of grain crops produced annually were used as "proxy" indicators of income as shown in table 5.1.

Table 5.1: Estimation of household income.

No. of animals owned	Code for No. of animals owned	No. of hectares of land owned	Code for hectares of land owned	No. of bags of grain crops produced annually	Code for No. of bags of grain crops produced annually
0	1	0	1	0	1
1-9	2	1-4	2	1-2	2
10-19	3	5-8	3	3-4	3
20-39	4	9-12	4	5-6	4
40-59	5	13-16	5	7-8	5
60 and above	6	17 and above	6	9 and above	6

The code for the overall household income category is:

Extremely low = 1, Very low = 2, Low = 3, High = 4, Very high = 5, Extremely high = 6.

In estimating the overall household income category the average of the three codes (animal No., No. of hectares of land and No. of bags of grain of crops) were used. For example, for a household owning 20-39 animals (Code 4), with 1-4 hectares of land (code 2) and producing 3-4 bags of grains of crops (code 3), the overall income category would be low (code 3) - which is the average of 4, 2 and 3.

The average household income was reported as having increased between 1989 and 1994, and the number of livestock per household owning cattle also increased (section 1.5.3). Furthermore, the average number of hectares of land allocated to individuals has increased from 7 in 1992 to 8 in 1995 (Government of Botswana, SDLB, Masunga, 1995).

5.6 Relationship between fuelwood consumption, household size and household income.

This relationship was established by use of two step-wise multiple regression analyses. One regression model examined the relationship between the daily household fuelwood consumption and such factors as household income and household size. The other regression model examined the relationship between the daily per capita fuelwood consumption and the same variables of household income and household size. The simultaneous effects of the two independent variables (household size and household income) on the dependent variable (fuelwood consumption) were assessed by constructing multiple regression equations, which described the amount of linear relationship between the dependent and the independent variables. The multiple regression equations took the form (Shaw and Wheeler, 1985):

$$Y = a + b_{01.2}X_1 + b_{02.1}X_2 \pm e$$

where:

- Y = the dependent variable (fuelwood consumption);
- X_1 & X_2 = the independent variables household size and household income respectively;
- $b_{01.2}$ & $b_{02.1}$ = the partial regression coefficients, which are the slopes of the regression line for each independent variable, controlling for the other;
- a = the intercept point on the Y axis for both X_1 and X_2 ; and
- e = the error term.

Table 5.2 provides selected statistics obtained as part of the output from SPSS sub-programme, regression on the daily fuelwood consumption per household and the household size and household income.

Table 5.2: Multiple regression statistics for daily fuelwood consumption per household with household size and household income.

R ²	F-value	Signif F	Degrees of freedom	Beta	Sig T
0.63689	49.9876	0.0000	2, 57	H = 0.480898 I = 0.368498	H = 0.0003 I = 0.0041 Constant = 0.0052

H = household size; I = household income.

The last column in the table displays the levels of significance of the t- value. The null hypothesis in the t-test suggests that the regression coefficients equals zero, that is there is no relationship between the daily fuelwood consumption per household and the household size and household income. Using a significance level of 0.05, the null hypothesis is rejected which means that the daily fuelwood consumption per household can be explained by both household size and household income. Furthermore, using the same significance level of 0.05, the F-test shows that there is a relationship between the daily fuelwood consumption per household and the household size and household income. The coefficient of multiple determination (R^2) in the table 5.2 reveal that 64 per cent of the variation in the daily fuelwood consumption per household was attributed to the household size and household income. Other things being equal, the Beta value indicates that household size has a greater importance than household income as far as the variation in daily fuelwood consumption per household is concerned. The multiple regression equation for the daily fuelwood consumption per household and household size and household income is as follows:

$$F_1 = -0.006131 + 0.001656 H + 0.002521 I \pm 0.00647728 \dots\dots\dots 1$$

where:

- F_1 = daily fuelwood consumption per household
- H = household size
- I = household income

In equation 1, the sign for the partial regression coefficient of household size and household income are positive. This implies that as the household size and household income increases the daily fuelwood consumption per household also increases. Furthermore, the partial regression coefficients may be used as a measure of the influence of each independent variable upon the daily fuelwood consumption per household. For example, the partial regression coefficient for household size of 0.001656 in equation 1 suggests that each unit in the daily fuelwood consumption per household is associated with an increase in household size of 0.001656 units if the household income is held constant. The relationship between the daily fuelwood consumption per person and household size and household income is shown in table 5.3 and equation 2.

Table 5.3: Multiple regression statistics for daily fuelwood consumption per person and household size and household income.

R ²	F-value	Signif F	Degrees of freedom	Beta	Sig T
0.29161	11.7319	0.0001	2, 57	H = 0.758347 I = 0.354070	H = 0.0000 I = 0.0441 Constant = 0.0000

H = household size; I = household income.

The sig T values in the last column in the table 5.3 indicate that at 0.05 significance level, the daily fuelwood consumption per person can be explained by both household size and household income. The F-test at the same significance level also reveal that there is a relationship between the above variables. The coefficient of multiple determination (R^2) shows that only 29 percent of the variation in the daily fuelwood consumption per person was attributed to the household size and household income. The Beta values indicate that household size has a greater importance than household income as far as the variation in the daily fuelwood consumption per person is concerned.

The multiple regression equation for daily fuelwood consumption per person with household size and household income is as follows:

$$F_2 = 0.01092 - 0.002022 H + 0.001876 I \pm 0.0070057852$$

where:

- F_2 = daily fuelwood consumption per person
- H = household size
- I = household income

From equation 2, it can be seen that the daily fuelwood consumption per person increases as the household income increases but decreases as household size increases.

The increase in the village population between 1991 and 1995 could have caused more fuelwood to be demanded. Jointly, household size and household income were more significant in explaining the daily fuelwood consumption per household than the daily fuelwood consumption per person. Rural household fuelwood consumption is too complex a factor to be explained in terms of just a few variables. In the present study other factors which might have contributed to the variation of fuelwood consumption are: the cooking styles; meals eaten outside homes; presence of children in some households who attend the primary school. Other factors could be those related to supply of fuelwood like its availability and accessibility.

Large households consume more fuelwood than small ones but use less fuelwood *per capita* than smaller ones. The consumption of more fuelwood by larger households is expected as more food is prepared for the larger households than smaller households. For the consumption of less fuelwood *per capita*, this may be due to the large size of cooking pots used which are more energy efficient than smaller ones. Studies carried out by Openshaw (1978); P.C. Fleuret and A.K. Fleuret (1978); Islam (1980); Leach (1987); Tietema *et al.* (1988) and Kgathi (1992) also found that fuelwood consumption *per capita* decreases with household size.

As household income increases more fuelwood is consumed. This might be explained by the fact that household income is correlated to household size. Larger households might generate more income due to extra labour available for agriculture. It is therefore to be expected that households with higher income (having larger household size) would consume more fuelwood. It was also found out that households with higher income destumped much of their fields because they could afford to hire contractors. Since most of the destumped materials were used as fuelwood, it is expected that those households would consume more fuelwood. It is also probable that households with higher income are the ones who have their children at the primary school. These children usually take the fuelwood from their respective family stock to the school, thus increasing the demand of fuelwood by those families.

CHAPTER SIX: THE NATURE OF THE FUELWOOD ISSUE.

6.1 Introduction.

Having discussed the possible causes of the reported fuelwood shortage as reflected by supply and demand in the previous section the nature of this problem will now be examined in order to find out the extent of the assumed shortage. This is done by looking at how people obtain and use fuelwood. Also peoples's perception of the problem will be discussed.

6.2 Severity of the reported fuelwood shortage.

It has been hypothesised that fuelwood shortage in North East District has reached a severe stage and this is reflected in the way people obtain and use the fuelwood (Government of Botswana, NEDC/NEDDC, 1989). An understanding of how severe the assumed fuelwood shortage is will help us to know the extent of the problem. Fuelwood problems can be understood by looking at how people respond to declining fuelwood availability. These responses can be taken as possible indicators of fuelwood shortage with different responses reflecting the severity of the problems. These may vary from person to person and some may occur simultaneously and can be interrelated. According to Howes (1985), the responses reflect an increase in collection time and distance travelled; a change in who collects wood; change from dead to green wood; use of less preferred tree species or parts of trees; an increase in cooking time; less cooking; use of fuel saving devices (like improved stoves); an increase in price of marketed fuel.

