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RURAL HOUSEHOLDS' ENERGY CONSUMPTION IN CENTRAL JAVA, INDONESIA

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by

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ABSTRACT

RURAL HOUSEHOLDS ENERGY CONSUMPTION IN CENTRAL JAVA, INDONESIA

By

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Reforestation in Indonesia, to some extent, has been negated by the reliance of rural households on fuelwood. The question as to whether or not household demand for fuelwood can be altered is relevant. This study analyzes factors that may affect a household's decision in choosing a particular type of energy, as well as the factors that may influence the levels of energy used.

In addressing those interrelated questions, Tobit model is employed. Tobit model jointly estimates the amount and the probability of a household in choosing a particular type of energy for cooking based on household income, price of fuelwood divided by kerosene price, family size, land ownership, and education level of the head of family.

The study uses data from Central Java region and shows that household income, family size and education significantly affect the amount and the probability of households in choosing fuelwood and kerosene. The effect of household income on the probability of using fuelwood and

the amounts are negative and positive, respectively. The effect of family size is positive for fuelwood and negative for kerosene. Low education level of the head of household, positively associated with the usage of agricultural wastes and fuelwood with significant coefficients.

In case of fuelwood consumption, the levels of use is 2.16 tons or 2.59 cubic meter per household per year or 0.49 cubic meters per capita per year. Increasing a household's income by 10 percent reduces fuelwood use by 12.3 kilograms or 0.0012 tons per household per year. This would lead to decreasing total fuelwood consumption for the region by 0.30 million cubic meters or eliminating fuelwood use by approximately 117,000 households (3 percent of fuelwood using households).

These results, indirectly suggest that reducing the deforestation rate by encouraging a household to use less fuelwood and use other types of fuel, theoretically, is a feasible endeavor. To achieve this objective, however, various programs such as job provision, education, and family planning have to be emphasized in the future.

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I. INTRODUCTION

Background and justifications

Biomass energy, fuelwood in particular, has long been used as a primary energy source among rural households and the urban poor (Susastro, 1983; Arnold and Jongma, 1978; Eckholm, 1975). Although fuelwood is primarily used for cooking purposes, in the mountainous areas fuelwood is also used by households as a heating source (Eckholm et al., 1984; Hadi, 1982). In addition to fuelwood, crop residues and cow dung are the other forms of biomass energy which have become increasingly important as either substitutes or supplements for fuelwood, especially in the areas where wood is becoming more scarce (Hadi et al., 1979; Eckholm et al., 1984).

The awareness of the importance of fuelwood as a source of energy in developing countries has been stimulated by the work of Erick Eckholm (1975) who first introduced the notion of the 'other energy crisis: fuelwood'. Prior to that time, the rural energy problem was largely ignored and overshadowed by cheap oil prices and overly optimistic hope for industrialization in most developing countries (Hosier, 1985b).

Many challenges facing other developing countries are shared by Indonesia, a country which comprises more than

13,000 islands, of which 6,000 are inhabited (Donner, 1987). The land surface of Indonesia covers an area of 1,999,443 square kilometers. The population of Indonesia in 1983 was 160 million, and ranked as the third largest population in Asia after the People's Republic of China and India. However, the population growth rate of 2.3 percent per annum (Biro Pusat Statistik, 1984) was higher when compared to China and India having rates of 1.5 and 2.1 percent, respectively (Donner, 1987). Although Indonesia has a relatively abundant land surface, almost 62 percent of its population lives in Java, an island which covers only seven percent of the total Indonesian land area.

As in other developing countries, fuelwood is an important source of energy in the rural areas of Indonesia. Nearly 80 percent of its total population in 1978 resided in rural areas (Hadi et al., 1979). Large numbers of rural households use fuelwood and other biomass substances as their primary energy source (Susastro, 1983; Haeruman, 1977; Sumarna and Sudiono, 1973). For example, about 75 percent of the rural households in West Java use fuelwood for cooking (Haeruman, 1977).

Estimates of average annual per capita consumption of fuelwood in rural areas of Indonesia, based on previous studies, shows a wide variation from one region to another. The reported levels ranged from 0.36 to more than 2.00 cubic meter per capita per year (Soesastro, 1983). Relatively high per capita fuelwood consumption levels have increased the awareness of the possibility of fuelwood shortages. Hadi et al.(1979), by comparing fuelwood production capability and fuelwood consumption levels, noted the presence of fuelwood shortages in some areas of Java. In fact, fuelwood shortages were not new to Java. For instance, as noted by Hamzah, in 1923 fuelwood shortages had occurred in the Wonosobo district as the demand for fuelwood by the tobacco drying industries had exceeded supply capability (Hadi, 1982).

Forest resource depletion in Java was mostly caused by an expansion of agricultural land resulting from demographic and economic development (Donner, 1987). An increasing population, which still largely relies on agricultural practices, has caused the need for more land to be used in food production. However, utilizing more land for growing food crops is usually at the expense of a natural forest cover.

A limited land resource in Java on one hand and the growing labor force in rural areas on the other hand have caused an increase of the landless farmer population. This situation in combination with the lack of employment opportunities in non-agricultural sectors has put more pressure on forest lands. Related to the lack of income earning opportunities, two other factors causing deforestation were identified by Fattah (Hadi, 1982). The first is illegal timber harvesting by people cutting forest trees for construction timber and subsequently selling it as their means of generating income. The second is excessive cutting by rural people to fulfill their fuelwood needs. In the Jogyakarta region, however, people also collect fuelwood from forest lands and market it for their income (Dick, 1980).

Impacts of population pressure on Java's environment are significant. By 1981, estimated devastation to either forest or agricultural lands in Java was 1.184 million hectares (Biro Pusat Statistik, 1984). Although successful planting programs have been reported from Central and East Java, successful replanting programs were often negated by increases in deforested lands resulting from population growth (Donner, 1987). In other words, the rate of reforestation oftentimes was below the rate of deforestation. Consequently, growing needs for food and fuel among rural people, which had been reflected by the amount of devastated land, have certainly burdened the government in its efforts at replanting these devastated lands.

Energy is a basic need, and it is a part of the government's responsibility to make energy available for the people. In compliance with this task, the Indonesian government has implemented a subsidy on kerosene (Susastro, 1983). The reasons behind the kerosene subsidy are two-fold. First, the government is attempting to stop further deforestation by encouraging rural people to use more kerosene and hence reduce fuelwood use. Second, this subsidy is based on the equity consideration, in the sense that rural people and urban poor are expected to be able to better afford this more convenient and higher quality energy if kerosene prices are kept lower (Gillis, 1980).

The subsidy policy has been criticized as short-sighted, because in the future it may promote the reliance on kerosene, a non-renewable energy resource, while at the same time it discourages the use of a renewable energy resource, fuelwood (Dick, 1980; Hadi, 1982; Donner, 1987). Further, the policy has been ineffective with respect to the income distribution. For example, only 20 percent of the kerosene was consumed by the poorest 40 percent of the population (Gillis, 1980). In other words, eventhough the kerosene subsidy helps the poor it benefits the relatively well-off even more. Therefore, since large numbers of rural households still rely on fuelwood, the pressure on forest and other vegetation still remains present.

Despite the kerosene subsidy debate, the Indonesian government has implemented a nationwide energy program which is comprised of three sub-programs, -- energy production, diversification and conservation (Anonymous, 1979). In relation to rural energy, the energy production sub-program is focused on the effort to increase fuelwood production through the expansion of fuelwood plantations and the introduction of fast growing tree species suitable for fuelwood such as the giant ipil-ipil (*Leucaena leucocephala*) and kaliandra (Calliandra callothyrsus). The energy diversification sub-program, was designed to widen energy alternatives in order to reduce the reliance upon conventional energy sources. Introduction of biogas and solar energy to rural communities is implemented under this energy diversification program. Finally, the conservation sub-program is focused on the effort to increase efficiency in using energy. A more efficient stove such as the Singer stove has been introduced and promoted in rural communities (Anonymous, 1979).

However, the effectiveness of these policy measures depends largely on the rural household as its ultimate target. The information on characteristics of rural households in association with energy use is certainly needed to evaluate the success of the energy policies. Unfortunately, little information of this kind is available.

Objectives of study

To facilitate a better understanding regarding rural energy use, in particular use for cooking purposes, this study is designed to achieve two objectives. The first objective is to provide a description of rural energy consumption. The type of energy used for cooking and the consumption levels for each particular fuel are presented. Household characteristics with regard to energy usage are analysed to provide information about the opportunities for interfuel substitution.

The second objective is to analyze the relationship between households' energy consumption and their economic and demographic characteristics and to examine the policy implications of this information. The direction as well as a magnitude of the effects of household characteristics on the decision to select a particular type of energy and the level of energy use are of interest. Implications of these characteristics are examined by estimating elasticities. A Tobit model is employed to accomplish this objective.

Scope of study

Although fuelwood crises commonly occur throughout Indonesia, especially in densely populated areas such as Java, the survey data are available only on rural energy use in the Central Java Region. The survey, from which data for this study originated, was conducted by the Forest Products Research Institute (FPRI) in 1983. Hence, this analysis is confined to that region. The second limitation of the present study is that, despite the fact that fuel availability is important in analyzing rural energy, the paucity of available data has focused this study on the consumption aspects of rural energy.

Finally, the study is focused on analyzing consumption of energy for cooking purposes. As previously mentioned, the reliance on fuelwood has created a serious environmental problem (Nasendi, 1978; Hadi, 1982; and Donner, 1987). In fact, energy consumed by rural households is largely used for cooking purposes (Susastro, 1983) for which fuelwood is the primary energy source. Thus, analyzing energy use for cooking, fuelwood in particular, may also provide useful information regarding environmental problems associated with rural household energy consumption.

Relation to other studies

Few studies on rural energy in Indonesia have been undertaken. Sumarna and Sudiono (1973) studied the fuelwood consumption by three sectors (i.e. household, industry, and railroad company) in the Province of East Java. Most rural energy studies following the research of Sumarna and Sudiono focused on finding the consumption levels of particular types of energy. Studies by Nasendi (1978) and Dwiprabowo et al. (1980) were among the few that tried to analyze relationships between various socio-economic factors and energy consumption levels.

Hadi (1982) also analyzed the effects of socio-economic factors on consumption levels. However, unlike Nasendi and Dwiprabowo et al., she proceeded by first, predicting the probability of households in selecting a particular fuel. This probability was analysed using the logit technique. Then, she estimated levels of energy use by relating them to socio-economic factors. The level of a particular type of energy use was estimated using the ordinary least squares (OLS). To do so, she restricted the estimation to subsets of the samples for each type of energy.

Tobit, a model that links the level of household fuelwood use and its economic and demographic characteristics, is utilized in this study. This model is also known as a limited dependent variable or a censored sample technique (Judge et al., 1985). It allows all energy users to be incorporated in the model instead of only subsets of energy users. The Tobit formulation is based on the cumulative normal function.

Organization of dissertation

Rural energy consumption, particularly in Java, has turned into a crisis which has negative impacts on the environment. Deforestation as a result of the growing population needing food and fuel for their subsistence livelihood is reflected by increasingly huge, denuded land areas. Eventhough this energy crisis has caused the government to considerably increase spending for land conservation and reforestation programs, nevertheless, the presence of an energy crisis, always results in rural people and the poor being worse-off. Subsistence households may adjust to fuelwood shortages by using less wood, switching to less convenient forms of energy (ie., agricultural wastes) or using up more of their precious time to collect wood.

It is clear that rural energy, in this case rural energy consumption, needs to be analyzed not only to increase the understanding of problems associated with rural energy, but also to provide information that may be useful as a basis for a sound energy policy. Previous studies on fuelwood and other types of rural energy consumption in Indonesia are described to provide insight concerning the present status of rural energy usage. Factors likely to affect energy consumption are discussed.

This is followed by a chapter which includes a descriptive analysis of the survey data. Energy users are defined and their characteristics are also identified. Categorization of rural households into energy user groups with discernible characteristics facilitates understanding of the decision-making process within households. Moreover, this categorization also facilitates an understanding of changes in energy-use patterns associated with changes of household status from subsistence living to the more modern, market-oriented households.

The presence of a decision-making process within a household in selecting a particular energy, is used as a basis for developing a probability model. The discussion of the Tobit model, which is employed to estimate the probability and amount of energy use, is presented. Variables used and expected coefficient signs of explanatory variables are discussed.

The study results are then presented. Tobit results are discussed and various factors that significantly affect the estimation are identified. Finally, the conclusions and possible implications of this study on rural energy policy are presented.

II. REVIEW OF PREVIOUS RURAL ENERGY STUDIES

This chapter has three sections. The first section focuses on the methods employed in past studies. It begins with explanations regarding earlier studies which were mostly concerned with finding data on consumption levels. The weaknesses of these approaches are presented. Then, a discussion is presented of several energy studies which collected information beyond the consumption level figures. The discussion in this first section leads to the method used in the present study, which is discussed in Chapter IV.

Variables that likely affect household energy use, especially the variables used in the past studies, are discussed in the succeeding section. The discussion in this section is used as a basis in selecting variables for the present study. Finally, the section discussing the changes in the patterns of rural energy use is presented. This section provides insights concerning the possible interfuel substitution as households move from subsistence to more modern life.

Rural energy studies

Early studies

As previously mentioned, forest land in Java, a densely populated island, has been a victim of population pressure for a long time. The strain on the sustainability of forest resources has been caused by local people in meeting their needs for food, fodder, and fuelwood through illegal cutting and land encroachment. Reasonably, most of the early rural energy studies in Indonesia were conducted by foresters, primarily in relation to the efforts of the Forest Agency to protect forest resources.

Those energy studies were intended to provide data on the levels of fuelwood consumption, and then by comparing them with the supply capability, the Forest Agency could decide whether or not it was necessary to designate a parcel of forest land for fuelwood production.

Soedarmo was among the earliest who studied fuelwood consumption in 1955 (Hadi, 1982). He estimated fuelwood use by household sector based on the assumption that fuelwood use per capita per year was 0.5 cubic meter. Although overall supply and demand were in balance, fuelwood shortages occurred in several districts. As a result of his estimation, the Forest Agency implemented fuelwood plantation programs.

A more in-depth study on fuelwood consumption was carried out by Sumarna and Sudiono (1973) in East Java province. One among their primary objectives was to examine the patterns and levels of fuelwood consumption in the household sector.

