

# Some of the Determinants of the Consumption of firewood energy in developing countries:

## The case of Rural Botswana

by

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### L. Introduction

For the majority of the world population, firewood is the main energy source. Fritz estimates that around 60% of the world's population depends mainly on firewood to satisfy its energy requirements.<sup>1</sup> Moss and Morgan quote FAO figures (1974) stating that firewood contributes upto 58.4% of the energy consumption in Africa; for developing countries as a group this figure is 22.4% compared with only 5-7% for the whole world.<sup>2</sup> In Botswana, firewood consumption amounts to slightly over half of the total energy consumption.<sup>3</sup>

In many developing countries firewood is depleting rapidly. Due to the rapid population growth, the demand for wood biomass often exceeds its production, resulting in a decrease in the amount of wood left. Furthermore, the arable area expands stripping large tracts of land of woody vegetation. On the other hand, widespread bush-encroachment due to overgrazing increases the amount of wood in the grazing areas. Fritz emphasises that firewood shortage is a locational problem: it occurs mainly around the population concentrations as a result of increased demand and reduced supply (due to clearing for arable or residential purposes).<sup>4</sup> To counteract the latter, reafforestation programmes have been initiated in many countries.<sup>5</sup>

People do not remain passive under conditions of firewood scarcity but adapt themselves in various ways, depending on the socio-economic position of individual households. Often these adaptations have a direct impact on other activities. For example, people may have less time left for agricultural production because of the increased time needed to collect firewood. This may have an adverse effect on crop production since research has revealed that labour shortage is a constraint on crop production.<sup>6</sup> It implies that firewood problems need to be studied in the wider context of rural development. An additional reason to study firewood in this wider context is that the production of wood competes with some other forms of land use, in particular crop production. Only fairly recently the concept of agro-forestry, considering trees as an agricultural crop and not as a separate form of land use, has gained more support.<sup>7</sup>

Given the increased interest in firewood problems, strikingly little data exists so far; certainly in Botswana. So far the available data refers mainly to case studies of villages.<sup>8</sup> Indeed very little is known about the complexity of factors determining demand, supply and ultimately the actual consumption of firewood in rural areas. We see an urgent need for a more systematic approach to solving rural energy problems, since the major problems at village level have been studied. Section three is a first attempt in this direction. A similar attempt towards a more systematic approach has been made for Indonesia.<sup>9</sup> It should be made clear from the start that lack of data does not allow for quantification as yet. It would be useful, therefore, to identify essential data and, in combination with data mentioned in the subsequent sections, to point out gaps in data and, hence, areas for future research. Section three is followed

by two categories of case studies, which examine the country's present firewood situation in rural villages (section 4). The second one discusses rural-urban relations in firewood demand and supply (Sec.5). Both of these sections highlight the spatial aspects of firewood scarcity: lack of wood close to human settlements. Although at present the firewood shortage may be less serious in Botswana than in some other countries, continuing rapid population growth and urbanisation will aggravate the firewood problem in the near future. Present research on firewood issues is needed in order to prepare for this.

A classification of energy sources, in particular the ones available in rural areas, precedes the sections discussed above. Different characteristics of energy sources are summarised. They show that firewood cannot be studied in isolation from other energy sources.

## 2. Energy Sources

Botswana has a number of energy sources within the country such as the sun, wind, coal, wood, cowdung and crop residues. In addition, oil and gas are used. The so-called primary energy sources can be used to generate a secondary energy source, i.e. electricity. Generally, two classifications of energy sources are widely used based on different criteria.

The first one uses renewability as a criterion, hence distinguishing non-renewable from renewable energy sources. Renewable sources can be considered as flows to the society from the environment (sun, wind, wood and agricultural residues). Present use of these energy sources does not affect future use at all (in case of sun and wind) or affects it only when their use exceeds the regrowth rate (wood, agricultural waste). In contrast, the present consumption of non-renewable energy sources (oil, gas, coal and material for nuclear power) directly affects opportunities for future use as it reduces the stock available. This classification throws some light on the possibilities to sustain economic development on the long run, be it national, regional or global.

The second classification takes the need for cash as the base for distinction; commercial versus non-commercial energy sources. Commercial energy sources (oil, gas, coal and nuclear power) generally have a market price. In contrast, non-commercial sources are usually not traded and hence have no market value. They have an economic value. Usually, firewood, dung and crop residues are considered as non-commercial sources. In general, firewood is the most important accounting for 83% of the non-commercial energy consumption, followed by cowdung (15%) and crop residues (2%).<sup>10</sup> However, this distinction is not clear-cut. Wood has become, locally, an object of trade, directly or indirectly (via the production of charcoal) and hence then becomes a commercial energy source. Furthermore, energy sources like the sun and wind are difficult to classify. Although the sources as such are non-commercial, their utilisation requires the purchase of mostly commercial equipment like windmills and sun collectors. The last classification is important particularly in rural areas, with mostly very low incomes, as it indicates the degree of monetarisation of the energy consumption, i.e. the extent to which households have to pay cash for energy. On a national level, the relevancy is that commercial sources, in the absence of national reserves, for example oil in Botswana, have to be imported. The possibilities to import depend on the country's foreign exchange situation and external factors (e.g. political events). Non-commercial energy sources are usually produced/collected within the country. They do not require foreign exchange and are not dependant on external factors. However, their local production or collection may have a negative impact, such as deforestation, on the environment and other

activities such as extraction of nutrients in case of use of agricultural waste. In general, commercial energy sources are more frequently used in urban areas than in rural areas. For example, Pachauri reports that non-commercial energy sources contribute up to 51% of the urban energy consumption in India compared to 80% in the rural areas.<sup>11</sup> Finally, it is useful to distinguish between domestic and industrial use. The latter comprises the manufacturing sector, services and trade. Whereas the former category is closely related to population development and the socio-economic development of households, industrial use is more linked to national economic development, and at a rural level, to opportunities to start rural industries.