6.2.1 Time taken for fuelwood collection.

Whenever people take longer to collect fuelwood, this might be taken as an indicator of its growing scarcity as nearby sources which would be collected easily have been exhausted.

Out of 100 households interviewed 94 use fuelwood, of which only 7 purchase fuelwood and the majority, 87 collect the fuelwood for themselves. This indicates how important fuelwood collection is in the village. This fuelwood is collected whenever the household thinks there is need and this may be weekly or daily. However, as rain approaches more time may be

devoted for collection. This is in anticipation of floods which would make paths impassable. All the households indicated that they took a shorter time, of not more than 3 hours per trip to collect fuelwood three to five years ago. In 1995 the time taken for fuelwood collection increased to an average of 4 hours per trip with some households taking up to 8 hours per trip. Through the discussions held with some household members and key informants and through direct observations, a time of more than 8 hours per trip causes much stress to the collectors, a time of 3 to 8 hours per trip causes medium stress and a time of less than 3 hours causes minimal stress. The burden caused to the households in fuelwood collection is referred here as stress.

Table 6.1: Time taken for fuelwood collection.

Time per trip.	Level of stress	Number of respondent	% of respondent
20 min.- 3 hours	Minimal stress	36	41.4
3 - 8 hours	Medium stress	49	56.3
more than 8 hours	Much stress	2	2.3
Total		87	100.0

Mean = 4.09; Std. dev = 1.63; Std. err = 0.175.

From table 6.1 it can be seen that more than half of the respondents experience medium stress and only 2.3 percent much stress indicating that the fuelwood situation may not yet be severe.

By accompanying ten households to fuelwood collection centres it was discovered that although the time estimated by respondents was approximate to the true time, part of it was spent in informal visits when some members would stop at colleagues' homes to chat. Also much of the remaining time was spent looking for dead preferred species of trees.

6.2.2 Distance travelled to collect fuelwood.

When near by sources of fuelwood have all been used up people travel longer distances looking for it. An increase in distance travelled thus indicates fuelwood shortage. From table 6.2 it can be seen that there is an increase in distance travelled to collect fuelwood. For example, 3-5 years ago none of the respondents travelled more than 7 km per trip, whereas 14 per cent travelled the distance in 1995.

Table 6.2: Distance travelled to collect fuelwood.

Distance (km)	Level of stress	No. of respondent who travelled the distance 3-5 years ago.	%	No. of respondent who travel the distance now in 1995	%
1-3	Minimal stress	64	73.6	43	39.1
4-6	Medium stress	23	26.4	41	47.1
more than 7	Much	0	0.0	12	13.8
Total		87	100.0	87	100.0

Mean = 3.966; Std. dev. = 1.633; Std. err. = 0.175. (All for 1995)

The percentage of the respondents who travelled shorter distance of less than 3 km per trip has decreased meanwhile the percentage of those who travel at least 4 km per trip has gone up. By accompanying some households to fuelwood collection areas it was possible to estimate the distance travelled. It was found to approximate to those indicated by the respondents. Furthermore, from discussions with some household members and key informants it was possible to arrive at the level of stress indicated in table 5.2. The majority of the respondents experience medium stress indicating that the fuelwood shortage might not yet be severe.

6.2.3 Fuelwood collectors.

Changes in collectors of fuelwood is taken as an indicator of shortage because when supply is good only adult females do the collection. But as supplies dwindle and sources are far, other household members especially adult males and children begin to assist (Howes, 1985; Earthscan, 1987; Leach, 1987).

Most fuelwood was collected by adult females in the study area (Table 6.3). From the discussions with household members and key informants, it was revealed that traditionally fuelwood collection has been the responsibility of adult females and children. Therefore fuelwood collectors have not changed. This indicator does not show a fuelwood shortage.

Table 6.3: Fuelwood collectors.

Collector	No. of respondents	%	Reasons.
Adult female alone	74	85.1	Responsibility of mothers traditionally
Children alone	5	5.7	Children helping mothers who are too old
Adult female plus Children	6	6.9	Children in school only help during week ends.
Adult male alone	2	2.3	- 1 is alone in house - 1 helps sick wife, no children.
Total	87	100.0	

6.2.4 Means of collection.

Similarly when fuelwood is in short supply, headloads alone may not be enough for households since it is usually collected from very far and so other means like donkey carts and vehicles are used (Leach, 1987).

Out of eighty seven households who collected fuelwood in the study area, 86 (99 percent) carry fuelwood on their head and only 1 household (1 percent), which is headed by a man uses donkey cart because he is the only one in the house. Traditionally carrying fuelwood by head is done by female and children. Since there has been no change in means of transport employed to collect fuelwood, this indicator does not show a fuelwood shortage.

6.2.5 Purchase of fuelwood.

According to Eberhard, (1986) when the demand of fuelwood increases and resources become less accessible, some of the people may devote themselves to collecting, transporting and distributing fuelwood to villages and urban centres. This creates employment in rural areas. This conversion of fuelwood from a material available to everyone free of charge to a product with cash value and price is taken as a symptom of growing supply problems (Deweese, 1989; Desai, 1977).

Only 7 out of 94 (7 percent) households who use fuelwood in Mulambakwena do buy fuelwood. The price of the fuelwood has increased from P30 per pick-up truck and P15 per donkey cart 3-5 years ago to P40 and P20 for the pick-up and the donkey cart respectively. However, since only a small percent of the households do purchase fuelwood, this indicator

does not seem to reflect a severe fuelwood shortage.

6.2.6 Storage of fuelwood.

When the supply of fuelwood is good and the sources are near by, wood can be collected just at the time it is needed for use. When people begin to store fuelwood this may be an indication of shortage (Leach, 1987).

All households visited store fuelwood within the home yard and according to them this is because during rainy seasons most rivers and streams flood and it becomes difficult to collect fuelwood during such times. Another reason given was that during agricultural seasons much labour would be required for weeding and harvesting, leaving no time for fuelwood collection. Therefore the storage of fuelwood in Mulambakwena does not show a fuelwood shortage.

6.2.7 Tree planting.

Tree planting may be taken as an indicator of fuelwood shortage when the supply is not enough and people plant trees so as to get fuelwood from them (Leach, 1987).

According to Hoffman (1995), tree planting is being encouraged by the forestry section of the department of agriculture. A tree nursery exists and people buy the seedlings of various species at subsidised rate. During the national tree planting day, seedlings are given free to the public. Thirty two households in Mulambakwena village area have planted trees just within their yard or compound for the purpose of shade, or as hedges, for ornamental, for fruits, and medicines. No trees have been planted specifically for fuelwood. The reasons given may include the following. The most preferred species for fuelwood is *Colophospermum mopane* which is naturally growing and people have never attempted to and do not like to grow it. Another reason is that since only dead trees are allowed to be cut for fuelwood, one who has planted his/her own trees has to wait until the trees have died. All the 32 households indicated that the major problem in tree planting is lack of water. Tree planting in Mulambakwena village area does not seem to indicate a fuelwood shortage.

6.2.8 Type and number of meals cooked.

It was assumed that households who cannot obtain enough fuelwood cook less number of meals per day and that meals which consume much fuel are avoided. In this section, only the 94 out of 100 households in Mulambakwena village area which use fuelwood are considered. Generally the usual number of meals in this village is three: in the morning, afternoon and evening. For the morning, tea and/or porridge is prepared and in the afternoon and evening meat or beans plus maize meal or sorghum. It was found that these meals are cooked in that order whenever it is available and needed, and not substituted for each other simply because of fuelwood shortage. From table 6.4 it can be seen that only 4 households (4 percent) actually cook less than the three meals purely because of lack of fuelwood. Thus if there is a shortage of fuelwood, then it is not yet expressed fully in terms of the types and number of meals cooked.

Table 6.4: Number of meals cooked and reasons.

No. of meals cooked per day	No. of respondents	%	Reasons given by respondent for cooking the numbers of meals.
3	35	37.2	Need all the meals because young children present.
2	52	55.3	- 33 said children take lunch to school - 9 said they take lunch at work - 4 said there is not enough food - 3 said there is lack of fuelwood - 3 said they work at night, sleep during breakfast time.
1	7	7.5	- 5 take tea and lunch at work - 1 not enough food - 1 lack fuelwood.
Total	94	100.0	

6.2.9 The cooks and fire management.

Where fuelwood is in short supply responsibility for cooking tends to be solely taken over by mothers in cases where other members of the family used to do it. This is because they are the ones who know how to economise fuelwood when cooking (Howes,1985).