Stratified random sampling was used by Sumarna and Sudiono in selecting household samples. The stratum were urban and rural areas. Surabaya, the capital city of the province, was treated as a special stratum. In addition, two districts and three districts were chosen at random to represent urban areas and rural areas, respectively. From each selected district, villages were randomly chosen. In total, 50 villages were selected for the entire province. The sampling intensity of the survey was 0.02 percent covering as many as 1,250 households as survey respondents for the whole province.

Among others, findings were: fuelwood is still a dominant energy source in rural areas ninety six percent of the total fuelwood consumed in East Java was used by households and levels of fuelwood consumption per household per year for the entire province was 2.51 cubic meters (Table 1). The per capita consumption level was calculated from the average per household energy use level divided by the average family size. By using the average family size of 4.9 persons, calculated average consumption per capita per year for the entire province was 0.51 cubic meters.

Several studies on fuelwood consumption have been undertaken in Indonesia. The summary of their estimation regarding fuelwood consumption levels are presented in Table 2. A map of location of those studies is presented in Figure 1. Those studies generally covered very limited geographic areas, such as a watershed or a river basin area (RBA), although, estimations for the entire country had also been made.

Table 1. Fuelwood consumption per household in East Java province in 1973

Stratum	Consumption level (cubic meter)
Surabaya municipal	0.13
Urban areas	0.56
Rural areas	2.80
Province	2.51

Source: Sumarna, K. and J.Sudiono (1973). FPRI Report No. 8.

Previous studies did provide some indication regarding the importance of fuelwood as a source of rural energy. However, those studies were characterized by lack of sufficient information and by inconsistencies. As a result, it was difficult to draw useful conclusions which might have provided reliable information for policy purposes (Susastro, 1983). Several factors may lead to variations in estimated fuelwood use levels.

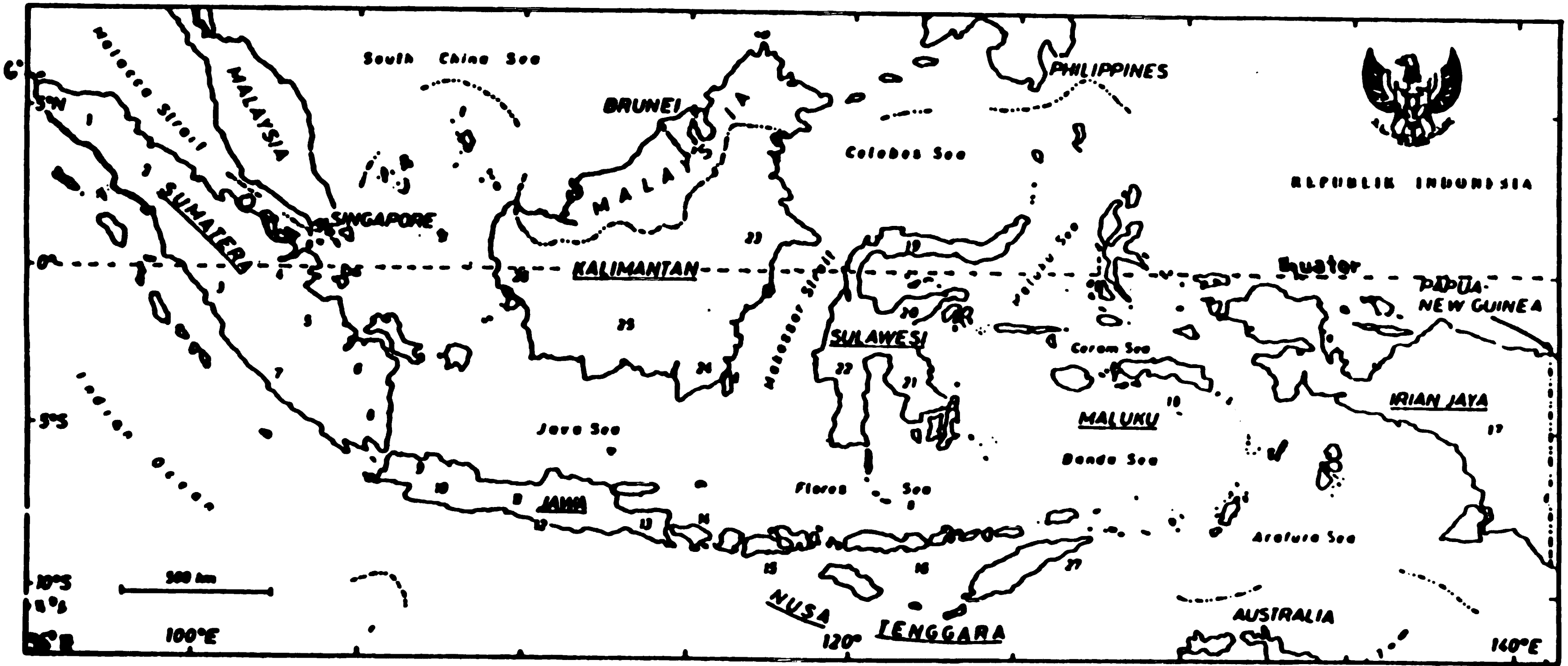
The first problem is related to how the actual energy consumption is measured. In most previous studies, estimated energy use was obtained through interviewing, rather than as a result of a direct observation (Hadi, 1982). Household respondents were asked to indicate the amounts of fuelwood or kerosene they normally used and then, the interviewer weighed and recorded the indicated amounts to provide use estimates.

Table 2. Rural Fuelwood Consumption in Indonesia (in cubic meter per capita per year) [1]

Location	Year	Consumption levels	Source
Indonesia	1956	0.50	LPHH (1970)
	1970	0.72	FAO estimates; Silitonga (1974)
	1975	0.86	Chandrasekharan (1977)
	1976	0.84	Atje (1979)
Java	1976	0.79	Atje (1979)
	1978	1.00	Hadi et al. (1979)
East Java	1971	0.51	Sumarna and Sudiono (1973)
	1978	1.27	Hadi et al. (1979)
Cent.Java	1978	0.64	Hadi et al. (1979)
Solo RB[2]	1969	0.74	LPHH (1969)
Solo RB	1975	0.36	Wiersum (1976)
Solo RB	1976	1.13	Wangsadijaya et at.,(1979)
West Java	1977	2.08	Haeruman et al.(1977)
	1978	0.43	Hadi et al. (1977)
Citanduy RB	1977	2.22	Nasendi (1978)
Citarum RB	1979	2.53	Rusydi et al.(1979)
Outside Java	1976	0.96	Atje (1979)
Bali	1978	1.06	Hadi et al. (1979)
Aceh:urban	1978	0.27	Dwiprabowo et al. (1980)[3]
rural		0.73	

1 Cited from Susastro (1983), p. 5.
2 RB is an abbreviation for River Basin.
3 Forest Products Research Institute (FPRI) Report No. 155, 1980, pp 25-32.

Figure 1. MAP OF INDONESIA



Provinces:

1 Aceh
2 North Sumatera
3 West Sumatera
4 Riau
5 Jambi
6 South Sumatera
7 Bengkulu
8 Lampung
9 Jakarta
10 West Jawa
11 Central Jawa
12 Yogyakarta
13 East Jawa
14 Bali
15 West Nusa Tenggara
16 East Nusa Tenggara
17 Irian Jaya
18 Maluku
19 North Sulawesi
20 Central Sulawesi
21 South-east Sulawesi
22 South Sulawesi
23 East Kalimantan
24 South Kalimantan
25 Central Kalimantan
26 West Kalimantan
27 East Timor

(Adopted from Donner, 1987)

In general, previous studies did not seriously consider variations of calorific value among different types of fuels (Hadi, 1982; Susastro, 1983). These variations are even more important when considering agricultural wastes, which normally have lower heat content than fuelwood and are increasingly used by rural households. If both fuelwood and agricultural wastes are simply added together into one energy category, this might account for those discrepancies.

Finally, most past studies were only concerned with finding fuelwood consumption levels and did not analyze the effects of socio-economic variables on consumption (Hadi, 1982). As a result, one could not really explain what factor or combination of factors accounted for any differences in the consumption levels.

Recent energy studies

Efforts to counter those weaknesess have been undertaken in more recent studies. For example, most recent studies have been based on the observation and direct measurement of the actual energy used instead of interviewing respondents (Susastro, 1983; Hadi, 1982). The presence of agricultural wastes has been treated by separating them into one type of energy source. Nonetheless, most of the studies were still concerned with finding consumption level figures. The exceptions are studies by Nasendi (1978), Dwiprabowo et al. (1980) and Hadi (1982); these researchers tried to analyze the effects of socio-economic factors on rural energy consumption. The remainder of this section presents an explanation of their studies and a comparison of their approaches for analyzing rural energy.

Nasendi (1978) studied rural energy consumption in the Citanduy River Basin of West Java with a special emphasis on fuelwood. His objectives were to estimate demand elasticity and to develop fuelwood demand projections for the region. The sampling technique employed was stratified random sampling. Three strata were determined based on population density per hectare of dry land (ie., low, medium, and high densities). The low density area was an area with less than 45 persons per hectare of dry land. Medium density was an area with the number of persons per hectare ranging from 45 to 70 persons. Finally, the high density area was an area with more than 70 persons per hectare of dry land.

Two villages for each stratum were selected at random. Each village represented rural and urban areas, respectively. Twenty households from each village were randomly selected resulting in total respondents of 120 households for the entire Citanduy River Basin. Amounts of energy used by individual households such as fuelwood, charcoal, and kerosene were directly observed and measured.

Economic and demographic characteristics of households, such as family income, education, family size and average age of husband and wife that might have affected energy consumption, were recorded. Relationships between the quantity energy consumed per household and economic and demographic factors were specified as follows:

$$Q_{ij} = a + bX_{1j} + cX_{2j} + dX_{3j} + eX_{4j} + \ddot{Y}_{ij}$$

where:

Q_{ij} = energy consumed per year by household j, in kilogram or litre; i=1 for fuelwood, i=2 for charcoal, i=3 for kerosene

X_{1j} = family income of household j

X_{2j} = family size of household j

X_{3j} = husband's level of education in household j

X_{4j} = average age of husband and wife of household j

$\ddot{Y}_{ij}$ = error terms

For each population density, Nasendi further classified population into low, medium, and high income classes. The low income class was for households with family income per year Rupiahs (Rps). 499,000 or less. The medium income class was comprised of those having income between Rps. 500,000 and Rps. 999,000 per year. Finally, high income households had income per year of Rps. 900,000 or more (Nasendi, 1978).

To analyze the effects of socio-economic variables on energy use, separate regressions were estimated for each population density, location (urban and rural), and income class. The regression equation for estimating the effects of socio-economic variables on energy consumption for the entire population, regardless of the differences on population density, location, and income class, was also derived. These separate estimations were intended to analyze the effects of economic and demographic variables on energy use levels for the following conditions:

1. energy use levels given the differences in income levels and population density,
2. energy use levels given the differences in income levels,
3. energy use levels given the differences in population density, and
4. energy use levels regardless of differences in income and population density.

Several study results are notable. Income levels were only important in explaining charcoal and kerosene consumption. They were less important in explaining fuelwood consumption in all locations, except for fuelwood use by low income households in low population density areas. Fuelwood consumption for low income households in low density areas was negatively affected by income levels. The effect of income on kerosene consumption was positive and significant for low income families in low and medium density areas.

Family size was a primary factor affecting the amounts of energy used for all type of energy for households with low income levels in low density areas as well as for high income households in high density areas. The effect of family size was also true in both urban and rural areas.

Tastes and preferences which were represented by the variables of the household head's education level and the average age of husband and wife were less important in explaining energy consumption.

Separate estimations based on income class show that family size significantly affected energy consumption for all types of energy in all income classes. However, within high income class households, education level of family head and average age of husband and wife were more important than family size in explaining energy use. The family income only significantly affected kerosene use in low as well as medium income classes.

The results of estimations based on location categories indicated that family income, family size, and education level significantly affected fuelwood use in low population density areas. The family size variable was more important than the income variable since it affected fuelwood use in most locations.

Estimation of energy use for the entire region, regardless of the differences in population density, income class and location, shows that family size was the primary factor affecting the use of all types of energy, fuelwood, charcoal, and kerosene. The income variable was only important in explaining charcoal and kerosene consumption.

Tastes and preferences which were represented by education level of family head and the average age of husband and wife only affected kerosene use.

Another study conducted by Dwiprabowo et al. (1980), examined fuelwood and other fuel consumption by households and industries in the Aceh province of Sumatera. The objectives of their study were to estimate the levels of fuelwood use by households and industries, and to analyze the relationship between household fuelwood consumption levels and various factors that may affect them.

In selecting household samples the authors utilized urban and rural areas as their survey stratum. Banda Aceh, the capital city of the province was chosen as reflecting urban, whereas Aceh Besar district represented a rural area. Counties in each district, as well as the villages in each selected county, were randomly chosen.

Fuelwood consumption was specified by using a multiple regression technique. Various variables that were perceived to affect fuelwood consumption levels were included in the model which was specified as follows:

$$Q = a + bX_1 + cX_2 + dX_3 + eX_4 + fX_5 + U$$

where:

Q = amount of fuelwood consumed (kilograms per capita per day)

X_1 = household income (Rps. per month)

X_2 = family size (N)

X_3 = fuelwood price (Rps per kilogram)

X_4 = education levels

X_5 = quantity of substitute fuels consumed (litres per capita per day)

U = error terms

Two estimations were made, one for urban and rural areas, respectively.

Study results indicate that fuelwood consumption in urban as well as rural areas was significantly and positively related to income and size of family. This implies that an increase in either income or family size caused household fuelwood consumption to increase.

Fuelwood price significantly affected fuelwood consumption, both in urban and rural areas, but with a negative coefficient. This implies that increases in fuelwood prices would reduce fuelwood consumption. Education level only significantly affected fuelwood consumption in urban areas, but was not important in explaining fuelwood use in rural areas.

Hadi (1982), in her study in rural areas of West Java, set two study objectives namely to describe the patterns of household energy consumption and to analyze the effects of socio-economic factors on the choice of fuel types and on the consumption levels of chosen fuels. Considering that not all household samples used any one particular fuel, Hadi employed the logit model to predict the probability of a household choosing one type of fuel such as fuelwood, agricultural wastes and kerosene. The probability of choosing a particular fuel was specified as a function of the location of a household and its socio-economic characteristics. The logit model was specified as follows:

$$P_i = \text{Prob}\ (Y_i = 1) = \frac{e^{X_i b}}{1 + e^{X_i b}}$$

where:

$i = 1, \ldots\ldots, n$ household samples

Y_i = dependent binary variables;

= 1, if taking a particular fuel

= 0, otherwise

P_i = the probability of Y taking the value 1

X_i = vector of independent variables affecting P_i

b = vector of estimate parameters

The model restriction is:

$0 \leqslant P_i \leqslant 1$

To further analyze rural energy use, she linked the amounts of particular fuels used by households to their socio-economic characteristics. The model employed was follows:

$$Y = a + b_i X_{ij} + \ddot{Y}_j$$

where:

Y = level of use of particular fuel

X_{ij} = vector of explanatory variables

$\ddot{Y}_{ij}$ = error terms

Explanatory variables used in this step were similar to those used in the model to predict the probability of using a particular type of fuel.