### 3. Some of the Determinants of Rural Firewood Consumption

#### a. Introduction

Firewood consumption cannot be studied in isolation from other forms of energy. Depending on the degree of access to other sources of energy and the specific conditions of households, people decide on the type(s) and amount of energy used. Furthermore, the rural sector cannot be studied in isolation from the urban sector. Firstly, there are energy-flows between these two sectors, for example, trade in wood, oil, and gas. Secondly, urbanisation, a widespread phenomenon in developing countries, influences both the rural energy consumption and the energy situation in and around towns.

Both aspects are incorporated in diagram 1. This diagram attempts to describe the most relevant factors explaining the ultimate consumption of firewood. Obviously, both the demand and the supply side are distinguished. Discrepancies between the two result in commercialisation of a so far non-commercial energy source or may induce price fluctuations of commercial sources. Finally, households decide on the actual energy consumption (types and amount). This may involve changes in the interaction between demand and supply. Government may influence the rural firewood consumption. This can be done intentionally as part of forestry policy, price policy for energy sources or even unintentionally. In the latter case, changes in the rural firewood consumption are indirect effects of government policies or actions (for instance, better access to paraffin and gas by improvement of the road system). The demand and supply side will be discussed in section 3.b and 3.c. Subsequently, the adaptation strategies of people are reviewed in 3.d. In section 3.e the role of government will be dealt with briefly.

#### b. Determinants of firewood demand

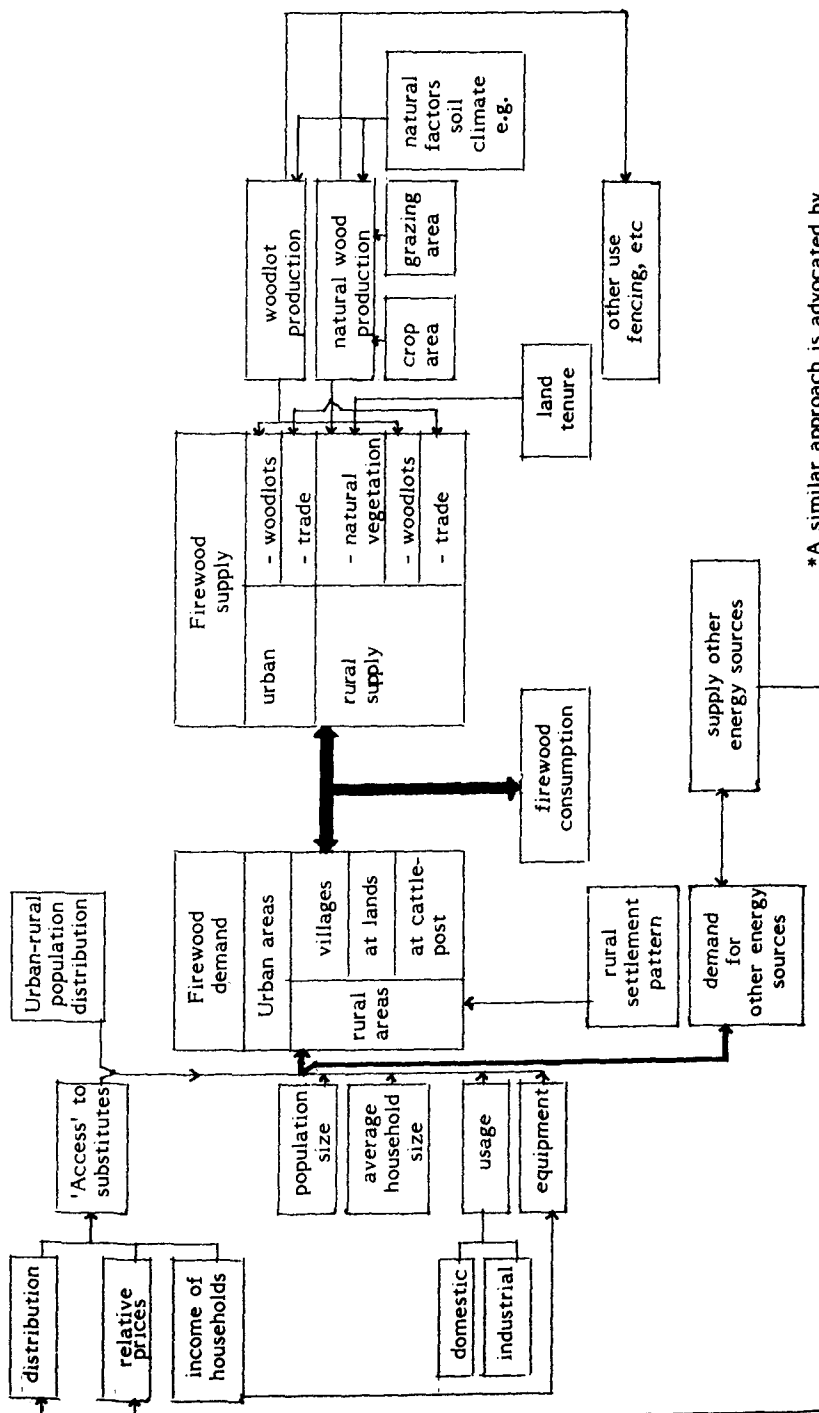
##### i. Population

Generally, population growth is associated with an increase in the energy demand of households. In most developing countries, population growth rates are considerably high. Africa's population increased by an average of 2.7% in the period 1970-1979.<sup>12</sup>

In reality the household is the usual consumption unit of energy; hence it would be more accurate to link energy demand for domestic purposes to the number of households rather than to the overall

DIAGRAM 1

Some determinants of firewood consumption\*



\*A similar approach is advocated by Kuyper and Mellink, 1983.

population. Wiersum shows that energy-consumption per capita declines with increasing household size.<sup>13</sup> One should realise however that members of one household may temporarily or permanently be at different places and have separate energy needs. Clearly, a careful definition of the household or consumption unit is required.