Most cooking in Mulambakwena village area is indeed done by mothers (84 percent of households). Discussion with household members and key informants revealed that this is in line with the culture and traditions. Where children cook (13 percent of households) as well

as fathers (3 percent) this was because either the mother was not well or not present. Therefore there is no indication that changes in cooking existed because of fuelwood problems.

Most fire places tend to be placed close to or against the wall which acts as a windbreak. Protecting fire against wind may not necessarily be done purposely to economise on fuelwood in every case, although in doing so it will. Wind might blow fire to cause damage to other household property and people. Some women were observed carrying out careful tending of fires by constantly pushing in the pieces of wood inside the fire interior. According to them this was because they needed food cooked fast, and not necessarily because they wanted to economise on fuelwood. It cannot therefore be concluded that fuelwood is in short supply because of the observed fire management.

6.2.10 Use of less preferred fuel.

When there is shortage of fuelwood people tend to use the less preferred fuel such as crop residues, cow dung, leaves, twigs and small branches of trees because these are the only fuels which would be readily available (Leach, 1987). The use of cow dung was recorded in only 2 households in Mulambakwena village area where it was being used in addition to fuelwood. One household used it for baking bread and the other one for keeping warm during winter. The main reason given for using cow dung is that it burns steadily and slowly, and thus more convenient for those purposes. Since it is used even when fuelwood is available, this may not be taken as a sign of fuelwood shortage. In 17 households, the use of twigs and small branches of trees of less than 5 cm diameter was observed, but mainly for igniting bigger pieces of wood in order to economise on paraffin which is normally used for that purpose. One household was seen using roots for cooking. The reason given was that they burn well, last longer, and were readily available after the trees were uprooted to allow for house construction.

Table 6.5 shows the responses of households to the use of preferred or less preferred tree species for fuelwood. It can be seen that more than half of the households still use the preferred species of trees for fuelwood although they said it was becoming more difficult to get the dead ones nearby. The fact that at least some households (43 percent) are using the

less preferred species may be taken at least as an indication of fuelwood shortage.

Table 6.5: Use of preferred/less preferred species of trees for fuelwood.

Type of species.	No. of respondents	%
Preferred species.	54	57.5
Less preferred species.	40	42.5
Total	94	100.0

6.2.11 Summary of severity of the reported fuelwood shortage.

From table 6.6 it can be seen that the indicators that seem confirm that fuelwood shortage exists in Mulambakwena village area are the increase in time taken and distance travelled in fuelwood collection; the reduction of the number of meals cooked and the use of less preferred tree species for fuelwood. In terms of the proportion of the households affected by those indicators, the increase in time and distance for the collection subjected the majority of the households to minimal stress and almost half of the households use the less preferred tree species for fuelwood. According to the above indicators, the fuelwood shortage is not yet severe. The proportion of the households affected by the increase in price of the fuelwood and those that reduced the number of meals cooked are very low and so the fuelwood situation would also be described as not yet severe in terms of those indicators.

According to Soussan *et al.* (1991); Leach and Mearns (1988), there is no generalised fuelwood problems, as shortages express themselves in many different forms and vary from places to places and may be specific to people. However, for Mulambakwena village area, considering all the indicators used, including those that do not seem to show a fuelwood shortage, it can may be said that there seems to be no fuelwood shortage. But they do indicate a potential shortage in future.

Table 6.6: Summary of the fuelwood indicators.

Indicator	Description of change in indicator	Indication of fuelwood shortage.	Proportion of household affected by the change.	Severity
Time for collection	Increased	Yes	56.3% - Medium stress 41.4% - Minimal stress 2.3% - Much stress	Not severe
Distance for collection	Increased	Yes	47.1% - Medium stress 39.1% - Minimal stress 13.8% - Much stress	Not severe
Fuelwood collectors	No change	No	-	-
Means of collection	No change	No	-	-
Price of fuelwood	Increased	Yes	7% only	Not severe
Storage of fuelwood	Exists - but not because of shortage	No	-	-
Tree planting	Exists - but not for fuelwood	No	-	-
Type of meals	No change	No	-	-
Number of meals	Reduced	Yes	4% only	Not severe
The cooks	No change	No	-	-
Fire management	Exists - but not due to fuelwood shortage	No	-	-
Use of less preferred fuel - Cow dung - Twigs - Roots - Tree species	Exists - but only for the use of less preferred tree species	Yes	42.5%- less preferred species 57.5%- preferred species	Not severe

6.3 People's perception of the fuelwood issue.

It is common knowledge that problems which rural people face are many and complex. In section 6.2 it was found out that the fuelwood situation is not severe and has not yet even reached a defined shortage, but there is a potential shortage in future. But it is also important to find out how the people themselves feel about this potential problem. According to ETC (1987), any survey on fuelwood should reflect the needs of those being surveyed so that the solutions will fit into the perceptions that exist. It has been hypothesised that fuelwood shortage is perceived by the people of Mulambakwena as a serious problem (Government of Botswana, NEDC/NEDDC, 1989). This section discusses what these other problems are, compares it to the reported fuelwood shortage to see how all the problems are connected to each other.

6.3.1 Major problems in the village area.

The problems that face the people in Mulambakwena are many. Table 6.7 shows the major ones and how they were ranked during a village meeting. The most serious problem was shortage of water with the highest percentage of votes, followed by lack of income. Fuelwood shortage ranks third.

Table 6.7: Major problems in the village area.

Problem	No. of votes	%
Shortage of water	15	36.6
Lack of income	11	26.8
Shortage of fuelwood	10	24.4
Shortage of land	5	12.2
Total	41	100.0

Fuelwood shortage is thus perceived by the people of Mulambakwena village area as a problem because it was among the first three major problems perceived in the village, but it was certainly not the most important. Shortage of water and lack of income came first and second respectively.

6.3.2 Problem tree in the village area.

In order to investigate how these problems identified in the village are connected to each other and also to other minor problems, a problem tree was constructed by the villagers. The way this was done had been described under section 4.4 and figure 3.1. The result is shown in figure 6.1 and it is purely their own ideas. Lack of fuelwood is linked to shortage of water, increase in population, insufficient land. Furthermore, from discussions with key informants about possible solutions to the major problem resulted in the findings in table 6.8.

Figure 6.1: Problem tree in Mulambakwena village area.

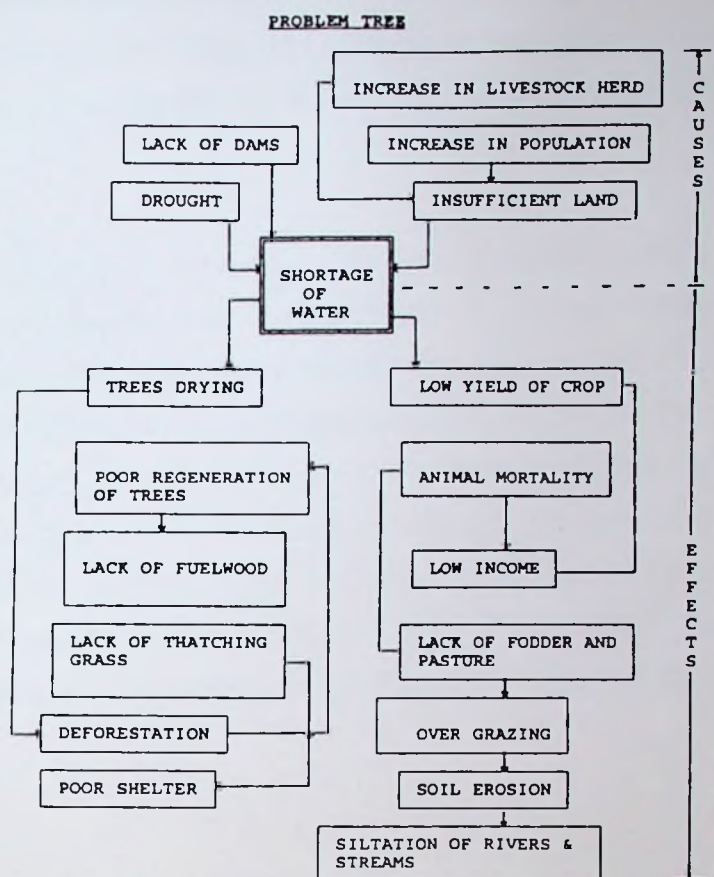


Table 6.8: Major problems and possible solutions suggested by the villagers

Major Problems	Possible Solutions
Water shortage	Build dams, Prayer to God to bring rain.
Shortage of land	Government acquire more land from 'Tati company*' for people
Shortage of fuelwood	Use coal, Government to subsidise paraffin and gas.
Lack of income	Government to create jobs

* Tati company owns the freehold land shown in figure 1.3. In 1880s the company was granted the area as a mining concession by the protectorate administration, and later on claimed absolute ownership of the land (Tapela, 1982).