One finding of the study was that factors affecting the choice were different for each type of fuel. A wife's education was important in explaining the probability of choice in all fuel types. The more years in school the lower the probability of choosing biomass energy.

As expected, the type of region whether urban or rural also affected the choice between the types of biomass energy used. The stage of village development was especially important in explaining the choice of fuelwood.

Land availability only affected the choice of fuelwood and agricultural wastes, except for charcoal. Income appeared to affect only fuelwood choice, however, the effect was negligible.

Several factors affected consumption levels. A wife's education only influenced charcoal use. A region, whether it is urban or rural, significantly affected the consumption levels of fuelwood, wastes and charcoal. The level of village development significantly affected the use of biomass energy, especially fuelwood and agricultural wastes. Family size was related to the fuel consumption levels, but the effects of family size on fuelwood and agricultural wastes were not significant. Income affected kerosene consumption, but not biomass energy use. A husband's education level was not significant, but might be correlated either with family income or his wife's education.

Comparison of recent studies approaches

Compared to Nasendi (1978) and Dwiprabowo et al. (1980), Hadi (1982) recognized the fact that not all households use a particular fuel. Thus, in analyzing energy consumption, first, she modelled a qualitative choice to predict the probability of choosing a particular fuel by a household using the logit model. Then, she estimated household consumption of a particular fuel used by relating it to socio-economic factors. The problem with Hadi's estimation of energy use levels was the fact that the non-users were excluded. This difficulty can be overcome by utilizing a technique that can handle the non-user problem and yield an unbiased estimate. The available technique is the Tobit model (Judge et al., 1985).

In the present study, the choice of types of rural energy is analysed by using a limited dependent variable regression model. This model is used due to the fact that not all rural households use a particular type of energy such as fuelwood. In other words, there is an option facing rural households to choose or not to choose fuelwood. For this purpose two models, logit and probit can be used. The differences between two models is the assumption about the distribution of error terms (Pindyck and Rubinfeld, 1985).

The logit is based on logistic distribution, while probit is based on cumulative normal function. In this study, however, a Tobit model is employed. Tobit like the probit, is based on the cumulative normal function (Judge et al., 1985; Pyndick and Rubinfeld, 1985). The probit model links households choice of a particular type of energy to its demographic and economic characteristics, whereas the Tobit model links the probability and levels of energy use to the household's characteristics. Explanation of Tobit models is presented in Chapter IV.

Factors affecting energy consumption

Various factors may be important in explaining energy consumption by rural households. This section will focus on the roles of household income, tastes and preferences, family size, energy availability, and fuel prices.

Household income

The relationship between income and fuelwood consumption levels is not very clear (Laarman and Wohlgenant, 1984). If fuelwood demand is derived mostly from household cooking, then increased income theoretically will increase demand for fuelwood through improving the quantity and quality of food consumed as usually happens in the developing countries. Energy used by the poor in developing countries is close to a basic minimal requirement. Therefore, increasing household income may be followed by increasing the consumption of many goods and possibly more nutritious foods and the energy required for cooking them (FAO, 1977; and Cecelsky et al., 1979).

However, Oppenshaw (1978) finds that increasing rural incomes leads to increasing energy consumption but does not necessarily coincide with a shift to more convenient forms of energy such as charcoal and kerosene. Whether or not they will shift to using more convenient types of energy depends on other factors including the investment required to buy a stove (Hughart, 1979). Nasendi (1978) notes that household income affects consumption of commercial-energy, including charcoal, but not fuelwood. This is possible because rural households have access to a relatively free fuelwood source.

Cultural background and lifestyle may also affect the energy consumption pattern. Households with similar incomes, but different life-styles could be expected to have different energy uses (Barnes et al., 1984). The income and energy consumption relationship might hold for households having similar life-style. Yet, due to the complexity of social structures, this simple pattern cannot not be generalized in most developing countries (Hosier, 1985b).

Laarman (1987) note two possible ranges of income elasticities. They can either be positive or negative depending on household income levels. Fuelwood consumption increases correspond to increasing food consumption as household incomes increase. However, as income further increases fuelwood may start to be substituted by alternative fuels, such as kerosene. In other words, above certain income levels, income elasticity for fuelwood becomes negative.

Tastes and preferences

Tastes and preferences are non-price factors that determine demand. If household tastes change in favor of using cleaner forms of energy, the demand curve for fuelwood will shift inward to the left, meaning fuelwood use decreases. Skog (1986) who has undertaken a study on household fuelwood use in the United States notes some factors determining a household's tastes and preferences such as the age of head of household, education, family size and number of employed household members, in addition to household income.

Nasendi (1978) in his study in the Citanduy River Basin of West Java province, Indonesia, finds that education levels and ages of heads of household are important determinants of tastes and preferences. Dwiprabowo et al. (1980) in their study in Aceh province of Sumatera found that in urban areas the effects of economic variables on fuelwood consumption was more important than in their urban counterparts. In urban areas, the taste factor represented by education level was more important than economic factors in affecting the fuelwood usage.

Family size

From various domestic energy studies, household size is clearly a factor affecting energy consumption. Increasing household size is followed by increasing fuelwood and kerosene consumption. As household size increases so does household fuel consumption, but on a per capita basis the amount of fuel consumed decreases. In other words, a larger sized family uses energy more efficiently than a smaller one (Hosier, 1985a; and Susastro, 1983). For example, a study by Susastro found that per capita energy input for cooking for a household of eight members or larger is about half that of a family having less than five members.

Energy availability

Fuelwood or any other fuel consumption depends on its availability. Earl (1975) observed the behavior of hill people of Nepal who had moved to new settlement areas in wood-rich valleys, found that the average fuelwood consumption in the new place was doubled compared to the level in their previous living environment. The tendency of rural people to use more fuelwood as the resource becomes more abundant has also been reported from various studies in Indonesia (Haeruman, 1977; Nasendi, 1978; and Susastro, 1983). Hosier (1985a) notes that fuelwood consumption will decrease as its source becomes increasingly scarce.

Fuelwood for most rural people in developing countries is largely a non-market commodity which means it can be 'freely' collected. Price of fuelwood in this situation is represented by the opportunity cost of labor to collect it. The opportunity cost is low when fuelwood is abundant, because less time is needed to gather fuelwood. However, when fuelwood becomes scarce, more time is required to gather fuelwood which means labor opportunity costs are higher. As a result, less fuelwood may be consumed. Rural households usually adjust to a decreasing fuelwood scarcity either through substitution or conservation (Hosier, 1985b).

Fuel prices

For commercial energy, the relationship between price and quantity demanded can be expected to correspond with the demand theory. That is, as the price increases quantity demanded goes down for the good and up for substitutes. However, fuelwood is often freely-gathered and is out of the monetary market. Demand for fuelwood may decrease as distance to source increases. Thus, the time required for collecting fuelwood may represent its price (Hosier, 1985b).

Yet, there is a segment of rural households, particularly salary earners such as teachers, who usually purchase fuelwood for cooking purposes. They, therefore, are outside of a usual pattern of subsistence living (Foley and van Buren, 1980). The price of fuelwood is an important factor to people who have to buy it at the market (Wardle and Palmieri, 1981). In other words, for this segment of rural households, the price and quantity relationship might still hold.

A study by Dick (1980) in the Jogyakarta region shows that the price of fuelwood did affect substitutability between fuelwood and other lower quality biomass energies such as crop residues. In his observation, Dick found that whenever markets for fuelwood exist, households tended to reduce their fuelwood consumption and sell it completely or partly for income. In this case, crop residues are consumed for their personal use. While household energy consumption for cooking in terms of total input energy does not necessarily decrease, household fuelwood consumption may sharply decrease.

Energy consumption and rural development

The use of fuelwood and other biomass energy, which normally are freely collected, is always associated with subsistence among the poor in developing countries. Some experts believe that this energy use pattern may continue into the distant future (Eckholm et al., 1984). This perception has influenced analysts to make pessimistic presumptions when trying to develop energy demand projections. For example, they often assume that levels of fuelwood use per capita will remain constant for a certain period of time, because they project slow growth in general economic development.

This line of thinking often ignores the dynamics of rural energy consumption. In fact, energy consumption patterns are related to the economic status of corresponding society. Fuelwood for most rural people in developing countries is a basic necessity. On the other hand, when affluent households in developed countries burn fuelwood for their fireplaces, it is more because they consume the amenities value of burning wood (Bohi, 1981). In other words, fuelwood may be perceived differently by households with different socio-economic status.

The subsistence life-style is characterized by the absence or a limited role of the market mechanism in allocating resources. If subsistence lies in one extreme, the capitalistic way of life lies in the other extreme position. Capitalism is characterized by the operation of market mechanisms in resource allocation. Between those extremes, there are transitional stages which blend the two life-styles. The tendency of economic development is always the movement from subsistence toward a market- oriented society.

This movement is likely to affect rural household behavior. For example, the objective of farmers was once to merely survive and maintain a subsistence level, however, it is now becoming more of a business-like orientation with profit maximizing behavior (Hosier, 1985b). This reorientation may also affect the energy use pattern among rural households. As people become increasingly wealthier, there is a tendency to shift from using fuelwood to using more convenient energy such kerosene. For instance, Susastro (1983) observed that the relatively rich households in rural areas of West Java preferred to use kerosene than fuelwood, because kerosene is perceived as 'clean' and easy to use.

To increase household well-being is one of the objectives of development programs now being undertaken by the government of Indonesia. Rural development is an important aspect within the national development programs. In promoting rural development, the government has classified villages based on their developmental stages. Three levels of village are Swadaya (traditional), Swakarya (transitional), and Swasembada (modern). Among indicators used in these classifications are economic criteria such as economic structure (percentage of population engaged in agriculture, industry and service) in the respecting village and the degree to which agricultural products are being valued in monetary terms (Susastro, 1983).

Hadi (1982) notes that village levels of development do affect fuelwood consumption. She observed that average households in more developed villages used less fuelwood than households in less developed villages. In more modern villages the number of wealthier households tended to be greater than in less developed villages. Clearly, there is a relationship between type of energy used and the levels of rural development, or to be more specific, a relationship exists between energy use patterns and the levels of socio-economic status of households, whether subsistence or modern.

The formal effort to link energy use patterns and households in transition was among others undertaken by Fisk and Hosier (Hosier, 1985b). Fisk proposed four categories of households in transition: " pure subsistence, subsistence agriculture with supplementary cash production, cash agriculture with supplementary subsistence, and complete market specialization." Hosier (1985b) in linking energy use patterns and rural transformation, first classifies households based on the degree of household involvement in the market economy. He categorized households into food-crop farmers, cash-crop farmers, and wage earners. He further broke down those farmer groups into non-surplus farmers, surplus farmers, cash/surplus farmers, and cash-crop farmers. Thus he came up with five categories of rural households starting from non-surplus farmer to wage earner.

Hosier found that fuelwood use is less among wage earners, while charcoal use is the highest among wage earners and cash-crop farmers. Paraffin use shows a little variation across household categories. He concluded that a household which is involved in the monetary economy is less likely to rely on fuelwood. In other words, dependency on fuelwood decreases as a household becomes more market oriented.

Summary

Fuelwood is the primary if not sole source of domestic energy needs in developing countries. There are many factors that affect household energy consumption which have been the focus of more recent rural energy studies. Among the studies that went beyond seeking energy use level figures were those by Nasendi (1978), Dwiprabowo et al. (1980) and Hadi (1982).

Nasendi (1978) and Dwiprabowo et al. (1980) employed an econometric technique to analyze the effects of various economic and demographic factors on energy use. The fact, that not all respondents use a particular type of energy was later elaborated by Hadi (1982) who employed a binary choice model, the logit technique, to handle the non-user problem. Yet, in linking energy use levels to economic variables she utilized the ordinary least square (OLS) technique, which in fact, is not designed to handle the zero dependent variable. Thus, in doing so she was restricted to the sample using a particular energy in question.

Various factors affecting fuelwood consumption by rural households have been reported ranging from economic to demographic factors. The summary of variables used by recent energy studies is presented in Table 3. Income seems the most important economic variable affecting the energy use levels. Family size was an important demographic variable for explaining both the probability of use of a particular energy and the level of energy use as well. Education of husband and wife may or may not affect the probability or the level of energy consumed. Land ownership affects the probability of choosing biomass energy. Physical factors such as energy availability which was reflected by region in the study by Hadi (1982) also influenced fuelwood consumption.

Finally, the effort to link energy use patterns to development stage shows that the decision-making process among households in choosing a particular type of energy does exist. In addition, it provides a sense that interfuel substitution may occur concurrently with the changes of the socio-economic status of households. Thus, changes in household characteristics can be expected to affect the patterns of energy use.

Table 3. Summary of the variables used in the previous rural energy studies and their significances

Variable	Energy type			Sources
	Wastes	Fuelwood	Kerosene	
Household income	ns[1]	ns	+ [2]	Nasendi (1978),
		+	na [3]	Dwiprabowo et al. (1980),
	ns	+		Hadi (1982).
Fuelwood price		+		Dwiprabowo et al. (1980).
Family size	ns	+	+	Nasendi (1978),
		+	na	Dwiprabowo et al. (1980),
	ns	+		Hadi (1982).
Average age of husband and wife		ns	ns	Nasendi (1978).
Education of wife	ns	ns	ns	Hadi (1982).
Land holding	ns	ns	- [4]	Hadi (1982).

[1] ns = non significant.
[2] Significant at 5 percent level.
[3] na = non applicable.
[4] Significant at 5 percent level.

III. RURAL ENERGY CONSUMPTION IN CENTRAL JAVA

In this chapter, the description of rural energy consumption in the Central Java Region of Indonesia is presented. This description, based on the rural energy survey conducted by the Forest Products Research Institute (FPRI) in 1983[1], is organized into three sections. The first section presents a brief explanation regarding the survey sample and its location. The second section focuses on the levels of energy consumption by types of energy. Variation of energy use among districts is also presented. The last section contains a discussion regarding the link between energy consumption and rural development.