For our purpose, population development has to be considered in relation to available land. Population densities (persons/ha) vary widely in developing countries. In general high population density results in high pressure on land and its related resources, including wood. In practice, people are not evenly distributed but are settled in other patterns (see section 3.b.vi).

ii. Usage

In rural areas, energy is generally used for domestic purposes such as cooking, heating and lighting. It is also used for rural industrial activities like beer brewing and brick moulding. According to the National Academy of Science "roughly 80% of the fuelwood consumed in developing countries is used for domestic purposes".<sup>14</sup> The type of use influences the choice of energy source. For example, paraffin is more important for lighting than for cooking. For cooking, firewood is still most popular. Kuiper and Mellink attribute this to the easy handling of firewood and the fact that no special provisions are required.<sup>15</sup> More so, open fires allow for more pots at the same time, which is more difficult with stoves.

iii. Equipment

The most important equipment is the stove for cooking. Another, obvious equipment is the lamp used for lighting. For cooking, open fires are still commonly used in rural areas. These fires have a low energy-efficiency rate, estimated to range from 6-10%.<sup>16</sup> This means that only a small fraction of the caloric value of wood is converted into energy for cooking.<sup>17</sup> The use of stoves may increase the efficiency of wood possibly to about 20-30%. However, it has been pointed out at the same time that "claims about efficient stove designs have seldom been substantiated by unequivocal tests".<sup>18</sup>

Stoves are at present not frequently used in rural areas. They require some adaptation in cooking methods since they are usually suited for, at most, two pots. Furthermore, the costs of buying them may be an obstacle. This constraint becomes less serious for stoves constructed from local materials whether natural or waste. People will be more inclined to use stoves if wood becomes scarcer with accompanying greater efforts to collect it. Savings resulting from the use of stoves become quite attractive. Of course, the income position of individual households plays a role in the acquisition of stoves. Finally, it has to be realised that a change in habits of people usually takes time.

Increased efficiency does not depend on equipment only, as can be seen from the wide range in efficiency rates of open fires and stoves. For example, simply soaking beans before cooking reduces the

cooking time substantially.<sup>19</sup> Protection of open fire against wind also increases the efficiency. Clearly, by proper management of the fire and cooking, efficiency rates can improve considerably.

iv. Access to Energy Sources

Access to energy sources has two different aspects:

- physical access, i.e. the distribution of energy sources in rural areas.
- 'economic' access, i.e. the prices of the energy sources in the rural areas.

Even if energy sources are physically available, they may be too expensive for widespread utilisation. This, of course, depends on the income situation of individual households. Wood is usually collected locally. Accessibility decreases if wood is becoming scarce. Access to crop residues depends on the arable activities of households; dung can usually be collected freely. Physical access to other commercial energy sources is generally more restricted. The distribution of these sources depends, among others, on the size and quality of the road system and focuses on the bigger villages. dung and crop residues are normally free of charge. In contrast with commercial energy sources, the price of firewood increases near settlements and, supply factors being equal, is highest in the towns. Commercial energy-sources, however, fetch higher prices with increased distances to the distribution points, usually the bigger villages or towns.

v. Income

Income level is an important factor in the acquisition of cooking equipment (3.b.iii) as well as in the use of commercial energy sources (3.b.iv). In developing countries, rural incomes are often very low. Formal job opportunities tend to be concentrated in urban areas or mining and sometimes agricultural enclaves in rural areas. Agriculture, the main source of rural income in many developing countries, usually does not provide people with adequate incomes. Apart from the average income level, the distribution of income has to be considered. Evidence suggests that various socio-economic strata can be distinguished at a rural level.<sup>20</sup> Difference in socio-economic positions between households will usually be reflected in different energy consumption patterns.

vi. Spatial distribution of firewood demand

The spatial distribution of firewood demand reflects human settlement patterns. This relates to both the distinction between urban and rural areas and the settlement pattern within rural areas. Owing to difference in income level, access to energy sources, e.g. the energy demand in urban areas differs significantly from that in rural areas. We saw already that commercial sources are more frequently used in urban areas, both for domestic and industrial purposes. Obviously, large differences exist also within the urban sector to the above-mentioned factors. Migration to urban areas may reduce rural

energy demand. It implies, however, additional demand in rural areas around the towns. Within the rural areas permanent and seasonal settlement patterns need to be distinguished. Under the assumption of equal supply, firewood problems tend to increase with the size of settlements. A rural population concentrated in a small number of villages will normally face more problems related to firewood than one which is more evenly spread over the rural areas. The latter is more likely to be close to firewood, still disregarding inequalities in supply. For the same reason, seasonal movements may alleviate firewood problems. The movements from the village to the lands or grazing areas reduces the concentration of population in certain periods of the year.

c. Determinants of firewood supply

i. Wood from Natural Vegetation

Usually, natural vegetation provides the bulk of firewood consumed. The amount of wood available depends on the forms of actual land use and natural factors (soil, climate), determining the potential wood production per hectare. Production of wood to meet the demand of firewood is at best considered as a secondary form of land use, if not neglected at all. In fact, agriculture is the dominant land use activity in rural areas of most of the developing countries. Access to firewood also depends on land tenure. Hence both land use and land tenure have to be considered.