The people suggested only alternative sources of fuel in order to overcome the fuelwood shortage. There were no mention of tree planting or tree management possibly because the most preferred tree species for fuelwood is naturally growing and also possibly because of the current regulation regarding the use of trees for fuelwood as earlier on mentioned in section 6.2.7.

The use of indirect indicators of declining fuelwood availability shows that there is no fuelwood shortage in Mulambakwena village. However, fuelwood shortage is perceived by the people as a problem (and not the most serious). It can thus be said that the result of using fuelwood indicators is different from the people's perception of the fuelwood situation. It was also found out that according to the local people, the fuelwood problem is directly linked to shortage of water, increase in population and insufficient land and can be solved by using coal, creating subsidies on paraffin and gas. Although the number of people who attended the village meeting was small it was still representative of the village. This is because the members came from almost all corners of the village and different age groups, and sexes were represented.

CHAPTER SEVEN: EFFECTS OF THE FUELWOOD ISSUE.

7.1 Introduction.

In the last chapter, some of the effects of the fuelwood issue are discussed. These are less cooking; the use of less preferred tree species as fuelwood; increase in price of fuelwood and increase in time taken and distance travelled to collect fuelwood. This section will continue to discuss some of these effects but also investigates the effects of the shortage on the labour and income of the households. It will also look at deforestation in the village in relation to this fuelwood issue.

People who do not have access to any other sources of energy have to devote an increasing proportion of their limited time, labour and money to obtain the supply they need (Deweese, 1989). This affects their well-being not only in terms of access to goods and services but also the way they perform work (Deweese, 1989). In regard to labour and income, the hypothesis postulated was that fuelwood scarcity creates a negative socio-economic effect by requiring the diversion of labour or income to obtain it.

7.2 Labour for fuelwood collection.

In section 6.2.1 it was mentioned that labour for fuelwood collection is predominantly undertaken by the women (85 percent of the households) and this collection is mainly by headloads (99 percent of the households). Children and men also collect fuelwood but only in a few households. In order to get a better idea of the labour used, the average time spent and the average distance travelled per week in the fuelwood collection are used. These were obtained by multiplying the time taken and distance travelled per trip by the number of trips made in a week to collect fuelwood respectively.

Table 7.1: Time spent per week in fuelwood collection.

Time per trip	No. of trips per week	Average time per week	No. of respondents	% of respondents
20 min. - 3 hrs	1	4 hrs 5 min	9	10.4
3-7 hrs	3	12 hrs 16 min	63	72.4
more than 7 hrs	2	8 hrs 11 min	15	17.2
Total			87	100.0

Time per trip: Mean = 4.09; Std. dev. = 1.63; Std. err. = 0.175

Over 90 percent of the respondents spent at least 12 hours per week in collecting fuelwood (table 7.1). P.C. Fleuret and A.K. Fleuret (1978) in a labour survey in Tanzania found that a time of 20 hours per week was used in fuelwood collection. The time spent by most people in Mulambakwena is thus not very high compared to the Tanzania one, indicating that the fuelwood situation in Mulambakwena village area might not be as severe as in Tanzania.

Table 7.2: Distance travelled per week in fuelwood collection.

Distance per trip (km)	No. of trips per week	Average distance per week (km)	No. of respondents	% of respondent
1-3	1	4.0	16	18.4
4-6	3	11.9	55	63.2
7 and above	2	8.0	16	18.4
Total			87	

Distance per trip: Mean = 3.966; Std dev. = 1.633; Std. err = 0.175

From table 7.2 it can be seen that over 80 percent of the respondents travel a distance of at least 11 km per week to collect fuelwood.

To compare this labour (in terms of time and distance) used in fuelwood collection with other productive activities, households were asked to indicate which activities take a lot of their time and efforts.

Table 7.3: The most difficult activities carried by households.

Activity	No. of respondents	%
Agriculture	27	27
Fuelwood collection	22	22
Looking after children	20	20
Cleaning house and compound	11	11
Cooking	10	10
Washing clothes	6	6
Water fetching	4	4
Total	100	100

From table 7.3 it can be seen that fuelwood collection is the second most difficult activity after agriculture. This shows that most of the time and efforts of the women is spent on fuelwood collection. This is so because even if agriculture ranks first it is only carried out during the agricultural season whereas fuelwood collection takes place almost through out the year.

Some women revealed that now they cannot find dead trees nearby compared to 3-5 years ago, and so they walk longer distance and take more time looking for it. Because of this they were forced to go with babies on their back looking for the fuelwood and when they come back late they perform overlapping duties at the same time. For example, cooking, washing and cleaning and child care. Most of those overlapping activities were not performed properly. Furthermore, for households where fuelwood collection is either done by children alone or adult females and children together, and where the children are school going, most fuelwood collection takes place during holidays and weekends. However, some children complained that at times they come back from fuelwood collection tired and late and may not be able to wash their clothes on Saturday. This makes them go to church with clothes unwashed or miss going to church altogether.

It can be argued that carrying out overlapping activities may be the norm in some

circumstances, but when it produces undesirable results and also causes stress then it becomes detrimental to the well-being. Furthermore, it may also be argued that having children with their parents helps tighten familial bonds, and skill formation and overall development of children. In this case when female children help their mothers in fuelwood collection this may be beneficial. But this depends on the circumstances in which it arises and the length of time or period this occurs. When it is too much then it becomes negative to their well-being.

From the above discussion, because fuelwood is not found near by, more time and effort is spent in its collection forcing some of them to go with babies on their back instead of properly caring for them at home and also forcing them to perform overlapping duties and children missing going to church. All these are negative to their well-being.

7.3 Fuelwood purchase.

If people cannot meet their energy needs by collecting fuelwood they must buy them and according to Soussan *et al.* (1991); Dewees (1989) and Desai (1985), fuelwood scarcity means fuelwood has a high perceived costs. In section 6.2.1 under purchase of fuelwood, it was reported that there were only 7 out of 94 (7 percent) households who buy the fuelwood. Five of the households buy it because the members consist of very small children and older people who are not able to collect fuelwood. The other 2 households lacked the time to collect the fuelwood.

The seven households buy fuelwood in terms of donkey cart load and pick-up truck and the prices were P20 and P40 respectively. In section 6.2.4 it was mentioned that out of 87 households who collect fuelwood, 86 carry fuelwood on their head and only 1 uses donkey cart. All the 100 households interviewed indicated that they do not sell fuelwood. It is therefore most likely that some of the fuelwood traders are from outside the village area. On average the fuelwood purchased lasts for a month, implying that those households spend between P20 and P40 per month on fuelwood. According to Government of Botswana, CSO (1995), the 1993/94 household income and expenditure survey indicate that the average rural household income is P200 per month. All the 7 households revealed that the money they spend in buying fuelwood is much and as a result some of them are forced to sacrifice certain

goods. For example, some cannot afford to eat rice and as one of them put it "there is no need to buy expensive food if there is no fuelwood to cook it with". From the above discussions it can be said that the time taken and the distance travelled to collect fuelwood and money spent in buying fuelwood are having a negative impact on some households which suggests that if the fuelwood situation does not improve more households will become affected by the diversion of labour and income in order to obtain it.

7.4 Deforestation.

According to Government of Botswana, NEDC/NEDDC (1989), there is a fuelwood shortage in the District. In section 6.3.1, it was found that fuelwood shortage is perceived as a problem in Mulambakwena village area. However, the use of fuelwood indicators (section 6.2) reveals no fuelwood shortage in the village presently but do indicate a potential shortage. This section attempts to investigate the changes in land use to find whether there has been deforestation and then later determine its causes to see whether fuelwood shortage as perceived by the people and as reported by NEDC/NEDDC has a significant contribution to it. A combination of methods were used including aerial photograph interpretation and ground truth observation, discussion with key informants especially the elderly and direct observation.

7.4.1 Changes in land use.

In section 4.2.1 the land use was categorised as dense woodland with the highest vegetation density and with minimum exploitation; less dense woodland with medium vegetation density and with less exploitation; and agricultural fields where the vegetation density is the lowest with maximum exploitation. Furthermore, in section 2.7.4, deforestation is defined as a permanent clear-felling of an area of forest or woodland.