Study location

The Central Java Region is comprised of two provinces, Central Java and Jogyakarta (Figure 2).[2] The region is bordered to the east by East Java province, and to the west by West Java province. The north and south borders are the Java Sea and the Indian Ocean respectively. The region

1 The survey was designed to address the weaknesses of past studies (see Chapter II pp. 15 and 18). For a further explanation regarding the survey, see Appendix 1.

2 This aggregation is merely for convenience of the study. The arguments for aggregation are two-fold, first is the fact that those two provinces are geographically located in the central part of Java island. And secondly, these two provinces are inhabited by the Javanese, which culturally is a homogeneous ethnic group.

covers an area of approximately 3.7 million hectares and was inhabited by more than 29 million persons or around 6 million households in 1983 (Biro Pusat Statistik, 1984).

The rural energy consumption survey covered six districts including Banyumas, Bantul, Blora, Pemalang, Purworejo, and Temanggung. Those six selected districts were expected to represent different ecological types within the region. The survey location is shown map in Figure 2.

Two counties in each district were randomly chosen and then in each selected county three villages were chosen at random. The selection of districts, counties, and villages was done prior to the field work. In each village, 25 households were randomly selected as survey respondents. Thus, the total numbers of households selected in that survey were 750 households[3] for the entire region. The selection of households was done in the field based on the household list provided by the village administration office. The results of sample selection are presented in Table 4.

Energy use levels

Energy, as defined in this study, is the energy used by a household for cooking. Energy use other than for cooking is not considered in the study.

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[3] The final 732 out of 750 questionnaires were chosen for further analysis by the survey coordinator. The reasons to drop some questionnaires are described in the Appendix 1.

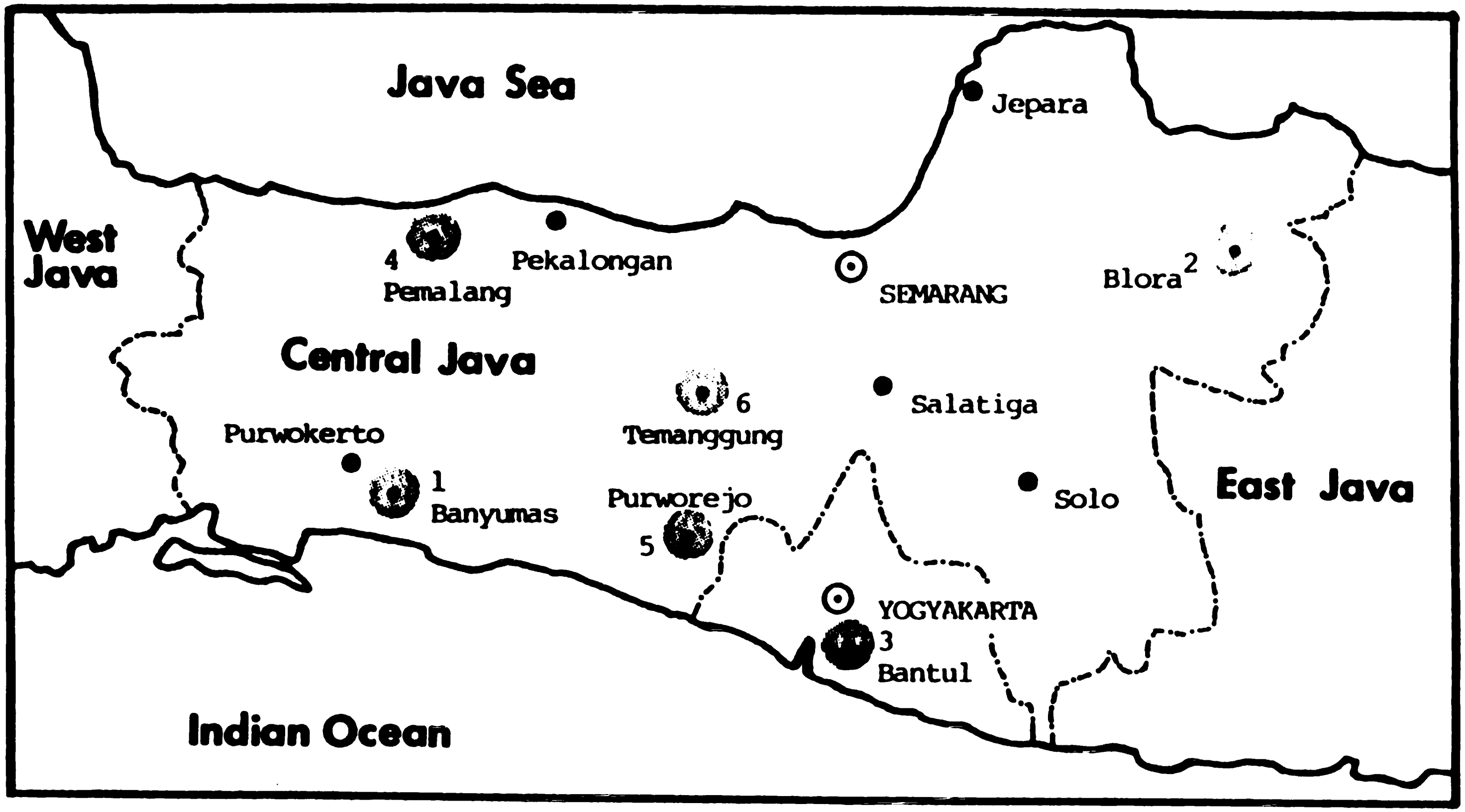

Figure 2. The locations of the rural energy survey (1983)

Capital city

District

1, 2, 3, 4, 5, and 6 were survey locations

Table 4. Districts, counties, and villages selected [1]

District	County	Village
Bantul	Kretek	Pr.tritis
		Donotirto
		Tirtohargo
	Pajangan	Sendangsari
		Triwidadi
Banyumas	Kebasen	Kebasen
		Madirancan
		Cindaga
	Patikraja	Patikraja
		Notog
Blora	Ngawen	Ngawen
		Srigading
	Cepu	Cepu
		Jipang
		Ngloram
Pemalang	Rd.dongkal	Rd.dongkal
		Kalimas
		Gongseng
	Petarukan	Petarukan
		Loning
Purworejo	Loano	Loano
		Jetis
		Maron
	Banyuurip	Banyuurip
		Kebasen
Temanggung	Ngadirejo	Banjarsari
		Mendari
		Katekan
	Pringsurat	Klepu
		Ngipik

[1] Central Java province: Banyumas, Blora, Pemalang Purworejo and Temanggung.
Yogyakarta province : Bantul district.

Based on survey data, the type of energy used for cooking by a household in the rural area of Central Java Region varied from agricultural wastes to kerosene. Agricultural wastes, henceforth are called wastes, are comprised of a wide range of substances such as residues from agricultural crops (e.g., rice stalks, rice husks, peanut shells, soybean shells, corn stalks, corn cobs, corn husks, and cassava stalks). Wastes such as coconut husks, coconut shell, coconut leaves and twigs were also commonly used especially in Banyumas and Purworejo districts.

A household might use one type of energy, but they might also use a combination of energy types. Based on the types of energy used, household samples are categorized into five groups as follows:

1. Agricultural wastes users (AGWA) consist of households using wastes entirely as their energy sources for cooking,
2. Mixed biomass energy users (FWAW) are households who use fuelwood in combination with wastes,
3. Fuelwood users (WOOD) are households using entirely fuelwood for their cooking purposes,
4. Mixed energy users (KEBI) are households using a combination of fuelwood and kerosene, and
5. Kerosene users (KERO) are households using only kerosene for their cooking energy.

The survey data shows that biomass energy, wastes or fuelwood, still plays an indispensable role as a source of energy in rural areas. Biomass energy is used by nearly 90 percent of household samples in the region (Table 5). The percentage of households using biomass energy varied from one district to another. It ranged from 76 percent in Pemalang to more than 97 percent in Bantul district.

Fuelwood is an important biomass energy source in most of the sample districts, followed by wastes. In three districts (Blora, Pemalang, and Temanggung) fuelwood was the only type of biomass energy used by household samples. On the other hand, in three other districts (Bantul, Banyumas, and Purworejo) the percentage of households using wastes, especially in combination with fuelwood (FWAW) was higher. Differences on the relative contribution of a particular type of energy in each district may be associated with its relative availability.

Although kerosene distribution has penetrated rural areas of Java (Susastro, 1983), its role as an energy source for rural people, in particular for cooking, is still limited. Susastro's observation is also supported by this survey data which shows that less than 20 percent of household samples in Central Java Region used commercial energy. No single household sample using kerosene (KERO) was recorded in Bantul district. The highest percentage of households using kerosene was in Pemalang (16 percent).

Table 5. Household responses by energy type and district [1]

District	Biomass				KEBI	KERO	Total
	AGWA	FWAW	WOOD	Total			Household
Banyumas	3 (2.40)	31 (25.00)	78 (62.90)	112 (90.30)	3 (2.40)	9 (7.30)	124 (100.00)
Bantul	20 (16.80)	31 (26.00)	66 (55.50)	117 (98.30)	2 (1.70)	0 (0.00)	119 (100.00)
Blora	0 (0.00)	0 (0.00)	106 (89.10)	106 (89.10)	2 (1.70)	11 (9.20)	119 (100.00)
Pemalang	0 (0.00)	0 (0.00)	93 (76.20)	93 (76.20)	9 (7.40)	20 (16.40)	122 (100.00)
Purworejo	25 (20.20)	91 (73.40)	5 (4.00)	121 (97.60)	2 (1.20)	2 (1.20)	125 (100.00)
Temanggung	0 (0.00)	0 (0.00)	111 (89.50)	111 (89.50)	4 (4.10)	8 (6.40)	123 (100.00)
Region	48 (6.50)	153 (20.90)	459 (62.70)	660 (90.20)	22 (3.00)	50 (6.80)	732 (100.00)

[1] Figures in parentheses are percentage of users to the total household samples.

Pemalang district, according to Biro Pusat Statistik (1987), is located in the zone which is categorized as a developed area. Therefore, high kerosene usage in Pemalang might be due to a better distribution channel for kerosene relative to channels in other districts.

The average daily energy use by energy type per household is presented in Tables 6, 7, and 8. There are three different calculations on the levels of energy usage. The first calculation is based on the energy level used when all household samples are included, regardless of energy type actually used (Table 6). The second calculation is based only on household samples using one particular type of energy. For example, average fuelwood per household is calculated based on household samples using entirely fuelwood (Table 7). The last calculation includes household samples using one or more specific types of energy. For example, the average fuelwood use per household is calculated based on household samples who used either entirely fuelwood, or used fuelwood in combination with other energy types, either wastes or kerosene (Tables 8).

The series of tables clearly indicate that the levels of energy use will increase if non-users are excluded from calculation. For example, in Table 6, average daily fuelwood use per household is 5.35 kilograms, and when non-users are dropped, the fuelwood use level is increased to 6.87 kilograms (Table 7).

Fuelwood use by households using a combination of energy, for instance fuelwood with agricultural wastes, is lower than households using entirely fuelwood. However, the amount of reduction may depend on the amount of fuelwood substitute used, ceteris paribus. For example, when a household used only fuelwood, the amount of wood use per day per household was 6.87 kilograms (Table 7). But when a household used fuelwood in combination with another energy type, the amount of fuelwood used was somewhat less, 6.18 kilograms (Table 8).

Daily fuelwood consumption per household among samples who used only fuelwood for all regions was 6.87 kilograms. The levels of consumption among districts ranged from 5.14 kilograms in Pemalang to 8.52 kilograms in Temanggung (Table 7).

Kerosene consumption per household per day for kerosene user (KERO) was 0.89 litres. Average consumption ranged from the lowest daily use of 0.77 to 1.17 litres in Blora and Banyumas districts, respectively (Table 7).

Standard errors of the mean energy use levels, both fuelwood and kerosene, were consistently high either at the region or district levels. These high standard errors indicated that the daily use of a particular energy among households varied considerably. The variation of energy use levels might be closely related to the variability of economic and demographic characteristics of households. For example, considerable variations on household size across

Table 6. Average daily energy use per household by energy type and district for all samples [1]

District	N	Energy type		
		Ag.wastes	Fuelwood	Kerosene
Banyumas	124	0.59 (1.57)[2]	6.64 (3.90)	0.10 (0.33)
Bantul	119	1.36 (2.56)	4.55 (3.76)	0.01 (0.06)
Blora	119	-	5.31 (3.87)	0.08 (0.26)
Pemalang	122	-	4.29 (3.42)	0.21 (0.26)
Purworejo	125	4.06 (2.95)	3.46 (3.56)	0.02 (0.12)
Temanggung	123	-	7.78 (4.73)	0.08 (0.25)
Region	732	1.04 (2.29)	5.35 (4.15)	0.08 (0.28)

[1] The levels of wastes and fuelwood used are in kilograms (kg), kerosene is in litres.
[2] Figures in parentheses are standard errors.

Table 7. Average daily energy use per household by energy type and district for samples using only one type of energy[1]

District	Energy type					
	Ag.wastes		Fuelwood		Kerosene	
	N	L [2]	N	L	N	L
Banyumas	3	6.41 (5.96)[3]	78	8.22 (3.13)	9	1.17 (0.31)
Bantul	20	5.94 (3.83)	66	6.56 (3.59)	-	-
Blora	-	-	106	5.90 (3.97)	11	0.77 (0.38)
Pemalang	-	-	93	5.14 (2.93)	20	0.92 (0.48)
Purworejo	25	5.86	5	6.12 (4.07)	2	0.94 (0.17)
Temanggung	-	-	111	8.52 (4.34)	8	0.86 (0.38)
Region	48	5.76 (3.10)	459	6.87 (3.83)	50	0.89 (0.36)

1 The levels of ag.wastes and fuelwood used are in kg., kerosene is in litres.
2 N = number of samples, L = levels.
3 Figures in parentheses are standard errors.

Table 8. Average daily energy use per household by energy type and district for samples who use one or more specific types of energy [1]

District	Energy type					
	Ag. wastes		Fuelwood		Kerosene	
	N	L [2]	N	L	N	L
Banyumas	37	2.17 (2.39)[3]	112	7.35 (3.40)	12	1.01 (0.48)
Bantul	51	3.17 (3.09)	99	5.58 (3.41)	2	0.44 (0.18)
Blora	-	-	108	5.84 (3.65)	13	0.77 (0.33)
Pemalang	-	-	102	5.13 (3.11)	29	0.87 (0.60)
Purworejo	118	4.13 (2.86)	98	4.41 (3.46)	4	0.57 (0.45)
Temanggung	-	-	115	8.32 (4.41)	12	0.77 (0.36)
Region	206	3.70 (2.97)	634	6.18 (3.84)	72	0.80 (0.45)

[1] The levels of ag.wastes and fuelwood used are in kg., kerosene used is in litres.
[2] N = number of samples, L = levels.
[3] Figures in parentheses are standard errors.

household samples might lead to the high variation of the daily energy use level per household as shown by high standard errors.