- Land Use

For crop production land is stripped of most of its trees and therefore this form of land use is incompatible with wood production (unless wood is regarded as a crop, i.e. agroforestry). Population growth and the extensive nature of agriculture (e.g. shifting cultivation) in many African countries, results in an expansion of the arable areas, particularly around the villages. Consequently, wood is produced further away from villages. In grazing areas, trees and hence wood production, are part of the vegetation. Overgrazing usually causes bush-encroachment, i.e. an increase in wood vegetation at the expense of grasses. Some of the 'invading species' are highly appreciated as firewood.<sup>21</sup> In some countries like Botswana, no pure crop production areas exist. Crop production is mixed with livestock production in so-called mixed farming areas. Grazing areas between the fields offer opportunities for wood production. These grazing areas include abandoned fields covered again by shrubs and trees.

- Land Tenure

The most relevant aspect is the distinction between areas of limited access (privately owned or leased) and areas open to all people (communal areas). Limited access reduces the possibilities to use wood. Significant tenure differences exist within developing countries.

## ii. Woodlots

Woodlots are pieces of land on which seedlings have been planted with the primary objective of wood production. It is possible to combine this with secondary activities like crop or livestock production. Wood is produced for various purposes like construction, fencing and use as an energy source. The choice of species depends on the purpose of the woodlot. For example, Eucalyptus wood is attractive for fencing and construction but less appreciated as firewood. In most developing countries, the contribution of woodlots to the overall firewood consumption is very limited. The World Bank concludes from the present inadequacy of current reafforestation programmes in Africa (some 70,000 ha per year) that "to gain self-sufficiency in wood energy by the year 2000 this rate would have to increase by at least fifteen-fold to a level of one million ha. per year".<sup>22</sup> Clearly, this seems unrealistic given the present problems with woodlot programmes, in particular the involvement of people. Unless woodlots are run by the users themselves, firewood from woodlots is likely to be a commercial energy source.

## iii. Suitability of firewood

The supply of wood is heterogenous, i.e. species are different and usually also differently appreciated as firewood. The type of trees grown depends primarily on climatic and soil conditions. It will be clear that semi-arid areas have different trees from humid areas. Land use also influences the occurrence of trees (e.g. overgrazing). The preference of people for firewood species is first of all determined by the availability of species, which grow or used to grow in their area. Subsequently, people look at factors like good embers, the absence of smoke, etc. Understandably the most preferred species are depleted first. People then have the choice to travel further to collect the preferred species or to collect less preferred ones nearby.

## iv. Size of wood collection area

The size of the collection area varies, depending on demand-supply relations and the situation of individual households (e.g. transport opportunities, labour). In general, people collect wood just around their home, seeking adequate supply with minimal efforts. With increased scarcity, the radius to points of wood collection will increase, herewith expanding the collection area. Another method which expands the firewood supply is the cutting of live trees. Normally, only dead wood is collected; in scarcity situations, cutting and burning down of trees becomes more attractive. This affects the future wood production of the area adversely. Firewood trade can be seen as a way to overcome local shortage of firewood. It is quite common in urban areas and in big villages in rural areas. In these cases, firewood has become a commercial energy source.

## The choice of types and amount of energy

The actual energy consumption by source and quantity results from interaction between supply and demand and the strategy of the users. Discrepancies between demand and supply may lead to changes in both



demand (action of the users) - and supply. In case of commercial sources discrepancies are often reflected in price fluctuations, adjusting supply and demand. Changes in demand are results of users' strategies, seeking to guarantee an adequate energy supply with minimal efforts or costs. The concrete form this takes depends on the users' economic position.

As far as firewood is concerned, its demand increasingly exceeds its supply, particularly in urban areas and large villages in rural areas. Users have a number of options to respond to this situation. For instance, they may:

- i. spend more time and/or labour in the collection of wood.
- ii. resort to less preferred species
- iii. cook more efficiently
- iv. cook less meals
- v. use more substitutes for wood
- vi. buy wood
- vii. plant trees (woodlots, individual trees on compounds, etc.)
- viii. cut live wood

These strategies all provide feedbacks to the demand and, sometimes, supply. Strategy one and two refer to the size of the collection area and the species collected. Strategies three and four imply a decrease in firewood consumption; strategy six refers to a decrease in overall energy consumption. Strategy six induces an increase in trade. Finally, strategy seven results in additional land claims, primarily used for firewood production (woodlots) or for more trees around the homesteads and lands. With a time-lag of 10-20 years, the supply of firewood near homesteads increases.

e. Government's role

Apart from the users themselves, government can intentionally or unintentionally influence the energy consumption pattern. The former offers various options. First, by ensuring accessibility to substitutes, including price regulations. Secondly, by stimulating the use of improved equipment thus increasing the efficiency-rate, for example designing of stoves and extension work. Thirdly, by promoting woodlots or other forms of tree planting. Finally, by the acknowledgement of firewood collection as a form of land use to be recognised in land use planning. This would imply an assessment of the effects of the changes in other forms of land use on firewood collection, and more general, rural energy consumption. In the introduction to this section (3.1.) we already mentioned that government policies and actions, not explicitly addressing energy issues, still influence energy consumption (provision of roads, settlement policies, etc.)