From figures 7.1 and 7.2 it can be seen that there has been a decrease in the dense woodland and increases in the less dense woodland and agricultural fields. Discussions with key informants revealed that between 1981 and 1988 some land was cleared of trees to make way for farming. It can therefore be said that deforestation probably occurred between 1981 and 1988.

Figure 7.2: Land use map of Mulambakwena village area for the year 1988.

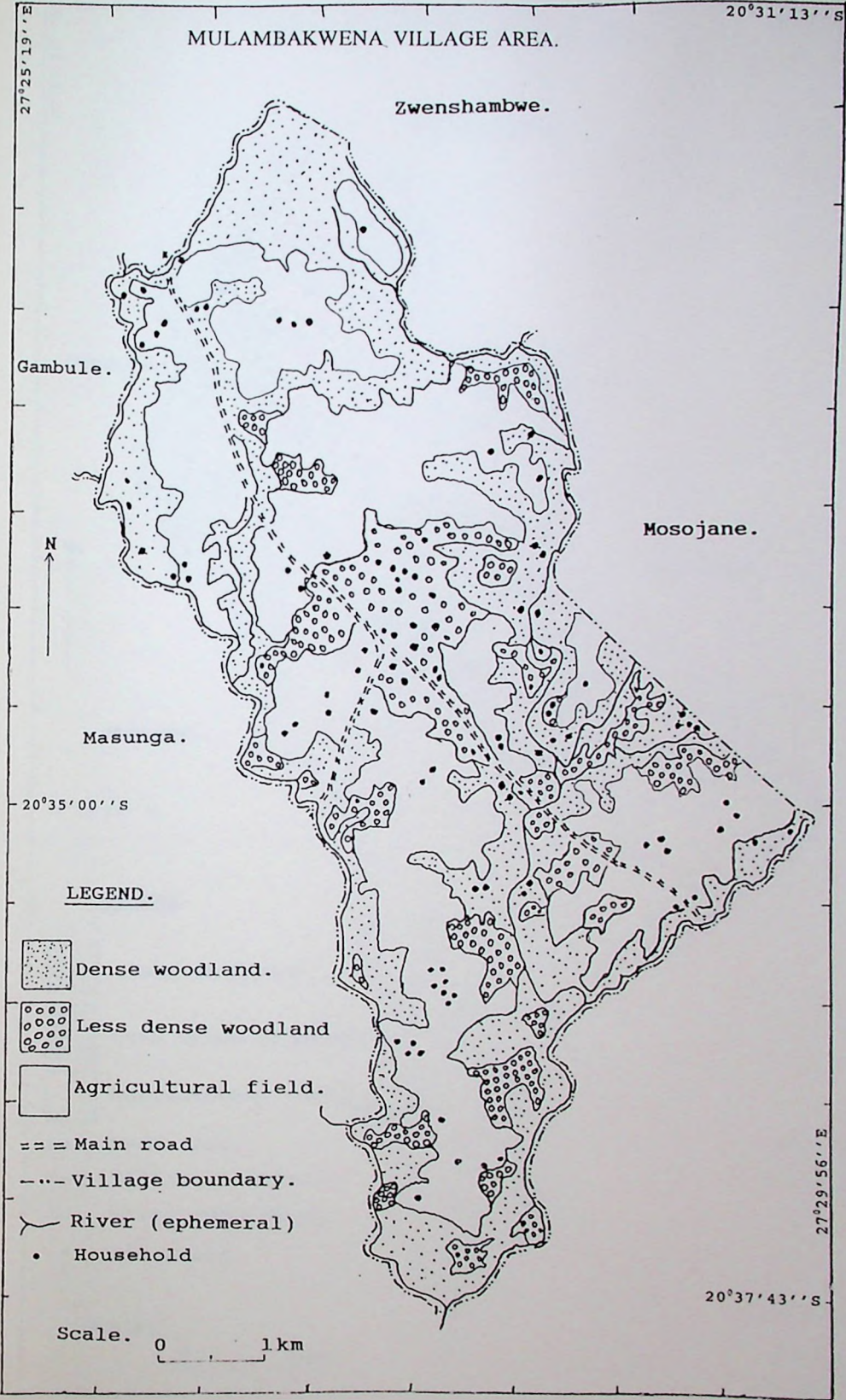


Figure 7.1: Land use map of Mulambakwena village area for the year 1981.

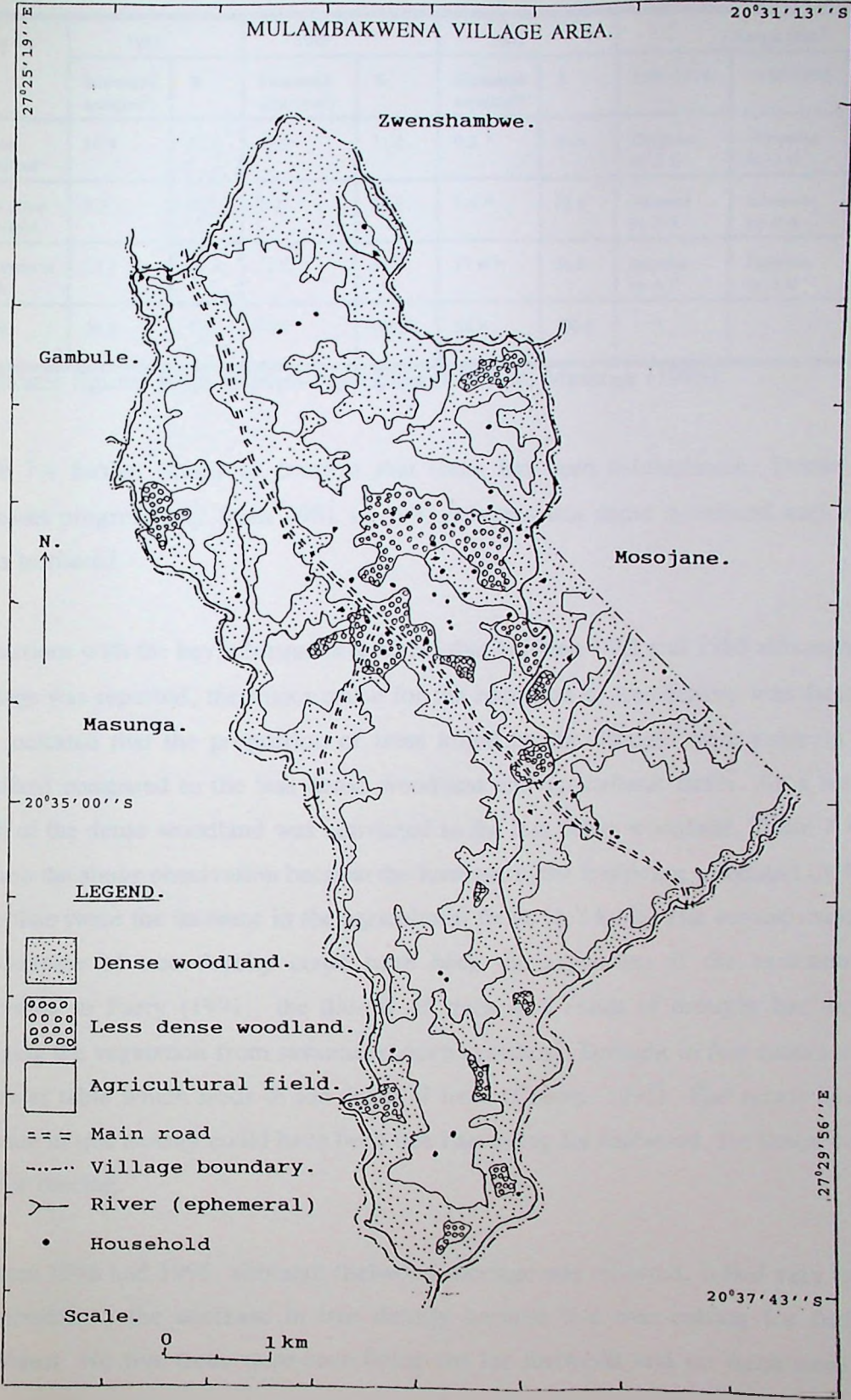


Table 7.4 Comparison of the land use for the years 1981, 1988 and 1995

Land use	1981		1988		1995		Change (km ²)		
	Estimated area(km ²)	%	Estimated area (km ²)	%	Estimated area(km ²)	%	1981-1988	1988-1995	1981-1995
Dense woodland	16.4	47.1	10.8	31.0	9.2 *	26.4	Decrease by 5.6	Decrease by 1.6	Decrease by 7.2
Less dense woodland	3.3	9.5	7.2	20.7	7.8 *	22.4	Increase by 3.9	Increase by 0.6	Increase by 4.5
Agricultural fields	15.1	43.4	16.8	48.3	17.8 *	51.2	Increase by 1.7	Increase by 1.0	Increase by 2.7
Total	34.8	100.0	34.8	100.0	34.8	100.0			

* indicates figures from District Agricultural Office, Masunga (1995).