Another factor contributing to the variation in the daily use of a particular energy may be the relative availability of respective types of energy to households. For instance, a household living near a forest or other fuelwood source may tend to use more fuelwood than a household far from a source, ceteris paribus. Unfortunately, instead of recording a distance to fuelwood source, survey recorded the distance to any energy source (Appendix 1, p. 144). Therefore, specific analysis using this variable can not be pursued.

Household characteristics and energy use

The variability on daily energy use levels by households as shown in the previous section encourages further exploration of the effects of some economic and demographic variables on energy use. In fact, those variables are likely to be interrelated in influencing the type of energy used as well as the levels of energy consumed by households. However, the following presentation emphasizes the effects of individual variables, such as income, family size, education and land ownership, on energy use.

Although income is not the only variable affecting household energy use, it is an important economic variable that is often used to measure the relative well-being of a household. Family income is expected to affect the level and type of energy use. To identify the income effect on energy use, household samples were separated into three monthly income categories. The levels of energy use by energy type and income class are presented in Table 9.

Household fuelwood use levels were significantly different across income classes. The use of fuelwood tends to increase as family income increases. The plausible explanation for this phenomenon is that households tend to purchase more food as their income increases which in turn, requires more fuelwood for cooking.

Although fuelwood use levels increased as household income increased, the number of households using fuelwood tended to decrease as household income increased. Similarly, the number of households using wastes decreased as household income increased.

The difference across income classes in the amounts of kerosene and wastes used were not statistically significant. The insignificance among kerosene users might have been due to the small number of samples in the low-income brackets using kerosene. Yet, there was a tendency towards the number of kerosene users increasing as household income increased. This implies, that as household income

Table 9. Average daily household energy use by energy type and monthly income class [1]

Energy type	Income class (in thousand Rps.)[2]		
	< 25	25 - 75	> 75
Wastes [ns]			
N [3]	118	77	10
levels (kg)	3.780	3.557	4.270
Fuelwood [**]			
N	310	261	61
levels (kg)	5.648	6.625	7.088
Kerosene [ns]			
N	4	12	57
levels (litre)	0.503	0.537	1.145

1 Household may use a combination of energy, therefore one household may be counted more than once.
2 Rps. stand for Rupiahs, the Indonesian currency. Exchange rate in 1983: 1 US $ = Rps. 450.
3 N = number of samples.
ns Non-significant at 95 percent level.
** Significant at 99 percent level.

increases, households tend to shift from using biomass energy to more modern types of energy such as kerosene.

Family size significantly affected household consumption of fuelwood and wastes, but not kerosene use (Table 10). The relatively small sample of households using kerosene might have contributed to this insignificance.

Increasing use of fuelwood and wastes along with increases in family size, ceteris paribus, might be due to the fact that a household with a larger family has more labor available for collecting fuelwood and wastes than a smaller size household would have. Among biomass energy users, household biomass energy use increases as household size becomes larger, but at decreasing rate. For example, the per capita daily fuelwood use for small, medium, and large families was 1.028, 0.727, and 0.473 kilograms, respectively.

Education of the head of family is significantly related to kerosene use, but not to biomass energy use (Table 11). It might be possible that when fuelwood and other biomass energy are relatively available, rural households would more likely use those energy sources, regardless of their educational background.

The largest number of households using biomass energy were those having low formal education or none at all. On the other hand, among kerosene users the number of households with higher education level (ie., middle school

Table 10. Average daily household energy use by energy type and family size [1]

Energy type	Family size [2]		
	< 5	5 - 7	>7
Wastes **			
N [3]	103	79	23
level (kg)	3.186	4.289	4.158
Fuelwood**			
N	223	297	111
level (kg)	4.741	6.582	8.104
Kerosene ns			
N	22	41	10
level (litre)	0.555	1.210	1.135

[1] Household might used a combination of energy, hence it might be counted more than once.
[2] Average family size for each family size groups were 3.1, 5.9, and 8.8, respectively.
[3] N = number of samples
** Significant at 95 percent level
ns Non-significant at 95 percent level

graduates or higher) was larger than households with lower educational backgrounds. This implies that, the higher their education is, the less likely that rural households will use fuelwood.

Land ownership or size of holdings significantly affected fuelwood and kerosene used by households. On the other hand, waste usage was not influenced by land ownership (Table 12). A possible explanation of this, was the fact, that agricultural wastes are residues from agricultural products which are often perceived as 'unuseful' substances and therefore, they are largely left in the field. They, in turn, become a free source of energy for people having little or no land. In other words, land ownership is not a necessary condition for having access to waste energy sources. Fuelwood use levels tend to increase as land owned by a household increases. This might be related to the fact that increases in land owned mean more fuelwood is available, and hence more fuelwood is consumed. With respect to kerosene usage, there may be rural households who own land and experience a surplus of agricultural products that could be traded for cash; or other households which possess land, but are engaged in off-farm income-generating activities (e.g., teachers and government employees). For this segment of the rural population, who may no longer be living in a subsistence condition, commercial energy such as kerosene is an affordable energy alternative and hence they would most likely use kerosene for their cooking energy.

Table 11. Average daily household energy use by energy type and education level [1]

Energy type	Education level		
	uneducated and elementary school	middle school	high school or college
Wastes [ns]			
N [2]	188	16	1
level (kg)	3.808	2.741	3.000
Fuelwood [ns]			
N	570	42	20
level (kg)	6.160	6.642	6.228
Kerosene **			
N	13	42	17
level (litre)	0.503	0.934	0.821

[1] Household might use a combination of energy hence it might be counted more than once. Education refers to the education of head of family.
[ns] Non-significant at 95 percent level.
[2] N = number of samples.
** Significant at 95 percent level.

Table 12. Average daily household energy use by energy type and land ownership [1]

Energy type	Land ownership (hectare)		
	0.25	0.25 - 0.50	0.50
Wastes [ns]			
N [2]	93	43	65
level (kg)	3.500	4.030	3.911
Fuelwood **			
N	265	121	229
level (kg)	5.060	6.463	7.406
Kerosene **			
N	32	5	34
level (litre)	0.708	0.666	0.983

[1] Household might be use a combination of energy, so it might be counted more than once.
[ns] Non significant at 95 percent level.
[2] N = number of samples.
** Significant at 95 percent level.

Energy consumption and rural development

This section focuses on the linkage between energy use patterns and status of households in the transition from subsistence to more market-oriented activities. The reason for examining this linkage is to identify dynamic elements influencing rural energy consumption patterns.

As previously explained, Hosier (1985b) classified households into groups that reflected a transition from subsistence households toward more market-oriented households. Then, he identified the type of energy used by each household category. Hosier concluded that as a rural household moves toward becoming more a modern household, it tended to shift from using fuelwood and wastes to using kerosene. [4]

In this study, the approach is reversed, in the sense that first, households are categorized into energy user group based on the type of energy they used. Then, household characteristics which would most likely distinguish one energy user group to another are identified. The presumption regarding this approach is that the categorization based on energy used starts with household behavior rather than life-style categories. Reasonably, there may be various household characteristics that can be used as a basis to distinguish one energy user group over

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[4] See explanation in the chapter of previous studies (p. 36).

another. This section is intended to identify the characteristics of households that most likely relate to specific energy-user groups.

Compared to the type of categorization used by Hosier (1985b), categorizing of households into user groups in this study is convenient and logical. Since the type of energy used by a household can be observed, there is not any problem in fitting a certain household into a specific category. The major criticism on the life-style categorization system used by Hosier is the difficulty in fitting households having continuous characteristics into discrete categorizations. In fact, numerous households simply not conform into any category. For example, what kind of category would be appropriate for a head of household working as a wage earner who simultaneously has a tract of land providing him with additional income? Would he be a wage earner or cash-crop farmer? Although Hosier developed a criterion to solve this problem, the criterion itself contained arbitrary elements.

As noted previously in this chapter, household samples can be categorized into five energy user categories: agricultural waste users (AGWA), waste and fuelwood users (FWAW), fuelwood users (WOOD), biomass and kerosene users (KEBI), and kerosene users (KERO). Additionally, we hypothesize that there must be some characteristics associated with each energy-user group.

Some variables characterizing those user groups are presented in Table 13. Analysis of variance shows that several household characteristics such as income, education, and household size are statistically very significant across user groups.

Household income and education of the head of household show a consistent pattern, hence they can be easily interpreted. For instance, households with high income levels can be expected not to belong to the AGWA group, because they are more likely to use fuelwood or kerosene. Education levels of household heads also showed similar patterns. The higher the household head's education was, the less the likelihood that this corresponding household would use fuelwood. On the other hand, even though household size is significant, there is no consistent pattern shown by this variable. The plausible explanation for the lack of pattern associated with family size may be that some variables were correlated with household size in explaining household behavior toward the choice of energy. Another possible explanation is that, while household size certainly influenced the level of energy use, some other variables might be more important in explaining energy choice than the household size variable.

The effect of the land ownership variable on energy use categorization was not significant. However, among households using biomass energy (AGWA, FWAW, WOOD, and KEBI)

Table 13. Household characteristics by energy user category

User group	N	Variables [1]			
		Family income** (Rps./mo)	Head of fam. Education**	Land own. (Ha)	Family Size**
AGWA	48	25.244	1.79	0.474	4.18
FWAW	153	30.326	1.86	0.556	4.80
WOOD	459	47.531	1.81	0.536	5.54
KEBI	22	118.968	2.68	0.736	6.68
KERO	50	143.970	3.20	0.533	5.04

[1] Income refers to monthly household income in 1000 Rps. Education refers to education of family's head; Education is categorized into 1= no education, 2=elementary graduate, 3= middle school graduate, 4= high school graduate, and 5 = college and university graduate. Land refers to household land ownership in hectares. Size refers to size of family.

** Significant at 99 percent level.

there was a pattern of land ownership associated with type of energy user. On average AGWA users had less land and KEBI users had the largest amount. Unlike others, KERO users were largely comprised of wage earners. Thus, they possessed land, it was not necessarily used as a source of fuelwood. Instead, it was more of a source for additional income.

Although some variables do differ across user groups, more information is still needed in examining this categorization. Information such as types of occupation, sources of income and distance to fuelwood sources are important.

Summary

Biomass energy, fuelwood in particular is still a dominant source of energy in rural areas of Central Java. Although kerosene is increasingly being used in rural areas, kerosene use for cooking purposes is still limited. Agricultural wastes play a significant role in the districts of Bantul, Banyumas, especially in Purworejo.

High average daily energy use among rural households tended to associate with high income class group. There is also an indication, that less respondents among the highest income class group used agricultural wastes.

Family size tends to positively affect levels of household daily energy used. The larger the size of family is, the higher the levels of energy use would be. However, the amount of use per capita declines as family size become larger.

Households with the head of family having lowest education level tend to rely on biomass energy (ie., agricultural wastes and fuelwood) for their cooking purposes.

Average daily fuelwood consumption tends to positively related to land holding size. The amount is higher for households having larger tract of land. This tendency is not clear on agricultural wastes and kerosene use.

High variation in energy consumption exists both in per household and in per capita levels. Thus, it is crucial to pursue analyses beyond average consumption levels in order to identify the factors affecting those variations.

The classification of household samples into five energy-user groups provides more information concerning the likelihood of household response to energy options. Income and education provide consistent patterns across energy user groups. These results strongly support the importance of including the decision to use or not to use a particular type of energy among households in modelling rural energy consumptions patterns.

IV. METHODS

In the traditional approach to demand analysis, utility is assumed to be derived from consuming a bundle of goods. In this sense, goods are perceived as direct objects of utility. Yet, this approach ignores intrinsic properties that goods may have (Lancaster, 1966). In fact, characteristics of goods provide very useful information for consumers in choosing particular goods.

Lancaster further argues that utility is derived from the properties or characteristics of the goods, not from goods themselves. He defines consumption as a process in which a combination of goods is transformed into output which is viewed as a bundle of characteristics. This bundle of characteristics is called a commodity (Becker, 1965). In other words, goods are inputs and commodities are outputs that are produced by combining various inputs. This argument implies that commodities, not goods, actually enter directly into the utility function.

The formulation of energy use in this study is in line with this notion of commodities, in the sense, that heat for cooking, not fuelwood, actually is consumed by a household. Therefore, fuelwood and other energy sources are inputs that together with other inputs (e.g., stoves) produce heat as a commodity. While other energy sources are substitutes for fuelwood, a stove is a complementary good. This formulation is also used by Hardie and Hassan (1986) and Skog (1986) in their energy studies in the United States.

Given the notion of heat as a commodity, we can formulate energy consumption decisions as containing two interconnected and continuous processes. First, given the availability of various types of fuel that can be used to produce heat, an individual household will decide to choose a particular energy among the alternatives. After a particular energy is chosen, the second step taken by a household is to determine the amounts of energy to use.

Decision to use a particular energy

The model of a qualitative choice has a general form as follows (Pindyck and Rubinfeld, 1981):

$$P_i = F(X'B) = F(Z_i) \qquad (1)$$

where:

P_i = probability to choose i type energy

X = vector of explanatory variables

B = vector of coefficients

Z_i = index which is determined by explanatory variable X

F = cumulative probability function

Two commonly used alternative probability functions are the normal and the logistic functions. If we assumed the cumulative probability is normally distributed, the probit[1] specification is appropriate. Assuming that the probability

[1] The probit specification is explained in Appendix 2.

is distributed in the logistic results in the logit specification.

One difference between the two distributions is that logit has a flatter tail (Pindyck and Rubinfeld, 1985) as shown in Figure 3. However, both probit and logit yield similar results, therefore the choice between them usually is based on a practical reason as Aldrich and Nelson (1984) noted:

> The logistic and normal curves are so similar as to yield essentially identical results. In practice, they yield estimated choice probabilities that differ by less than 0.02 and which can be distinguished, in the sense of statistical significance, only with very large samples. The choice between them, therefore, revolves around practical concerns such as the availability of computer programs and personal preference and experience (p. 34).

The amount of energy use

In this study the amount of a particular fuel used by an individual household for cooking is estimated by relating the level of use to the household's economic and demographic characteristics. The estimation of the amount of a particular energy used by a household is modelled by assuming weak separability of a household's utility from energy use. That is, an equation to predict amount of energy used is formed without referring to prices of non-energy products used (Skog, 1986).