#### 4. Rural Energy Situation: Botswana

##### a. Energy consumption by energy source

In rural Botswana where more than 80% of the people live, each person is estimated to consume 1.5 cubic metres of wood per year.<sup>23</sup> Virtually all rural households use firewood as fuel. Table 1 shows that almost all households interviewed in the villages of Shoshong, Mosomane

TABLE 1  
The Use of Energy Sources by  
Rural households (as % of households)

	Ditshegwane (Kweneng District)	Shoshong (Central District)	Mosomane (Kgatleng District)
Type of Fuel	%	%	%
Wood	100	99	100
Dung	31.3	2	N/A
Crop Residue	12.0	0	N/A
Paraffin	63.2	93	88
Gas	N/A	6	4

N/A = Not available

- Sources:
1. Oki, J. and Majaha-Jartby, J. Botswana Village Energy Report, Gaborone, BRET, 1983, pp.16 and 32
  2. Arntzen, J. Firewood Collection in Mosomane: Kgatleng Gaborone, NIR, 1983, p.7.

and Ditshegwane used firewood as fuel. Other forms of non-commercial energy are also consumed in rural Botswana, but as the table shows, they are not as important as firewood. Cowdung is the most common but it is mainly used as a supplement for firewood. Crop residues are sometimes consumed but they are not a common source of energy. The relatively high utilisation of cowdung and crop residues in Ditshegwane may point at firewood shortage and relative poverty, which prohibits the use of commercial energy-sources. Paraffin seems to be the most common commercial energy source. The use of this form of energy seems to correlate with shortage of wood and affluence. Areas which experience a greater scarcity of firewood tend to use more paraffin. Among the villages discussed above, Shoshong seems to have the highest frequency of paraffin users (93%) followed by Mosomane (88%). This may be due to the fact that firewood is scarcer in Shoshong compared to other villages. Other reasons could be that the level of affluence is higher in this village and

and also that the supply of paraffin is more reliable in Shoshong. Differences in the degree of access to paraffin may also explain why there is a high percentage of paraffin users in Mosomane compared to other Kgatleng villages such as Oodi and Matebeleng, despite the relative poverty of Mosomane village. Other forms of commercial energy include electricity and gas but these are rarely used in rural areas since the rural populace cannot afford them.

b. Uses of wood and other forms of energy

In rural Botswana, like in many other parts of the developing countries, firewood is mainly used for cooking. White estimated that about 60-70% of wood consumed in Botswana is used for "heating water, either for cooking or bathing, of the remainder, a small proportion is used to cook foods which are not boiled and the balance is used mainly as a source of heat and light especially in winter.<sup>24</sup> This figure can be compared with that of Pura (India) which is estimated at 82% as well as that of Thailand and Gambia which is within the Botswana range (70%).<sup>25</sup>

Evidence suggests that virtually all households in rural Botswana cook over open fires which are protected from wind by mud walls. When open fires are used, the energy utilisation efficiency of fuelwood is as low as 7-9%.<sup>26</sup> The Botswana Renewable Energy Technology Project has therefore designed stoves which can increase the utilisation efficiency of wood energy to about 15-21%.<sup>27</sup> When the utilisation efficiency of wood is increased, less wood may be used by rural households. At present most rural households are not using energy saving stoves, implying that there are chances of increasing the conservation of fuelwood in Botswana. However, the main problem is that most rural households cannot easily afford the costs of stoves even though they are generally not so expensive.

In many parts of the developing countries firewood is also used a lot in the rural industrial sector particularly by cottage industries and other manufacturing industries. In Botswana, industrial use of firewood seems to be mainly limited to beer-brewing. The Botswana Village Energy Survey, for instance, revealed that about 69% and 70% of rural households interviewed in the villages of Ditshegwané and Shoshong respectively, used wood for the purpose of brewing traditional beer.<sup>28</sup> Data showing the amount of firewood used in the rural industrial sector vis-a-vis that used in other rural sectors is not available. However, the amount of firewood for rural industrial use seems to be far below that for domestic use.

The agricultural sector also consumes other forms of energy such as diesel and petrol for such activities as pumping water in rural areas. Electricity is rarely used in rural areas but in areas where it is available, it is mainly used for the purpose of lighting. Like electricity, paraffin is also mainly used for lighting. Some rural households use it for cooking as well, particularly during the rainy season when wood is wet. Other forms of non-commercial energy such as cowdung and crop residues are also sometimes used for industrial purposes such as beer-brewing, brick-baking, etc.

c. Production and collection of wood

Natural production of wood is very low in Botswana due to a number of factors such as poor soils and the semi-arid nature of the climate. White

estimates that "the standing volume of trees rarely exceed 25 cubic metres per hectare."<sup>29</sup> However, Botswana is fortunate in that it has a relatively small population implying that the total demand for wood in the rural sector may not be as high as in other developing countries with a larger rural population. However, the rural population is growing at about 3% per annum and this means that the fuelwood crisis may hinder rural development if careful methods of environmental management are not resorted to. Programmes of forestry aimed at producing wood and poles have been established by private organisations such as the brigades; government's involvement has been limited so far.<sup>30</sup> The plantations are mainly those of Eucalyptus trees, indicating that the production of wood is more geared towards the needs of fencing and construction than to firewood since Eucalyptus trees are not highly appreciated for use as firewood.<sup>31</sup>

The rural people depend mainly on 'natural wood' for their supply of energy. Firewood collection is the task mainly prescribed to women although men sometimes take part in this activity. Whenever men are involved in wood collection, they either use donkey carts, vehicles, sledges or even bicycles. In Mosomane village (Kgatleng District), 79% of households interviewed collected firewood by head whereas the rest collected it either by donkey carts (27%), sledges (4%) or by other means (4%).<sup>32</sup>

#### d. Scarcity of firewood?

In section 3.4 various adaptation strategies to fuelwood shortage have been mentioned. These can be used as indicators of firewood scarcity. The degree of firewood scarcity in Botswana, however, varies according to the nature of settlement. Around most of the lands areas and cattleposts, population density is generally low; it varies also according to seasonality. For instance, during the agricultural off-season, people migrate to villages and this results in lower population density in the lands areas.