Table 7.4 further seems to confirm that there has been deforestation. Dense woodland decreases progressively from 1981 to 1995 whereas less dense woodland and agricultural fields increased.

Discussions with the key informants revealed that between 1981 and 1988 although fuelwood shortage was reported, the major cause for the reduction of tree density was drought. They also indicated that the proportion of trees killed by the drought were more in the dense woodland compared to the less dense woodland and agricultural fields. As a result of this much of the dense woodland was converted to the less dense woodland. Table 7.4 seems to confirm the above observation because the increase in the less dense woodland (3.9 km²) was more than twice the increase in the agricultural fields (1.7 km²). The second major cause of the decrease of tree density could have been the expansion of the agricultural fields. According to Parry (1991), the die-off of trees as a result of drought has the effect of changing the vegetation from savanna to open grassland. Drought in fact causes a decline in the water table which leads to the death of trees (Crump, 1991). The minor causes of the decrease in tree density could have been tree harvesting for fuelwood, for house construction and for fencing.

Between 1988 and 1995, although fuelwood shortage was reported, it had very insignificant contribution to the decrease in tree density because live tree cutting for fuelwood was prohibited. No live trees were seen being cut for fuelwood and no fresh trees were seen

being carried as fuelwood. According to the key informants, the major cause of the decrease in the dense woodland during this time was clearing land for agriculture. From table 7.4, it can be observed that much of the 1.6 km² decrease in the dense woodland was converted to agricultural fields (1.0 km²) compared to and only 0.6 km² which was converted to the less dense woodland. The minor causes of the decrease in dense woodland could have been cutting trees for house construction and for fencing.

Table 7.5: Summary of the major changes in land use.

Year	Population	Population density	No. of households	Average household size	Area of dense woodland (km ²)	Area of less dense woodland (km ²)	Area of agricultural fields (km ²)	Comments
1981	824 **	24	113 ***	7	16.4	3.3	15.1	No fuelwood shortage
1988	785 **	23	135 ***	6	10.8	7.2	16.8	Fuelwood shortage reported
1991	742 **	21	132 **	6	na	na	17.4 *	Fuelwood shortage exists
1995	781 **	22	na	na	9.2 *	7.8 *	17.8 *	Fuelwood shortage exists

Area of the village = 34.8 km²

* indicates figures from District Agricultural Office, Masunga.

** indicates figures from Central Statistic Office, Gaborone.

*** indicates figures from Barnhoorn and Th. Riezebos (1990);

na indicates no data available.

From table 7.5 it can be observed that there was an increase in population between 1991 and 1995. During the same time agricultural fields also increased. This might be the major cause of deforestation during this time. It is to be noted that although there were no figures available for the number of households in 1995, indications are that it increased. This is because during the household survey some households were found with no numbers which could mean they were new households. During the 1991 census all the 132 households were given numbers (see section 3.2). The increase in household number could have also contributed to deforestation.

It can therefore be said that before the introduction of the NCS regulation prohibiting live

tree cutting for fuelwood, the perceived and reported fuelwood shortage could have had some contribution to deforestation. After that, this contribution seems to have reduced drastically as cutting of live trees for fuelwood was banned. Therefore, presently, fuelwood scarcity does not appear to have any significant contribution to environmental degradation in the form of deforestation.

CHAPTER EIGHT: SUMMARY AND CONCLUSIONS

8.1 Introduction

In order to address the problem of fuelwood shortage which was identified in the North East District of Botswana, there was a need to know the extent, causes and effects of the problem. It was also necessary to establish people's perception of the fuelwood problem. Previous fuelwood surveys carried out in the District never attempted to investigate the above issues. An in-depth study was conducted in only one village, Mulambakwena which was considered representative of the 32 villages in the District in terms of the fuelwood situation. Conceptually, fuelwood shortage if it exists at all, is either caused by an increase in demand of fuelwood and/or a decrease in supply of wood. The factors affecting the supply of fuelwood investigated were: the availability, distribution, preferability and acceptability of woody biomass resources in the village; and the accessibility to those resources for fuelwood. Similarly, the factors affecting the demand for fuelwood examined were: the total village population; the household size; and the household income. The extent of the fuelwood shortage was estimated by studying how people in the village obtain and use fuelwood. The effect of the fuelwood shortage on household labour and household income; and on deforestation was also investigated. Lastly, people's perception of the problem was examined. The methods that were used in collecting the data include: household questionnaire survey; fuelwood consumption measurements; direct observations; informal interviews and group interviews; aerial photograph interpretation; vegetation sampling; and ground truth verification. The following is the summary of the main findings.

8.2 Summary of the main findings.

The rural energy in Mulambakwena village area is predominantly fuelwood which is used by 94 percent of the households mainly for cooking and heating in the open fires. The other households (3 percent) use gas and the remaining 3 percent use paraffin for cooking. Nearly all the households use paraffin for lighting.

8.2.1 Fuelwood supply factors

The woody biomass in Mulambakwena village area was divided into three classes. The first one is the dense woodland. This occupies 26 percent of the total village area, has the highest growing stock of trees and is relatively unexploited. It has the highest stocking of dead standing trees. The second woody biomass class is the less dense woodland. It occupies 22 percent of the total village area, has medium growing stock of trees and is more exploited than the dense woodland. This class has only a few dead standing trees. The agricultural fields is the last woody biomass class. It occupies more than half of the total area of the village, has the least growing stock of trees and is highly exploited. However, it has the highest stocking of dead felled tree on the field boundaries. Generally, the three classes of woody biomass are evenly distributed in the village.

The tree size class distribution of the woody biomass in the village shows more trees in the smaller diameter classes and only a few trees in the larger diameter classes, possibly because the trees in the larger diameter classes are usually harvested for poles for building and fencing. The most dominant tree species in the village area are *Colophospermum mopane*. This is due to the facts that it is the predominant species. The same tree species has the highest basal area and so it is the most dominant woody biomass source in the village. The fuelwood regulation in the district prohibits the cutting of live trees for fuelwood and because of that, the distribution of dead trees in the village was estimated. The trees which were not used for fuelwood (*Ziziphus mucronata*), and the trees less preferred for fuelwood (for example *Acacia fleckii*) have high percentages of dead standing trees. Meanwhile, the trees most preferred for fuelwood (*Colophospermum mopane*) had no proportion of dead standing trees and the second most preferred tree for fuelwood (*Combretum imberbe*) had very low stocking of dead standing trees. Fifty seven percent of the households were using the preferred species of trees and 43 percent were using the less preferred species of trees for fuelwood.

Households which are near the dense woodland or surrounded by agricultural fields are more accessible to the fuelwood resources because they travel shorter distance to collect fuelwood than households in the less dense woodland. This might be explained by the fact that there are more dead trees in the dense woodland and on the agricultural field boundaries. The

majority of the households are within the less dense woodland. The major land tenure in the village consists of granted land (both lease and not leased), and common land. Access to the common land for fuelwood is not restricted but once land has been granted, then the grantee have control over the resources and have the right to exclude others from using the resources. It was found out that households which have been granted land get relatively enough fuelwood because they can collect the fuelwood from both the land granted to them as well as from the common land whereas the landless rely only on the common land for fuelwood supply. The proportion of the landless was, however, very small. Under the arable land use, the destumping scheme was introduced to encourage farmers clear their lands of trees and stumps in order to expand arable production. Twelve households were destumping their fields, and 9 of them were using contractors to destump. A total of 42 hectares had been destumped since 1986 by uprooting old stumps and felling new trees.

8.2.2 Fuelwood demand factors

Fuelwood is demanded in the village mainly for household consumption. The only non-household use of fuelwood is in one primary school. Whenever the pupils are asked to take fuelwood to the school they usually get it from their respective homes.