In analyzing factors affecting fuelwood use levels, Hadi (1982) in her study on rural energy in West Java employed ordinary least square (OLS) techniques to estimate

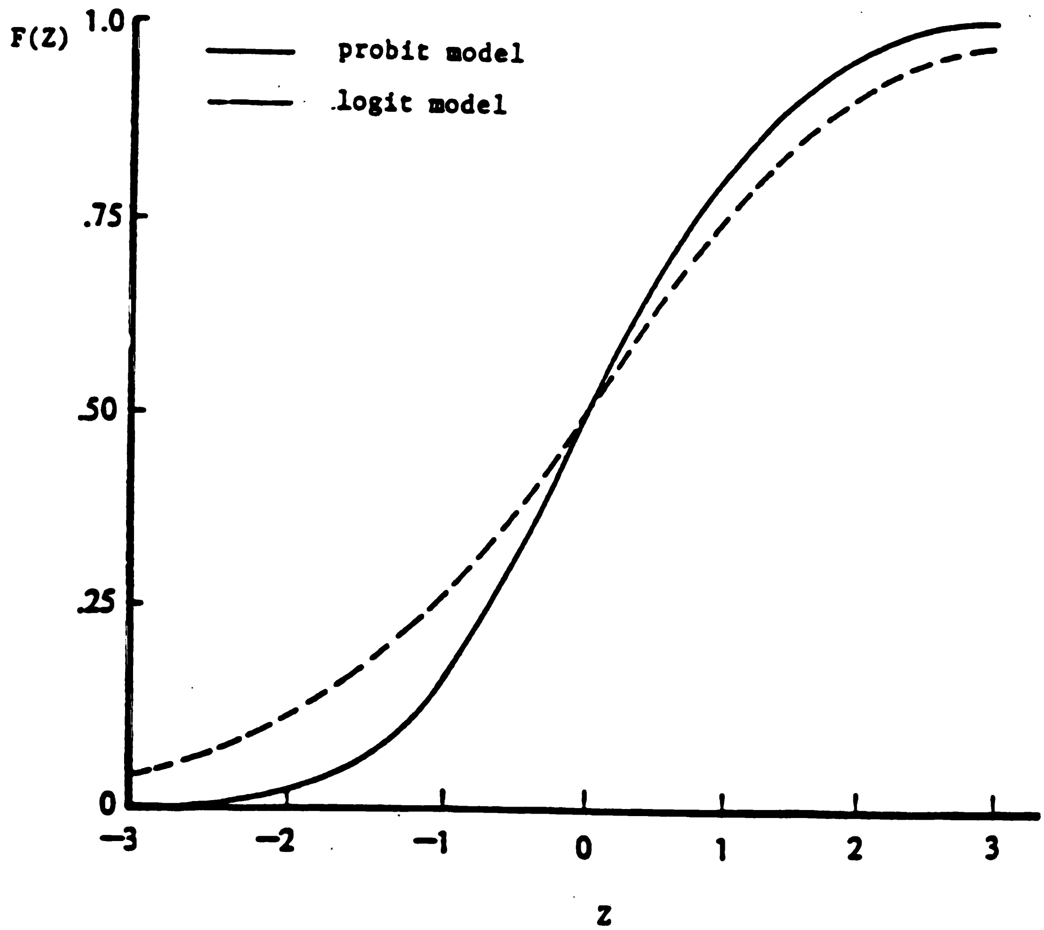

Figure 3. Comparison of logit and probit cumulative distributions

(Adopted from Pindyck and Rubinfeld, 1981)

fuelwood consumption among households using fuelwood for their cooking. To solve the problem of zero responses, Hadi excluded all non-users in estimating fuelwood consumption.

A seperate estimation for the probability and the ammount of a particular energy used, as in two-step approach, could only be done if in fact these equation are statistically independent. Yet, if equations are interdependent, the OLS technique will yield a biased estimate (Hardie and Hassan, 1986; Tobin, 1958).

Hardie and Hassan further show that the expected value of the random component in estimating the amount of energy used using OLS is as follows:

$$E(e_i \mid d_i = 1) = \sigma_{12}\lambda_i \tag{2}$$

where:

e_i = conditional expected error,

σ_{12} = interequation variance,

λ_i = f(.)/F(.)

The terms f(.) and F(.) are the density function and the cumulative function of the standard normal random variable, respectively. The conditional mean of e_i would equal zero if σ_{12} equalled zero. That is, if both equations (estimating choice and amount) are independent. To solve the problem, Hardie and Hassan (1986) assumed that interdependence existed and introduced an instrumental variable λ_i in their equation for estimating the amount of energy used. Then, they tested the significance of the coefficient for λ_i

Survey data for the present study indicate that not all household samples used fuelwood for their cooking energy. However, the characteristics of all individual households were recorded. This situation, wherein some observations on the dependent variable corresponding to known sets of independent variables are not observable, is known as a censored sample (Judge et al., 1985). However, instead of employing approach used by Hardie and Hassan (1986), the Tobit model, which is designed to overcome a censored sample, is employed in the present study.

Like probit, the Tobit technique allows one to have zero observations. The difference is, instead of qualitative binary responses, a dependent variable in the Tobit technique is the amount of energy used. But, unlike the probit, Tobit simultaneously estimates both the amount of energy use and the probability.

A generalized Tobit model (Judge et al., 1985) can be written as follows:

$$\begin{aligned} Y_i &= X_i B + e_i && \text{if } Y_i > 0 \\ &= 0 && \text{otherwise} \end{aligned} \qquad (3)$$

where:

Y_i = amount of fuelwood burned (kg per day),

X_i = vector of explanatory variables,

B = coefficient vector, and

e_i = disturbance terms.

Assuming that S out of T observations are zero, the regression function can be written as :

$$E(Y_i | X_i, Y_i > 0) = X_i'B + E(e_i | Y_i > 0)$$

$$i = 1, \ldots\ldots T-S \qquad (4)$$

If the disturbances, e_i, are independent and normally distributed $N(0,\sigma^2)$ then:

$$E(e_i | Y_i > 0) = E(e_i | e_i > -X_i'B) = \sigma f(Z_i)/F(Z_i) \qquad (5)$$

where:

$Z_i = X_i'B/\sigma$

f(.) and F (.) = the density function and the cumulative density function of a standard normal random variable, respectively.

Both f(.) and F(.) are evaluated at the argument (Judge et al., 1985).[2] Hence, the regression function can be written as:

$$E(Y_i | X_i, Y_i > 0) = X_i'B + \sigma f(Z_i)/F(Z_i) \qquad (14)$$

$$i = 1, \ldots. T-S$$

The second term on the right hand side of equation (6) is an expected value of random component as in equation (2). If this second term is omitted during estimation, a problem is

[2] Both the probit and Tobit are based on cumulative normal distribution. As Figure 3 shows, the slope will depend on the value of X_iB selected in evaluating the impact of change.

created. The estimator of B is biased and inconsistent, using either the entire sample or the subsample of complete observation (Judge et.al, 1985). Thus, the potential bias is eliminated in the Tobit by jointly estimating the choice and the amount.

To solve this problem, a maximum likelihood procedure will provide consistent and asymptotically normal parameter estimates for censored samples when the disturbance terms are normally distributed (Amemiya, 1973).

Model specification

Based on the discussion of previous studies and data available from the 1983 Rural Energy Survey the following variables are used as explanatory variables: household income (INCOME), age of the head of family (AGE), education of the head of family (EDUC), family size (SIZE), and size of land owned by household (LAND).

Distance to a fuelwood source is a variable reflecting fuelwood scarcity (Hosier, 1985b). Unfortunately, the distance variable (DIST) available from the survey did not reflect the distance to a fuelwood source. Instead, it reflected the distance to any particular energy source used by a respective respondent. Since this variable could not be used to test the hypothesis that distance to the wood source may affect household fuelwood use, the DIST variable had to be dropped. Available fuelwood price data is used to reflect its relative scarcity.

Fuelwood price (PRIWOO) and kerosene price (PRIKER) are used as explanatory variables in this study. Price data are based on the recollections of household respondents regardless of whether or not the households did in fact use a particular energy. In the case of fuelwood, specific information on which households actually purchased fuelwood is not available. Therefore, fuelwood price is used as relative scarcity proxy for all the household samples.

Decision to use a particular type of energy and its level

A Tobit model was developed to estimate the amount of energy use as well as the probability of using a particular type of energy. Both Tobit and the probit are specified as follows:

$$Y_i = c + a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 + a_6ED + \sum_{n=7}^{11} a_iDi \qquad (15)$$

where:

for Tobit:

Y_i = amount of energy i used (i = agricultural wastes, fuelwood, kerosene),

= 0, otherwise,

for probit:

Y_i = 1, if a respective household use energy i,

= 0, otherwise.

for both:

c = constant,

X_1 = income (in Rupiahs per month),

X_2 = ratio of fuelwood price/kerosene price (in litres/kilograms),

X_3 = age of the head of family (in years),

X_4 = family size,

X_5 = land ownership (in hectares per household).

ED = dummy variable for education, coded 1 if education of the head of family is elementary or less, and 0 if otherwise,

D_i = dummy variables for six districts (i = 1,....,5), where RBA = 1, if Banyumas; = 0, otherwise

RBT = 1, if Bantul; = 0, otherwise

RBL = 1, if Blora; = 0, otherwise

RPM = 1, if Pemalang; = 0, otherwise

RPW = 1, if Purworejo; = 0, otherwise

RTM = 0, if Temanggung.

Estimation for each type of energy (agricultural wastes, fuelwood and kerosene) is done separately. This separation is based on the assumption that an individual household usually faces two alternatives energies at a time. This sense is supported by the results of descriptive analysis (Chapter III). For example, households using agricultural wastes are likely to perceive fuelwood as a substitute for wastes, whereas among wealthier households using fuelwood, kerosene is a potential substitute. Use of single equation model such as Tobit for a particular energy explicitly incorporates the interdependence between energy and its close substitute.

Total energy consumption

Total fuel consumption of energy i (Q_i) for the entire region is calculated based on the number of households using fuelwood in an entire region multiplied by average fuelwood burned per household (Hardie and Hassan, 1986). The equation is as follows:

$$Q_i = p_i * N * q_i \tag{16}$$

where:

Q_i = total daily energy consumption for the entire region (tons),

p_i = proportion of households using fuelwood,

N = total households for the entire region,

q_i = the amounts of daily fuelwood used per household (in kilograms), and

i = type of energy.

Proportion of households using fuelwood, p_i, and the quantity of fuelwood used by a household per day, q_i, are estimated based on the Tobit results. If one were pursuing a two-step approach similar Hadi's, probit could be used to estimate p_i and OLS could be used to estimate q_i. This is not, however, the preferred approach.

Expected coefficient signs of explanatory variables on probability and consumption

Household income is expected to be negatively related to fuelwood consumption, because fuelwood for cooking is mostly perceived as an inferior good. So, increasing household income will broaden energy alternatives available to the respective household. Increasing purchasing power enables them to purchase a more convenient form of energy such as kerosene. Hence, it is expected that the use of fuelwood will decrease as income increases because households may shift from fuelwood to using kerosene. This also implies that the probability of households using fuelwood decreases as household incomes increase.

Demand analyses generally include the price of the good in question and the price of its substitute. In most developing countries, fuelwood is often freely collected and seldom passes through the marketplace (de Montalembert and Clement, 1983; Hosier, 1985b; Wardle and Palmieri, 1981). Hence, the market price for fuelwood, which is often available in the official statistics publication, only provides a tentative indication of the real cost. Cost of fuelwood is different for different people. For most rural households, fuelwood price refers to their own time and labor devoted to collecting wood. For the fuelwood trader, the fuelwood cost might include labor costs, costs of equipment to harvest it, as well as transportation and storage costs (Wardle and Palmieri, 1981). In fact, the market price simply does not accurately reflect all those costs.

For people who never pay cash for fuelwood, price is most likely not an important determinant in fuelwood consumption. On the other hand, for people who buy fuelwood from the market or local trader, the price of fuelwood is a crucial factor (Wardle and Palmieri, 1981). Unfortunately, in this present study, information regarding whether given households purchase or collect fuelwood is not available. Therefore, the price of fuelwood which was based on respondents' recollection is used to reflect a relative scarcity of fuelwood regardless of how households actually obtained it.

Energy studies in West Java by Hadi (1982) and Hosier (1985b) in rural Kenya did not include price of wood as an indicator of scarcity. Hosier developed three surrogates for wood price namely time spent in collecting wood, distance to wood sources, and an indices for scarcity. None of those surrogates for price were statistically significant in affecting fuelwood consumption. Dwiprabowo et al. (1980) in their study in Aceh province of Sumatera included fuelwood price in their estimation and found that fuelwood price affected fuelwood consumption significantly.

In this study price of fuelwood is expected to negatively affect the probability as well as the level of fuelwood use. On the other hand, the effect of kerosene price is expected to be positive on the probability of choosing fuelwood. The amounts of fuelwood used is a priori assumed to be independent of the price of kerosene.

The effect of family size on fuelwood consumption is expected to be positive. Increasing numbers of family members will certainly increase the amount of food the family consumes. Probability of using fuelwood, ceteris paribus, is expected to be positively influenced by family size. As noted in the third chapter, households with larger family sizes are likely to use biomass energy due to the relative availability of labor needed to collect fuelwood. The effect of family size on fuelwood use is also expected to be positive.

Education is likely to affect the type of occupation of the head of family and to some extent it may correlate to family income. For example, the study by Susastro (1983) indicated that among the fuelwood purchasers in rural areas were notably teachers and other income earners. The majority of these individuals have higher education levels compared to those in average rural households. The higher the education of the head of the family is, the less likely that the respecting household will use fuelwood. In other words, the effect of education on both the probability and fuelwood consumption is expected to be negative.

Land ownership is expected to positively affect both the probability and level of fuelwood consumption. The reason is clear; land possession guarantees availability of fuelwood for household use. The importance of the home garden as a source of fuel and food in Java, and particularly in Central Java, has been extensively discussed, for example by Stoler (1978).

The effect of districts, both in their magnitude and the signs of coefficient are not all clear. The uncertainly is due to the fact that districts are created merely as administrative units. Thus, they do not necessarily reflect the ecological stratification which may be more important in influencing fuelwood consumption. In fact, ecological variability within districts can be very substantial. For example, Pemalang district covers ecologically distinct lands ranging from lowland coastal to semi-highland areas. The district also consists of villages in different developmental stages, which to a lesser degree, influence fuelwood consumption. Hadi (1982) found that fuelwood consumption in more modern villages is less than that in traditional villages.