Around most lands areas, scarcity of firewood is not yet significantly felt; however, it is becoming a problem around the lands areas near large villages or urban centres. Kgathi for instance, found that in Ga-Kutwe lands area (Kweneng District), about 30km from Gaborone, preferred species of firewood were no longer easily available.<sup>33</sup> Around small villages, shortage of firewood is also emerging as a problem. Arntzen found that in Mosomane (Kgatleng District; population = 576) most households (52%) collected firewood around 0-4 km from the village.<sup>34</sup> In this village about 70% of the households interviewed said wood was not enough whereas only 4.2% said wood was not enough at the lands areas of this village. Firewood shortage was therefore not perceived to be so much of a problem in the lands areas of Mosomane as much as in the village. Scarcity of firewood is also reflected by a shortage of some species of firewood. In Mosomane about 83% of people interviewed preferred Acacia mellifera (mongana), as firewood whereas 14% and 21% respectively preferred Acacia erubescens (moloto) and Combretum imberbe (motswere).<sup>35</sup> Collection of these species was, however, difficult even though they were preferred by people. Other species were also preferred: Dichrostachys cinerea (moselesele, 43%), Combretum apiculatum (mohudire, 49%) etc., but the collection of these species was on the other hand easier. Jellenic and Van Vegten also revealed that in Matebeleng village (Kgatleng District) women used to

collect wood from the Combretum imberbe and Combretum apiculatum trees, but in 1981 people generally collected different species of firewood such as D. cinerea and A. erubescens because preferred ones were no longer easily available.<sup>36</sup>

Oki and Majaha-Jartby revealed that the points of firewood collection were as far as 5km in Ditshegwane, a small village in Kweneng District with a population of 821 and about 85 km north-west of Molepolole, the capital of Kweneng District. On the other hand, in the larger village of Shoshong (population = 4,600) in Central district, these points could be as far as 12 km.<sup>37</sup> In fact, around most large villages, the cutting of live wood is becoming common because dead wood is no longer easily available. For instance, Jelenic and Van Vegten observe.<sup>38</sup>

Around Molepolole the situation has become desperate enough to force people to chop live wood as energy source. Similar cause for live wood destruction is found around the major towns, but the wood shortage forces people to buy firewood from traders.

As the above quotation notes, scarcity of firewood has led to commercialisation of firewood. In most villages, particularly the large ones, commercialisation of firewood is becoming increasingly important. Even in relatively smaller villages, firewood trade seems to be emerging. In Gabane village, a single axle donkey cart load cost about P6-10.<sup>39</sup> Another aspect of firewood trade (rural-urban) will be discussed in the next section.

## 5. Rural-Urban Relations: Botswana

### a. Patterns of energy consumption

The economies of most developing countries are compartmentalised into two distinct sectors, the so-called "traditional" rural sector and the "modern" urban sector. Patterns of the various aspects of the economies of these countries, including energy use, also reflect this dualistic structure. The urban sector consumes more commercial energy whereas the rural sector depends more on non-commercial sources. Unfortunately, data on the breakdown of energy consumption into domestic and industrial use is not available. Table 4 shows that the per capita consumption of non-commercial energy in the rural sector of Botswana was about 2 times higher than in the urban sector in 1982. The table further shows that the per capita consumption of commercial energy in the urban sector was about 49 times higher than in the rural sector. In the urban sector, commercial energy accounts for about 88.9% of total energy used. This form of energy is mainly consumed by the mineral sector. For instance, in 1980, the Bamangwato Concessions Limited (BCL) Copper Mine consumed about 278 GWH of electricity, "which accounts for about 70% of Botswana's electricity sales."<sup>40</sup> In addition, about 130,000 tones of coal, which is more than 30% of the total production in Botswana, were consumed by BCL.<sup>41</sup>

In Botswana's capital city, Gaborone, like in other urban centres, the most expensive form of energy is electricity which cost about P1415.00 per 10<sup>7</sup> cal in 1980. On the other hand, wood cost about P 73.00 per the same unit. However, one should take into consideration the fact that the

TABLE 2

Per-Capita Consumption by Urban  
and Rural Sectors (in kg. oil equivalent)

Type of Settlement	Non-Commercial Energy	Commercial Energy	Total
Urban	290-330	2430	2720-2760
Rural	560-680	50	610- 730
Total	520-620	410	930-1030

utilisation efficiency of electricity (90%) is higher than that of wood (6-20%). The prices of electricity and wood per usable calorific value (10<sup>7</sup> k cal) were therefore about P1572 and P365-P1216 respectively in 1980.

b. Energy flows (supply)

The urban sector mainly depends on the rural sector for its supply of firewood whereas other forms of energy such as coal are distributed to both the rural and the urban sector.