Population of the village area decreased between the years 1981 and 1991 and then increased between 1991 and 1995. It was found that larger households tend to consume more fuelwood than smaller ones but use less fuelwood *per capita* than smaller ones. The survey also revealed that a household with high income consumes more fuelwood than a household with lower income. Household size was found to be more important in determining the variation of fuelwood consumption than household income. Generally there was an increase in the average household income between 1989 and 1993 as reported by CSO. The average number of animals and the average number of hectares of land owned also increased. Since household income and household size are usually correlated, it is expected that the household size also increased.

8.2.3 The nature of the fuelwood issue.

In using indicators of fuelwood availability to find out the extent of the reported fuelwood shortage, it is the time taken, distance travelled to collect fuelwood and the use of the less preferred tree species of trees for fuelwood which suggested there may be a shortage in future. Other fuelwood indicators which also revealed that there could be fuelwood shortage in future were the increase in price of fuelwood and the reduction of the number of meals cooked per day. Tree planting in Mulambakwena village area does not seem to indicate fuelwood shortage, because none of the trees so far planted was for fuelwood. Lack of water was one of the problems hindering tree planting. The people also indicated that since only dead trees are allowed to be cut for fuelwood, one who has planted his/her own trees has to wait until the trees have died before using it as fuelwood. Therefore, in terms of the fuelwood indicators which were examined, there seems to be no fuelwood shortage in Mulambakwena village area at present. However, there are signs of fuelwood shortage in future.

Although the indirect indicators of fuelwood availability reveals that the fuelwood situation has not yet reached a defined shortage, the people of Mulambakwena themselves consider fuelwood shortage as a problem, but not the most serious one. Shortage of water, and lack of income are the first two most serious problem according to the villagers. Shortage of land was the fourth major serious problem. However, the villagers linked the fuelwood shortage to shortage of water. According to them lack of water causes trees to dry which in turn leads to deforestation. Shortage of water also causes poor regeneration of live trees. The deforestation and the poor regeneration of trees lead to fuelwood shortage. These were purely the villagers perception of the situation, however, it may be argued that when the trees die, more fuelwood becomes available. The villagers could have probably thought of the ultimate consequences of the tree mortality which reduces the total growing stock of the woody biomass.

8.2.4 The effects of the fuelwood issue.

The labour, in terms of time spent and distance travelled in fuelwood collection was found to create a negative effect on the people involved in the collection. For example, women are forced to perform overlapping activities like cooking, washing, house cleaning and child

care. This reduces their efficiency in carrying out those activities.

The price of fuelwood has gone up and the amount of cash spent in purchasing it was considered high compared to the average household income. This means some households could not afford certain items as the money required to obtain them was diverted to purchasing fuelwood. For example, some of the households who wanted to eat rice would rather spend the money for buying fuelwood than for buying the rice.

Between 1988 and 1995, although fuelwood shortage was reported and perceived to be a problem, it had very insignificant contribution to the decrease in tree density because during this time people in the village were not allowed to cut live trees for fuelwood. The major cause of deforestation during this time seems to have been clearing land for agriculture. However, between 1981 and 1988, when live tree cutting for fuelwood was not yet prohibited, fuelwood wood collection could have had some contribution to deforestation.

8.3 Conclusions.

The total woody biomass resources seems to be well distributed. It is mostly available in the preferred type (*Colophospermum mopane*), but lacking in the accepted form (dead trees). The only source of this tree species for fuelwood seems to be from the agricultural field boundaries. It can therefore be said that the existing regulation prohibiting the cutting of live trees for fuelwood has contributed to reducing the fuelwood supply of the preferred type to the people of Mulambakwena village area. The accessibility to the woody biomass resources seems to be influenced by the location of the woody biomass resources in relation to the households. The fact that majority of the households are less accessible to the woody biomass resources (because they are within the less dense woodland), could be one of the reasons explaining why fuelwood is relatively scarce in the village area. Land tenure seems to influence accessibility to the woody biomass resources for fuelwood. However, since the proportion of the landless was very small, the existing land tenure may not be taken as the cause of the reported fuelwood shortage. The salvage of the woody materials from destumping could temporarily increase the fuelwood supply to the households practising it. However, the ultimate consequences of this destumping will be a reduction of the growing stock of the woodland because the annual production of wood for the area would decline. It

may be argued that this situation is generally balanced by the cutting ban. But it is to be realised that the destumping exercise seems to contribute more to the reduction of the total tree density as it involves clear felling. Even if live tree cutting for fuelwood is allowed people would only cut those trees most preferred for fuelwood (selective cutting). A possible cause of the reported fuelwood shortage in the village is therefore the destumping exercise. Another cause of the reduction of the fuelwood supply has been drought. Just as the destumping exercise, drought appears to have temporarily increased the supply of dead trees, but the overall consequences was a reduced growing stock of the woodland.

The increase in population of the village between 1991 and 1995 seems to have caused an increase in the demand of fuelwood since there has been no substitution for fuelwood. Larger households consume more fuelwood than smaller ones because they need more energy for cooking. However, the *per capita* consumption of fuelwood decreases with household size due to the economies of scale. Households with high income tend to consume more fuelwood than households with low income, possibly because they have more people eating in the house and also possibly because they destump more hectares of land than poorer ones who may not afford to hire contractors to destump for them. It is also probable that it is the households with high income who have their children in the school in the village. They would be expected to consume more fuelwood because their children take fuelwood from the family stock to school. Therefore the increase in household income and household size could have contributed to the increase in demand of fuelwood in the village.

From the above discussions on the supply and demand factors, the causes of the fuelwood shortage seems to be both the decrease in supply and an increase in demand. However, it is to be noted that it is the decrease in supply which appears to be more important than the increase in demand in explaining the fuelwood shortage.

Although the fuelwood shortage was not considered the most serious problem, its shortage is having a negative impact on some households which suggests that as the shortage increases more households will become affected by the diversion of labour and income in order to obtain it. Presently, the reported fuelwood shortage seems to have very little effect on deforestation since people in Mulambakwena are prohibited from cutting live trees for

fuelwood. The current deforestation taking place in the village is certainly due to land clearing for agriculture and wood harvesting for poles for building and fencing.

Like all shortages, fuelwood problems need to be solved by a combination of increasing supply and reducing demand. The supply may be increased by planting more trees or by increasing the productivity of the existing wood sources. People of Mulambakwena need more awareness on the needs to plant trees especially those which can be used as fuelwood. Incentives could be introduced in the tree planting programme. For example, people who have planted trees could be allowed to cut those trees for fuelwood even if the trees are not yet dead. Increasing the productivity of the woodland requires better management of the woodland. For example, during destumping exercise farmers could be encouraged to leave large trees especially those preferred for fuelwood along the edges of their fields to be used in future as fuelwood.

The demand on fuelwood can be reduced by a number of ways. One way is by increasing the efficiency with which it is used. This could be done by introducing fuelwood saving cooking stoves in the households and also in the school. However, the success of the stoves will depend on cost. If the cost is high then it may not be successfully adapted especially in the rural areas where the three-stone fire is still free. Another way which could be used in reducing the demand of fuelwood is by shifting to alternative energy sources such as coal. But this will require efficient coal stoves to minimise the possible adverse effects associated with the domestic use of coal.

The solution to the fuelwood problem must be based on peoples' needs, on their priorities in dealing with what they perceive as the most important problem. For example, in Mulambakwena, the villagers see shortage of water and lack of income as a bigger problem than shortage of fuelwood. Solutions devised for the villagers with a purely fuelwood focus might fail. The villagers have also linked the fuelwood problem to shortage of water. They have also indicated that the major problem they experience in tree planting is lack of water. The best approach to solve the fuelwood problem is to tackle it in connection with water, land, and income. For example, if a dam was built to relieve the water problem, the people

might be encouraged to plant more trees because part of the water may be used to water the trees. If they are given extra land, part of it may be used for planting trees. Similarly, some people may shift to alternative sources of energy such as gas or paraffin for cooking if their income is increased.

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APPENDICES

APPENDIX I

QUESTIONNAIRE FOR HOUSEHOLD SURVEY

RURAL ENERGY SUPPLY AND DEMAND IN BOTSWANA AND ITS IMPLICATIONS: THE CASE OF FUELWOOD IN NORTH EAST DISTRICT.