Expected signs of coefficient of variables used in this study are presented in Table 14.

Table 14. Variables, variable names and expected coefficient signs

Variable		Variable name	Expected sign [1]
1.	Household income	INCOME	-
2.	Fuelwood price	PRIWOO	-
3.	Kerosene price	PRIKER	+
4.	Education of the family head	EDUC	-
5.	Family size	SIZE	+
6.	Land ownership	LAND	+
7.	District	RBA= Banyumas RBT= Bantul RBL= Blora RPM= Pemalang RPW= Purworejo	?

[1] Signs +, -, and ? represent a positive, negative, and an ambiguous effect, respectively.

V. FACTORS AFFECTING RURAL ENERGY CONSUMPTION

The explanation of factors affecting energy consumption is presented in three sections. It begins with a brief explanation of the variables used in the estimations. The subsequent section focuses on the explanation and discussion of various factors affecting levels of a particular type of fuel used and the probability (Tobit model results). Then, the estimation of energy use for the entire region is presented.

Variables used in the present study

Tobit analysis is used to estimate the relationship between the amount of a particular type of fuel used and a set of explanatory variables. The variables are comprised of economic and demographic characteristics of household samples. Table 15 provides a list of explanatory variables which are used in the estimations in the next two sections.

Table 15. Variables summary

Acronym	Variable (unit)
INCOME	Household monthly income (Rps. 1,000).
AGE	Age of the head of family (years).
SIZE	Family size (number of members).
LAND	Household land ownership (hectares).
ELES	Dummy variable, coded 1 if the education of household head is elementary school or less, and 0 if otherwise.
PRIRAT	The ratio of fuelwood price and kerosene price (litres/kilograms).
RBA	Dummy variable for district, coded 1 if Banyumas, and 0 otherwise.
RBL	Dummy variable for district, coded 1 if Blora, and 0 otherwise.
RBT	Dummy variable for district, coded 1 if Bantul, and 0 otherwise.
RPM	Dummy variable for district, coded 1 if Pemalang, and 0 otherwise.
RPW	Dummy variable for district, coded 1 if Purworejo, and 0 otherwise.

Results of Tobit estimations

A prior comparison of several estimations using the Chi-square test indicates that the inclusion of district as a dummy variable, in aggregate, is significantly different from that of the estimations without dummy variables for districts (Appendix 3). This implies that the district is crucial in estimating either the probability or the amounts of energy used. As a result, dummy variables for district are included in estimations. However, in the Tobit for estimating levels of agricultural wastes usage, districts variables are dropped altogether due to the failure of the model to achieve convergence after 20 iterations.[1]

The education background of the head of family is categorized differently than the categorization used in Chapter III (p. 61). In this chapter, education levels are classified into two categories, elementary school or less and middle school or more. Model estimations using three education categories did not provide any significant effect of education on the probability of using a particular type of energy. This may be due to the limited sample size for education levels at or above the middle school level. Further, this aggregation scheme yields reasonable outcomes when employed in both Tobit and the probit estimations.

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[1] A computer printout is available, but the result is not amenable to interpretation.

Finally, the selection of final estimates is also based on the coherence of the coefficient signs to their expected signs and their statistical significances. The validation steps taken here follow general validation tests suggested by Kaplan (1964) which include the test of correspondence, coherence, and pragmatism. That is, how study results parallel the real world, relate to the body of knowledge, and are useful in the sense of their workability. The results of Tobit analysis appear in Table 16 (The probit results are presented in Appendix 4).

Discussion of Tobit results begins with an explanation of the estimated sign and statistical significance of each coefficient. This is followed by the magnitude of the effects of the explanatory variables on the probability of using fuels and on levels of use.

Signs and statistical significance

Household income

Household income in Tobit models for agricultural wastes and fuelwood, as expected, provides a negative sign. The coefficient of income variable, reflecting the effects of household income on the probability of choosing agricultural wastes and fuelwood and the amounts of use, are statistically significant. The results imply that household income did alter the pattern of energy use and the probability of using biomass energy.

Table 16. The results of estimation using Tobit technique

Variable	Type of Energy		
	Wastes	Fuelwood	Kerosene
CONSTANT	-8.1442** [1]	1.4334	-0.7529
INCOME	-0.370E-01** (0.953E-02) [2]	-0.107E-01** (0.0034)	0.434E-02** (0.113E-02)
PRIRAT		15.1992* (7.0216)	11.5729** (3.4772)
AGE	0.876E-01** (0.229E-01)	-0.498E-02 (0.134E-01)	0.200E-02 (0.613E-02)
SIZE	0.891E-03 (0.1546)	0.5083** (0.847E-01)	- 0.1146** (0.0416)
LAND	1.0863 (0.3924)	0.3083 (0.2193)	- 0.2391** (0.0828)
ELES	1.5160 $ (1.0302)	2.9074** (0.5092)	- 1.5741** (0.1920)
RBA		-1.3897** (0.5435)	- 0.2976 (0.2280)
RBL		-2.8649** (0.5550)	0.0463 (0.2230)
RBT		-3.4234** (0.5561)	-1.1645** (0.3305)
RPM		-3.2334** (0.5500)	-0.1106 (0.2305)
RPW		-3.9387** (0.6274)	-0.1878 (0.3163)
L.likelihood=	-859.97	-1894.80	-155.67

[1] ** , * and $ are significant at 1, 5 and 10 percent, respectively.
[2] Figures in parentheses are standard deviations.

The negative sign shows the tendency of decreasing the probability of a household using fuelwood as the household's income becomes higher. In other words, a household with a higher income level may likely shift from using fuelwood to using kerosene (or other more convenient forms of energy). However, among households which decide to use fuelwood, increasing income may increase food consumption and thus, would require the use of more energy for cooking.

Increasing a household's income also decreases the household's probability choosing agricultural wastes. They may switch to either fuelwood or kerosene. Which energy form they may actually use depends on how much their income increases, ceteris paribus. The descriptive analysis presented in the previous chapter (Table 13) indicates that differences in the average monthly income are statistically significant for the users of agricultural wastes (AGWA), fuelwood and wastes (FWAW), fuelwood (WOOD), fuelwood and kerosene (KEBI), and kerosene (KERO).

Conversely, the coefficients of the household income variable in kerosene results were positive with significant coefficients. Therefore, higher income encourages a household to use kerosene and probably other convenient forms of energy as well. These findings are also supported by the descriptive analysis presented in Chapter III. The descriptive analysis shows that a household in the highest income level category did belong to the kerosene user group (KERO). On the other hand, household samples using entirely agricultural wastes (AGWA) did belong to the group with the lowest average income level.

Age of head of family

In most cases, the variable (AGE) is not significant in estimating either the probability of a household using a particular type of energy or the amounts of a particular fuel used. This is consistent with the findings of Nasendi (1978) and Hadi (1982) that the inclusion of the average age of husband and wife, and age of husband did not provide a significant effect on fuelwood consumption.

The age variable, however, significantly affected the level of wastes used with a positive sign. This implies, ceteris paribus, that a household with an older family head is more likely to use more agricultural wastes. The older family head is likely to have a smaller number of family members (Appendix 5) which means less labor is available. As a result, this encourages them to use the energy source which is relatively more available near the house such as wastes. In fact, a home garden (see the discussion on land ownership) is also an important sources for agricultural wastes such as branches, twigs, and leaves which are common source of energy.

Education level

Low education levels (ELES) positively affected both the probability of using agricultural wastes and fuelwood and their amounts. On the other hand, the ELES variable is negatively and significantly influences both the probability of using kerosene and the amounts of kerosene used. The results imply that, given the availability of energy, a household with a higher education level has a lower probability for using fuelwood and wastes than those households with lower education levels.

There are several possible explanations for this phenomenon. First, education may widen one's opportunity to seek jobs other than farm work, such as teaching or other salary earning type occupations. Having cash money at hand, in turn, seems to broaden one's access to commercial energy, especially kerosene.

Second, in addition to the occupation type, Burk noted the importance of a "reference group" in affecting expenditure patterns (Hadi, 1982). A peer group, for example, may also influence the life style of a member of a corresponding group, including the energy type they use.

Third, it is likely that people with higher levels of education have more access to various kinds of information. For example, access to farm inputs, capital markets and new technologies may likely benefit them more than would be the case for those with little or very limited amounts of information. As a result, they may be able to improve their land productivity and produce a surplus that could be traded for cash. They even have the possibility to getting non-farm jobs to supplement their income. Thus, in relation to the categorization by Hosier (1985a), they may more appropriately be categorized as cash-surplus farmers, rather than subsistence farmers. The evidence shows that cash-surplus farmers use less fuelwood as compared to subsistence farmers.

The descriptive analysis in Chapter III also showed that the average education of a household using entirely kerosene (KERO) was higher than that of a household using agricultural wastes (AGWA). In fact, there is a gradual increase in terms of the average education of household head when moving from the users of the least convenient form of energy to the most convenient energy forms.

Size of family

The family size variable is not significant in Tobit models estimating agricultural waste usage. As mentioned previously, wastes might be relatively available and easier to collect than fuelwood, hence its collection does not require too much labor.

Family size yields a statistically significant coefficient for Tobit fuelwood models with positive signs. This sign and its significance implies that both the probability of using fuelwood and the amounts used is higher as family size gets larger.

A possible explanation for this tendency is the fact that increasing the number of household members, especially children, may mean additional labor for the family. The importance of children among peasant families was studied by Nag et al. (1978) in a Javanese village in the Jogyakarta area. They found that there was a tendency among households to adopt the reproductive strategy which calls for "having as many children as they can afford and find useful". This strategy is based on the commonly held perception among the peasants that children are a source of capital and labor. Children also mean security, because children are expected to take care of their parents when parents reach old age.

Nag et al. (1978) also found that the average time spent in collecting fuelwood among children of age six to fourteen years was longer in Java compared to the time spent in Nepalese villages. Larger families have more labor available for various activities including collecting wood.

The family size variable is negative and significant in the Tobit model for kerosene. Larger families among kerosene-using households result in additional income sources and the ability to afford commercial energy, kerosene. Alternatively, a larger family has more labor available for gathering wood, hence discouraging households to use kerosene. As a result, the amounts of kerosene used is lower as family size gets larger.

Land ownerships

Land ownership, measured in hectares, is positive but not significant in affecting the amount of agricultural wastes and fuelwood. Variables other than land holdings may be more important in explaining the amount of wastes and fuelwood used. On the other hand, the quantity of kerosene is negatively and significantly influenced by land holdings. Increasing land ownership likely increases income and may encourage households to use more kerosene as this commercial fuel become more affordable.

Land has a crucial role within Javanese society. Land is not only perceived as a productive means, but it is also a status symbol for the owner. In the case of fuelwood production, land possession especially in the form of a home garden is a significant contribution as a fuelwood source (Stoler, 1978). Unfortunately, in this present study there is no information regarding the type of land use by each household sample.

As previously mentioned, a surplus of agricultural products may result from increasing land holdings. These products can be traded for cash leading to increases in household income. As a household's income increases, its expenditures for food stuffs are also expected to increase therefore requiring increased quantities of fuelwood. However, above certain income levels, households may consider using their excess income for switching completely to commercial energy and dropping fuelwood entirely as an energy source for cooking.

Energy price

The coefficients for the price ratio are positive and significant in both Tobit models for fuelwood and kerosene. For kerosene, this implies that increasing the price ratio increases amount of kerosene used as expected. The positive and significant price ratio for estimating fuelwood levels is different than expected. A possible explanation is that fuelwood users are comprised of both households which purchase fuelwood and households which collect fuelwood. As long as a fuelwood source is relatively available, households collecting fuelwood might use more than households purchasing it. For the latter group, the amount of fuelwood used is most likely limited by the price of fuelwood. As a result, when both groups are included in the calculation of the average amount of fuelwood used per household, the average figure may be biased upward. Unfortunately, this argument cannot be verified further as the information that would permit a categorization of fuelwood users into purchasers and collectors is not available.

In spite of how one measures fuelwood scarcity, increasing wood scarcity is most likely to reduce the probability of households using fuelwood. However, whether or not the corresponding household will actually consume kerosene may depend on other factors such as income and energy availability.

Region

Regional effects are different for each type of energy. All districts included as dummy variables give negative and significant coefficient in the Tobit model for fuelwood use. This reflects a substantial variation in fuelwood use levels across the sample districts; all are lower than use levels in the district of Temanggung. The levels of fuelwood used in Temanggung district is calculated by setting all district dummy variables equal to zero. Tobit results for kerosene also gives negative and significant coefficient for Bantul district.

The probability of using a particular type of energy

As previously mentioned, the Tobit model provides both estimations on the probability and the amount of energy use. The probit model, on the other hand, only provides an estimate of the probability of using a particular type of energy. To see a consistency between the two models, the results of probit and Tobit are used as a basis in predicting the probability. The estimations are calculated at the mean for all samples, the results are presented in Table 17.

Table 17. Probability of using energy F(Z) based on the probit and Tobit results

Model	Energy type		
	Ag. wastes	Fuelwood	Kerosene
probit	0.25	0.92	0.02
Tobit	0.25	0.89	0.02

Both the probit and Tobit provide consistent results in estimating the probability of using a particular type of energy. Those models yield a similar probability for agricultural wastes and kerosene. In estimating the probability of using fuelwood, the probit gave somewhat higher value the than Tobit model. However, both results show that the probability of using fuelwood are high. Since the Tobit model provides more information than the probit, Tobit results are used in the subsequent analysis.

The amounts of energy use

In order to describe in detail the effect of a household's characteristics on energy use levels, the Tobit results for each type of energy are examined.

The probit and Tobit as previously mentioned are based on the cumulative standard normal distribution function, hence the marginal change is greatest near the point where the probability to use fuelwood is 0.5 and the change gradually decreases as we move away from 0.5 in either direction. Therefore, the interpretation of the probit and Tobit are usually evaluated at different values of X_iB.