i. Firewood

Firewood is exported from the districts to the nearby urban centres where it is mainly consumed by those who do not have access to other forms of energy. It is mainly needed for domestic purposes particularly by low-income households. The high income group also uses firewood but mainly for the purpose of heating. Many people in low income urban areas collect firewood either by bicycles or motor vehicles from the rural sector. Some purchase it from firewood traders who collect it from the rural sector by donkey carts or motor vehicles. Kgathi indicates that there were at least about 35 traders who operated between Kweneng district and Gaborone and they collected firewood on the average about 45 km from the consumption area in Gaborone.<sup>42</sup> Most traders took about 12-14 hours to travel from the harvesting points to the consumption area. The species preferred by consumers in Gaborone were those with long lasting embers such as *Combretum apiculatum* (mohudire) and *Combretum imberbe* (motswere). About 43 tons of firewood were exported by traders from Kweneng district to urban Gaborone per month. The figure is likely to rise in winter when wood has a higher demand due to cold weather. By-laws on the exportation of firewood out of the districts exist. For instance, Kgatleng district prohibits the exportation of firewood whereas Kweneng district imposes a tax on whoever removes firewood out of the district. A trader transporting firewood by a one axle donkey cart (carrying approximately about 350 kg of wood) is charged a tax of about P1.00 whereas a trader with a two ton truck full of wood is charged a tax of about P2.00. The by-law also forbids people to cut live wood. However, there is clear evidence that people continue to cut live wood and also evade paying firewood tax. It seems this by-law will only have an impact if its enforcement can be improved.

As the urban population increases, one would expect the demand for firewood to increase in the urban sector unless this resource is considerably substituted by other forms of energy. During the intercensal decade of 1971-81, the urban population in Botswana grew at an average of 10.7% as it can be seen in Table 3.

TABLE 3  
Urban Population and Growth Rates (1971-81)

Town	1971 Census <sup>(1)</sup>	1981 Census <sup>(1)</sup>	Growth Rates <sup>(2)</sup>
Gaborone	17 713	59 657	12.9
Francistown	18 613	31 065	5.3
Lobatse	11 936	19 034	4.8
Selebi Phikwe	4 940	29 469	19.6
Orapa	1 209	5 229	15.8
Jwaneng	n/a	5 567	n/a
Total	54 411	150 021	10.7

n/a = Not available.

Source = 1. 1981 Population and Housing Census: Guide to Villages and Towns of Botswana, Gaborone, Government Printer, 1983.

2. Calculated from the formula:  $P_n = P_0 (1+r)^n$

where n = Number of years (intercensal decade)

$P_n$  = Population after n years

$P_0$  = Initial Population

r = growth of population per annum

New towns such as Selibe-Phikwe, Gaborone and Orapa had very high growth rates during this period as it should be expected. Despite such an increase in the urban population, very little has been done to establish woodlots which can supply the urban population with wood for fuel since naturally produced wood seems to be scarce around urban centres. Woodlots established by the local government in Jwaneng are a good example. These plantations do not depend on rain but make use of sewage water. The Ministry of Agriculture has some forestry plantations in Gaborone and Lobatse but it no longer initiates any new programmes; instead it supports organisations which engage in this activity.<sup>43</sup> Like in rural areas, most of the woodlots in the urban sector are those of Eucalyptus trees which are not suitable for use as firewood as already mentioned.

## ii. Other Forms of Energy: Coal and Electricity

This section mainly discusses two government programmes which attempt to increase the use of electricity and coal in rural areas. The rural electrification and coal distribution programmes aim at providing the rural population with electricity and coal since it depends almost entirely on wood.<sup>7</sup>

A P260 million central power station is being constructed in order to supply some villages and towns with electricity. Small generators using domestic coal may be used to supply remote areas with electricity since it might be too expensive to connect them to the central power system.<sup>44</sup> The price of electricity in the rural sector will be the same as in the urban sector despite the fact that incomes are generally low in the rural sector. It is, therefore, reasonable to conclude that this project will only benefit those who can afford to pay electricity bills.

The government is also working out a strategy of marketing coal from Morupule, and other areas to the rural and urban population. It is estimated that in these areas the mineable coal reserves known, amount to about 3,600 million tonnes.<sup>45</sup> The Morupule mine is, however, the only coal mine which has started production. Morupule coal is relatively cheaper compared to imported coal as well as other forms of energy such as firewood, gas and electricity. For instance, in 1982, the Ministry of Mineral Resources and Water Affairs estimated that the price of Morupule coal in Gaborone was about P35.00 per 10<sup>7</sup> k cal whereas that of firewood, kerosene and electricity were about P73.00, P588.00 and P1,415.00 respectively, per the same unit of calorific value.<sup>46</sup> A major disadvantage of coal is that its users need cooking stoves which may be an obstacle for many households. Moreover, the use of coal is associated with more serious air pollution problems.

## C. Some Impacts of the Rural-Urban Energy Flows

The sale of firewood provides those who are unemployed or under-employed with income. In some African and Asian countries it is the main source of income for the landless people.<sup>47</sup> In Botswana, this trade mainly supplements agricultural incomes since most rural households have access to both arable and grazing land.

Firewood trade between urban Gaborone and rural Kweneng provided self-employment to about 35 people in early 1983. These people generated additional employment to other people who assisted them in harvesting and transporting firewood to the market. On the average, the traders earned at least P77.00 per month.<sup>48</sup> In low income areas of Gaborone such as 'White City' and Bontleng, expenditure on this fuel amounted to about P10.00 to P12.00 per month. This implies that this fuel accounted for about 10% to 12% of the budget of the lowest paid industrial class workers who earn about P4.77 per day.<sup>49</sup> If firewood trade is not properly monitored, it can lead to deforestation which can make the soil prone to wind and water. This may lead to the depletion of the soil fertility which may lower agricultural productivity. In the long run, rural underdevelopment may become even more serious if no attempt is made to



address this problem. In Botswana, deforestation is a problem particularly around urban centres and major villages where firewood is depleting very rapidly and most land is cleared of vegetation for crop production. In these areas, as already mentioned in section 4, preferred species of firewood are no longer easily available. About 80% of women interviewed in Ga-Kutwe lands area, in Kweneng District, revealed that firewood trade contributed to the depletion of the Combretum imberbe (motswere) trees. The few of them which were available about 10 years ago had drastically reduced in number. The elderly women mentioned that the growth of Gaborone had led to an increase in the demand for firewood in the surrounding districts such as Kweneng and Kgatleng. The increasing scarcity of firewood in this town led to its commercialisation.