1. Name of Village _____ Date _____
2. Household Number _____
3. Household location:
 - a. Surrounded by agricultural fields _____
 - b. Within the less dense woodland _____
 - c. Near the dense woodland _____
4. Name of household head _____ Sex _____
5. How many people live in the house? _____

Sex	Age	Work in the house

6. For how many people is cooking done each day? _____
7. Who normally does the cooking? _____
8. How often is cooking done per day? _____

9. What types of food is normally cooked, and how long does it take to cook it?

Time of the day	Type of food cooked	Time taken to cook it (hours)
Morning		
Afternoon		
Evening		

10. Which method do you use for cooking? (Rank)

- Open fire []
- Wood stove []
- Paraffin stove []
- Gas stove []
- Others (specify) []

11. If you use open fire for cooking, which fuels do you use? (Rank)

- Firewood []
- Dung []
- Stalks []
- Cobs []
- Others (specify) []

12. If you use wood stove for cooking which fuels do you use? (Rank)

- Charcoal []
- Firewood []
- Dung []
- Stalks []
- Cobs []
- Others (specify) []

13. If you use firewood for cooking most of the time what are the problems that you experience? _____

14. Which fuels do you use for lighting? (Rank).

Firewood	[]
Dung	[]
Stalks	[]
Cobs	[]
Gas	[]
Paraffin	[]
Others (specify)	[]

15. Which type of fuels do you use for the following?

Beer brewing	_____
Heating water	_____
To keep warm	_____
Pressing clothes	_____
Ceremonies	_____
Others (specify)	_____

16. If you had a choice, which fuel would you prefer for cooking, lighting, and heating?

cooking	lighting	heating
---------	----------	---------

17. What is the source of fuelwood?

(gathering free, purchase) _____

18. If fuelwood is purchased, is it ALL YEAR? YES/NO _____

19. What is the price now? _____

20. What was the price before? _____

21. If fuelwood is gathered, what is the source?

(Own land? Communal land?) _____

22. Who gathers? (Specify relationship to head of household)

23. How is it gathered? _____

24. How often is it gathered? _____

25. How long does the stock last? _____

26. Roughly how much is gathered during each trip?

Diameter 1	Diameter 2

Length of bundle _____ m Volume _____ m³

27. How long does it take for each trip? _____ hours
28. Approximate distance travelled for each trip _____ km
29. Do you sell fuelwood? _____
30. Which tree species are most preferred for fuel?

Reasons for preferring _____

31 Which tree species are less preferred for fuelwood?

Why? _____

32. Which part or parts of trees are less preferred for fuelwood?

Why? _____

33. Is wood stored? Yes/No _____

34. Do you get enough fuelwood? _____

35. If not which major problems does the household experience in supplying fuelwood need? (Rank)

- | | |
|----------------------------------|-----|
| Cost | [] |
| Time for collection | [] |
| Distance to collection point | [] |
| Diminishing fuelwood supply | [] |
| Use of inferior quality fuelwood | [] |
| Labour | [] |
| Others (specify) | [] |

36. What do you do to overcome such problems? _____

37. Would you use more fuelwood if the supply was better?

38. Are there any restrictions to firewood collection from the communal land? _____

If so what restrictions? _____

39. How was the fuelwood situation in the past 5 years?

40. Does the household anticipate future deficiencies in meeting fuel need? _____

41. If YES, why do you think so?

Suggest possible solution _____

42. Does the household practice any fuelwood saving means? _____

43. To what other uses is wood put apart from the above stated?

44. Do you plant trees? _____

45. If yes who is responsible? _____

46. What species? _____

47. For what main purpose are the trees planted? (fodder, fruit, fuel, cultural, shade, medicinal, environmental protection (state) _____

48. Where do you plant them? _____

49. Any difficulties regarding tree planting?

50. Have you noticed any changes in woody biomass in the different land-uses? _____
51. If so what changes? In your opinion why? _____

52. Do you see any environmental degradation in your surrounding?

53. If so which one? (eg soil erosion, siltation of river, etc)

54. Which of these do you think is associated with tree cutting?

55. For what primary purpose were the trees cut? (agriculture, infrastructure, firewood, building poles etc)

56. What solutions can you suggest? _____

57. What are your major sources of income?
Cattle sale _____
Business _____
Agriculture _____
Others (Specify) _____
58. Land holding:
Do you own land? _____ If so how much? _____ ha.
Is land borrowed? _____ If so how much? _____ ha.
59. Destumping
a. Have you ever carried destumping exercise on your field?
Yes _____ No. _____
- b. If yes do you have to cut down trees when you destumped your land or were you just removing old stumps?
Trees _____ Stumps _____ Both _____
- c. How much area did you destump? _____ ha and which years? _____
- d. Who destumped? Family _____ Contractor _____
- e. What did you do with the trees that you took out?
Fuelwood _____
Fencing _____
House construction _____
Unused _____

Others (specify) _____

f. Did you leave some trees in your field? If yes why?

g. What do you use for ploughing your land?

50. Livestock owned

	0	1-9	10-19	20-39	40-59	60 and above
Cattle						
Goats						
Sheep						
Others						

61. Number of bags of grain crops produced annually.

	0	1-2	3-4	5-6	7-8	9 and above

APPENDIX II **FIELD SHEET FOR TREE MEASUREMENT**

PLOT NO. _____ LAND-USE: _____ DATE: _____

TREE NO.	TREE NAME		DIAMETER (cm)
	SCIENTIFIC	LOCAL	
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

COMMENTS _____

APPENDIX III (a)

TREE SPECIES COMPOSITION IN THE WOODLAND

Name		No. of Trees in plots	No. of Trees/hectare	Percent
Scientific	Local			
<i>Acacia fleckii</i>	Mhahu	14	77.8	6.7
<i>Acacia mellifera</i>	Mongana	8	44.4	3.8
<i>Acacia tortilis</i>	Mosu	17	94.4	8.1
<i>Colophospermum mopane</i>	Mophane	113	627.8	53.8
<i>Combretum imberbe</i>	Motswere	21	116.7	10.0
<i>Kirkia acuminata</i>	Modumela	11	61.1	5.2
<i>Ziziphus mucronata</i>	Mokgalo	13	72.2	6.2
Unknown (unidentified)		13	72.2	6.2
TOTAL		210	1166.6	100.0

APPENDIX III (b)

SIZE CLASS DISTRIBUTION OF THE TREES IN THE WOODLAND

Tree diameter (cm)	No. of trees
0.013	2
0.016	7
0.023	1
0.024	1
0.026	2
0.029	5
0.035	9
0.041	15
0.043	1
0.045	5
0.048	6
0.051	11
0.054	3
0.057	2
0.060	1
0.061	14
0.067	3
0.068	1
0.070	5
0.073	1
0.076	3
0.077	1
0.086	1
0.102	1
0.111	1
0.127	1
0.131	1
0.134	1
0.137	2
0.146	1
0.159	1
0.236	1
0.264	1
0.268	1

APPENDIX III (c)

COMPOSITION OF DEAD TREES IN THE WOODLAND

Name		No. of trees in plots	No. of trees/ha	Percent
Scientific	Local			
<i>Acacia fleckii</i>	Mhahu	10	55.5	26.3
<i>Acacia mellifera</i>	Mongana	3	16.7	7.9
<i>Acacia tortilis</i>	Mosu	4	22.2	10.5
<i>Colophospermum mopane</i>	Mophane	0	0	0
<i>Combretum imberbe</i>	Motswere	2	11.1	5.3
<i>Kirkia acuminata</i>	Modumela	1	5.6	2.6
<i>Ziziphus mucronata</i>	Mokgalo	11	61.1	28.9
Unknown (unidentified)		7	38.9	18.5
TOTAL		38	211.1	100.0

APPENDIX III (d)

STAND DENSITY IN BASAL AREA FOR THE WOODLAND

Name		BA in plots (m ²)	BA/ha (m ²)	Percent
Scientific	Local			
<i>Acacia fleckii</i>	Mhahu	0.03629	0.20	3.8
<i>Acacia mellifera</i>	Mongana	0.16612	0.92	17.3
<i>Acacia tortilis</i>	Mosu	0.08341	0.46	8.7
<i>Colophospermum mopane</i>	Mophane	0.49132	2.73	51.4
<i>Combretum imberbe</i>	Motswere	0.06034	0.34	6.4
<i>Kirkia acuminata</i>	Modumela	0.04309	0.24	4.5
<i>Ziziphus mucronata</i>	Mokgalo	0.05699	0.32	6.0
Unknown (unidentified)		0.01844	0.10	1.9
TOTAL		0.95600	5.31	100.0