The distribution and supply of coal and electricity to the rural sector may reduce the consumption of firewood energy in the long run. This will, however, depend on many factors such as the coal marketing system and the levels of subsidies on these forms of energy. Experience of other developing countries indicates that only a few rural people benefit from rural electrification programmes. For example in 1975, it was estimated that even though 25% of the villages had electricity in India "the proportion of the villagers using electricity was low, the extent of use usually slowing greatly after 20% of the population becomes users".<sup>50</sup> As far as coal is concerned, one wonders as to whether it will really reach the remote areas considering the problems associated with its distribution. However, if a substantial number of people were to resort to using coal or electricity (or both) the demand for firewood would decrease, hence alleviating the deforestation process.

## 6. Concluding Remarks

In most developing countries, including Botswana, shortage of firewood has become a problem. The rapid population growth means not only an increased demand for firewood but also an additional demand for wood (e.g. construction of huts, fencing). Furthermore, it contributes to the expansion of the arable area, implying a clearing of the vegetation and hence a reduction of the supply of firewood. As a result, the demand for firewood may exceed its supply. Shortage of firewood has been described as a locational problem, i.e. firewood is depleting around the human settlements. In particular, in countries with a low population density like Botswana, shortage of firewood mainly occurs around the towns and large villages. In their effort to overcome firewood shortages, people may resort to burning down of living trees, hence further threatening their wood supply in the future and the quality of the soil (erosion, etc). Other adaptation strategies include travelling longer distances to collect firewood, using less preferred species, purchasing wood, increasing the demand for substitutes, reducing firewood demand by cooking with more efficient stoves or by cooking less frequently. Case studies in Botswana indicate that most of these strategies are actually used. However, there is no evidence that people cook less meals or resort to using stoves as a result of firewood shortage. The situation appears to be more serious in towns (e.g. Gaborone) and large villages (e.g. Shoshong). The situation in towns is aggravated by the rapid urbanisation.

The analysis of determinants of demand and supply of firewood shows how, many developing countries, as a result of their demographic and socio-economic characteristics, suffer from imbalances between demand and supply of firewood (see diagram 1). The fact that firewood is the main source of energy in most developing

countries, underlines the fact that shortage of wood is not only a concern of the direct users but also a concern of government as well.

We have already indicated how firewood users are affected by its shortage and how they might adapt themselves. Adaptations often take place at the expense of other activities, particularly in the case of low income households. For example, cash spent on energy cannot be used for food etc. Increased utilisation of household labour may affect other productive activities. Clearly, rural energy problems, particularly firewood, cannot be isolated from overall rural development. Adaptation strategies may also aim to supplement the wood production of the natural vegetation. In Botswana, natural wood production is low due to semi-arid conditions. However, wood production tends to be higher in overgrazed areas due to bush encroachment. Woodlots and planting of trees around the villages have up to now contributed only very little to firewood supply. Woodlots are to a large extent meant to supply wood for construction and fencing in Botswana. This is illustrated by the selection of Eucalyptus species, which are not highly appreciated as firewood.<sup>51</sup>

Although the shortage of firewood in Botswana has not yet reached the level of many other countries, the present signs of scarcity suffice the launching of a comprehensive rural energy policy, comprising also programmes of substitutes for firewood. Special attention should be paid to the areas with the most serious shortages, i.e. towns and villages. Firstly, firewood collection should be recognised as a separate form of land use. This would imply that changes and policies affecting land use should be evaluated taking into consideration their impact on firewood production. If the effects of the policy are not desirable, action should be taken to counteract this. Firewood collection should be one of the facts determining the management of land (others are, for example, crop and livestock production and wildlife). There is need for consideration as to whether areas around villages should be assigned an exclusive use by the villagers. This traditionally existing situation is threatened by the emerging shortages and related phenomenon like firewood trade. Traders should collect wood far away from villages so as to avoid interference with firewood collection by villages. This is pressing, particularly around towns. Trade is one way of overcoming shortfalls of "naturally" produced wood. Another option is the planting of woodlots. Secondly, access to substitutes for firewood should be improved, particularly around towns and large villages. This implies that the distribution and pricing system of the substitutes should be worked out in such a way that many people would have access to them. At present these forms of energy are beyond the reach of most households since only a limited number benefit from them because they cannot afford their prices. Future utilisation of these forms of energy will also depend on the development of the firewood price and the average income level of rural households. Thirdly, continued efforts to raise the energy utilisation efficiency of firewood should be supported. Special emphasis should be given to the reduction of investment costs for people and the facilitation of the acceptance of energy-saving equipment. It is expected that people will be more inclined to use stoves if the firewood shortage continues.

This paper has shown that there is a shortage of data on various aspects of firewood consumption. Therefore, more research on rural and urban firewood consumption (in  $m^3$  and kg) needs to be carried out. Furthermore, a breakdown has to be made between domestic and industrial use. Trade in firewood, particularly around towns, should be monitored so as to be able to evaluate the impact of the existing regulations. Various forms of firewood substitutes should be studied so as to assess a realistic contribution of these sources to the rural energy supply in future. Particular attention should be paid to the determinants of the selection of substitutes for firewood (income level, access to substitutes, price differences e.g.).

At present, data seems to be very fragmentary and needs supplementation bearing in mind the factors behind firewood consumption. <sup>52</sup>

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