The Tobit results for each type of energy are evaluated at mean values for all samples and for samples using a particular type of fuel in question. The interpretation of the Tobit follows the procedure proposed by McDonald and Moffitt (1980). The expected value for level of fuelwood use for all samples, E(Y), can be calculated based on the expected level of use conditional upon being above the limit, $E(Y^*)$, times the probability of being above the limit, F(Z), or:

$$E(Y) = F(Z) * E(Y^*) \tag{17}$$

They further decomposed the effect of a change in the k^{th}, variable of X, on Y into two parts: (1) the change in Y of those above the limit, weighted by the probability of being above the limit, and (2) the change in the probability of being above the limit weighted by the expected value of Y if above (McDonald and Moffitt, 1980). The total effect is as follows:

$$dE(Y)/dX_k = F(Z)[dE(Y^*)/dX_k] + E(Y^*)[dF(Z)/dX_k] \tag{18}$$

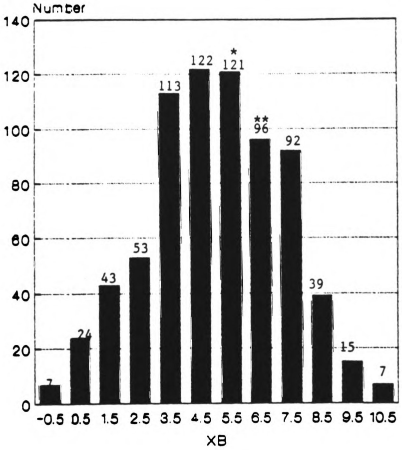
As mentioned previously, the Tobit models are evaluated at the means for all samples and means for samples using a particular type of fuel. However, the computation of X_iB for fuelwood based on the variable mean for samples using fuelwood and the mean for all samples (Table 18) yield values of X_iB equal 6.23569 and 5.93024, respectively. Since those figures are almost the same, for comparison purposes the Tobit results are interpreted at two values: (1) $X_iB = 6.2357$ calculated on the mean values for households using fuelwood, and (2) $X_iB = - 0.500$ which is chosen arbitrarily to represent the lower and negative values. The distribution of X_iB for fuelwood is presented in Figure 3.

Results of the Tobit decomposition for agricultural wastes, fuelwood and kerosene are presented in Tables 19, 20, and 21, respectively.

As previously mentioned, the marginal change of the probability near 0.5 is higher than at the point distant from 0.5. For example, at the mean for household samples using fuelwood with $F(Z) = 0.9333$, the marginal change in the probability ($dF(Z)/dX_k$) is less than at $X_iB = -0.500$ with $F(Z)=0.4528$ (Table 20). Specifically, the values of the marginal change in the probability are 0.031 and 0.095, respectively. This implies that the change in one explanatory variable, for example household income, may

Table 18. Mean values of the variables for samples using fuelwood and for all of the samples.

Variable	Mean for	
	samples using fuelwood(N=634)	all samples (N=732)
INCOME	45.29302	50.71264
PRIRAT	0.09982	0.10037
AGE	49.38013	49.63115
SIZE	5.39274	5.28962
LAND	0.55395	0.54740



* all samples
** samples using fuelwood

Figure 4. X_iB distributions for all samples

Table 19. Decomposition of Tobit model for agricultural waste use

	Evaluated at	
	Mean for all samples $X_iB=-3.7923$	Mean for samples using wastes $X_iB= -2.7059$
Expected waste used (kilogram) $E(Y)$	0.8585	1.1692
Probability of using wastes: $F(Z)$	0.2546	0.3192
Expected wastes used conditional upon being above limit (kilogram): $E(Y^*)$	3.3718	3.6629
Change due to a a change in variable X_k :		
$dE(Y)/dX_k$	0.2546 B_k	0.3192 B_k
$dF(Z)/dX_k$	0.0560 B_k	0.0624 B_k
$dE(Y^*)/dX_k$	0.2588 B_k	0.2842 B_k
Change due to a change in waste use: $F(Z).dE(Y^*)/dX_k$	0.0658 B_k (26 %)	0.0907 B_k (28 %)
Change due to a change in probability of using wastes $E(Y^*).dF(Z)/dX_k$	0.1888 B_k (74 %)	0.0907 B_k (72 %)

Table 20. Decompositions of Tobit model for fuelwood use

	Evaluated at		
	the value of X_iB=-0.5000	Mean for all samples X_iB= 5.0237	Mean for households using fuelwood X_iB=6.2357
Expected fuelwood used (kilograms):			
$E(Y)$	1.4122	5.2464	6.3510
Probability of using fuelwood (in proportion):			
$F(Z)$	0.4528	0.8868	0.9333
Expected fuelwood used conditional on being above limit (kilograms):			
$E(Y^*)$	3.1222	5.9195	6.8057
Changes due to a change in variable X_k :			
$dE(Y)/dX_k$	0.4528 B_k	0.8868 B_k	0.9333 B_k
$dF(Z)/dX_k$	0.0955 B_k	0.0461 B_k	0.0310 B_k
$dE(Y^*)/dX_k$	0.3409 B_k	0.6924 B_k	0.7740 B_k
Change due to a change in fuelwood use (kilograms):			
$F(Z)\ dE(Y^*)/dX_k$	0.1541 B_k (34%)	0.6140 B_k (69%)	0.7223 B_k (77%)
Change due to a change in probability of using fuelwood:			
$E(Y^*)\ dF(Z)/dX_k$	0.2987 B_k (66%)	0.2727 B_k (31%)	0.2110 B_k (23%)

Table 21. Decomposition of Tobit model for kerosene use

	Evaluated at	
	Means for all samples $X_iB=-1.6206$	Mean for sample using kerosene $X_iB=-1.0540$
Expected kerosene used (in litre): $E(Y)$	0.0077	0.0387
Probability of using kerosene (in proportion): $F(Z)$	0.0250	0.1021
Expected kerosene use conditional upon being above limit (in litre): $E(Y*)$	0.3084	0.3793
Changes due to a change in variable X_k :		
$dE(Y)/dX_k$	0.0250 B_k	0.1021 B_k
$dF(Z)/dX_k$	0.0706 B_k	0.2139 B_k
$dE(Y^*)/dX_k$	0.1303 B_k	0.2052 B_k
Change due to a change in kerosene use: $F(Z).\ dE(Y^*)/dX_k$	0.0032 B_k (13%)	0.0209 B_k (20.5%)
Change due to a change in probability of using kerosene: $E(Y^*).dF(Z)/dX_k$	0.0218 B_k (87%)	0.0811 B_k (79.5%)

likely to encourage households in the border (near point 0.50) to switch from fuelwood and use other type of fuel for their cooking energy.

Decomposition of Tobit models for agricultural wastes and kerosene (Tables 19 and 21) show that values of E(Y), F(Z), and $E(Y^*)$ are consistently greater when evaluated at the mean for samples using either wastes or kerosene than at the mean for all samples. Those values of X_iB for samples using either wastes and kerosene are located closer to the 0.50 than all samples.

The total response to a change in one explanatory variable can be separated into the response due to increasing the level of a particular fuel used by households and to increasing the proportion of households using that particular type of fuel. The relative contribution of each part in the total response will depend on the value of X_iB selected. In this study, decomposition evaluated at the mean of households using fuelwood shows that 77 percent of the total response is due to increasing the amount of fuelwood used, whereas the rest is due to the increasing proportion of households using fuelwood. Conversely, at the point $X_iB = -0.500$, the larger part of the total response (66 percent) is caused by the increase in the probability of households using fuelwood.

In general, this implies that a marginal change in one explanatory variable, ceteris paribus, will lead largely to a change in the amount of use among households already using a particular type of fuel. Whereas, the total response to change in one variable among non-using households, will be influenced more by changes in the probability of using a particular fuel.

It is important to examine the effect of a change in an individual variable on the expected amount of energy used, E(Y), the probability, F(Z), and the expected amount of energy used conditional upon being above the limit, $E(Y^*)$. To evaluate the effect, each individual variable which gives a significant coefficient, is assumed to increase by 1, 5 and 10 percent, holding other variables constant at their means. The results are presented in Tables 22, 23, and 24. Elasticities are presented in Tables 25, 26 and 27.

Increasing some explanatory variables by 1 and 5 percent give negligible effects both on the probability and the expected amount of energy use. Income increases by 5 percent reduces the daily household amount of wastes and fuelwood used by 0.012 and 0.029 kilograms, respectively when evaluated at the mean for all samples. The reduction on fuelwood use level, for example, comes forth from an 0.2 percent decrease in the expected probability of using fuelwood and 0.020 kilograms decrement in the amount of fuelwood used among households who actually used fuelwood.

Table 22. Effect of change in income on the expected use level E(Y), probability F(Z), and expected level conditional upon being above the limit $E(Y^*)$ for agricultural wastes

	Calculated at mean for all samples		
	1%	5%	10%
E(Y)	- 0.0030	- 0.0124	- 0.0376
F(Z)	- 0.0031	- 0.0063	- 0.0126
$E(Y^*)$	- 0.0054	- 0.0075	- 0.0497

Table 23. Effects of change in explanatory variable on the expected use level E(Y), probability of using F(Z), and expected level conditional upon being above the limit E(Y^*), for fuelwood

	Calculated at mean for all samples		
	1%	5%	10%
	Change in E(Y) in kilograms:		
INCOME	- 0.0033	- 0.0287	- 0.0411
SIZE	0.0202	0.1178	0.2218
PRIRAT	0.0127	0.0678	0.1048
	Change in F(Z)		
INCOME	- 0.0000	- 0.0019	- 0.0076
SIZE	0.0005	0.0057	0.0110
PRIRAT	0.0004	0.0035	0.0057
	Change in E(Y^*) in kilograms:		
INCOME	- 0.0037	- 0.0197	- 0.0337
SIZE	0.0193	0.0939	0.1742
PRIRAT	0.0103	0.0527	0.1017

Table 24. Effects of change in explanatory variable on the expected use level E(Y), probability F(Z), and expected level conditional upon being above the limit E(Y^*), for kerosene

	Calculated at mean for all samples		
	1%	5%	10%
	Change in E(Y) in litres:		
INCOME	0.0000	0.0002	0.0004
PRIRAT	0.0004	0.0016	0.0037
SIZE	- 0.0004	- 0.0008	- 0.0066
LAND	- 0.0001	- 0.0001	- 0.0020
	Change in F(Z):		
INCOME	0.0000	0.0010	0.0056
PRIRAT	0.0000	0.0044	0.0094
SIZE	- 0.0002	- 0.0016	- 0.0197
LAND	- 0.0000	- 0.0006	- 0.0062
	Change in E(Y^*) in litres:		
INCOME	0.0000	0.0056	0.0148
PRIRAT	0.0080	0.0148	0.0224
SIZE	- 0.0085	- 0.0140	- 0.0149
LAND	- 0.0029	- 0.0052	- 0.0068

From the above explanations several observations concerning rural household behavior toward energy usage using Tobit model are notable. The effects of 1 and 5 percent change in one explanatory variable using Tobit results yield a small change in the probability to use or not to use a particular energy. The effects are somewhat larger if we increase explanatory variable by 10 percent. This implies that a substantial change in most explanatory variables is needed to influence the probability. The change on the probability to use or not to use a particular type of energy is greater near mid-point in the cumulative normal distribution function. Therefore, for households close to this point, a small change in one variable may be sufficient to affect their decision to choose one energy over another. Conversely, for those far away from that point, a substantial change in an explanatory variable is needed to change their decision.

Subsistence households may need a considerable increase in their income, ceteris paribus, before switching to commercial energy. On the other hand wealthier rural households may shift from using wood to kerosene with from a small increase in their income. The Tobit model indicates that among households using a particular energy, a change in one variable is associated with a change in the amount of energy used and the probability of use. Elasticities are presented in Tables 25, 26 and 27.

Table 25. **Elasticity of income calculated at the mean for all samples for agricultural wastes**

	Elasticity
E(Y)	- 0.5565
F(Z)	- 0.4127
$E(Y^*)$	- 0.1440

Table 26. Elasticities calculated at the mean for all samples for fuelwood

Variable		Elasticity
INCOME	E(Y)	- 0.0917
	F(Z)	- 0.0282
	$E(Y^*)$	- 0.0635
SIZE	E(Y)	0.4545
	F(Z)	0.1398
	$E(Y^*)$	0.3145
PRIRAT	E(Y)	0.2579
	F(Z)	0.0793
	$E(Y^*)$	0.1785

Table 27. Elasticities calculated at the mean for all samples for kerosene

Variable		Elasticity
INCOME	$E(Y)$	0.7146
	$F(Z)$	0.6215
	$E(Y^*)$	0.0930
PRIRAT	$E(Y)$	3.7720
	$F(Z)$	3.2812
	$E(Y^*)$	0.4909
SIZE	$E(Y)$	- 1.9682
	$F(Z)$	- 1.7119
	$E(Y^*)$	- 0.2561
LAND	$E(Y)$	- 0.4250
	$F(Z)$	- 0.3697
	$E(Y^*)$	- 0.0533

Total energy consumption

The calculation of the total energy use for each type of fuel by household for the entire region is based on the equation (16) described in Chapter IV. For example, the total daily energy use for entire region, Q_i, is computed as:

$$Q_i = p_i * N * q_i \tag{19}$$

where:

Q_i = annual use of energy i (i=1, 2, and 3, each for wastes, fuelwood, and kerosene),

p_i = proportion of households using energy i,

N = number of households, and

q_i = the amount of energy i used by household.

The proportion of households using fuelwood, **p**, and the amount of daily fuelwood use by a household, **q**, are computed based on Tobit results. The population of households in the region, **N**, is based on the estimates released by the Central Bureau of Statistics (Biro Pusat Statistik, 1984). The results of computation along with the respective figures from the survey are presented in Table 28.

The proportion of household using a particular type of energy based on Tobit estimations and the survey show that the proportion of households using agricultural wastes, fuelwood and kerosene are underestimated. Estimation of proportion of households using agricultural wastes yields a substantially low figure compared to the survey results.

This underestimation is likely due to the exclusion of regional dummy variables in Tobit equation for agricultural wastes.

The underestimation in Tobit for wastes and kerosene might have resulted from too few samples for household using those types of energy as observed in the survey. Waste users for example, had not even been observed in three districts (ie., Blora, Pemalang, and Temanggung). No single household using kerosene for cooking was observed in the district of Bantul, while the total number of households using kerosene for cooking in the entire region accounted for less than 10 percent of the total household samples. Since the estimate for agricultural wastes yields very low proportion, prediction of the total wastes use for the entire region is not undertaken.

Total number of households in the rural area of Central Java region was approximately 4,744,042 households in 1983 (Biro Pusat Statistik, 1987). The proportion of households using each type of fuel based on the survey and Tobit results are presented in Table 29.

The total energy consumption by rural households for the entire region based on the Tobit models in comparison with survey results is presented in Table 30. Annual consumption for each type of fuel by household is calculated based on the level of daily energy use both from the survey results and Tobit estimates.

Table 28. Comparison between survey results and Tobit on the proportion of households using a particular type of energy and their levels

Energy type/ users	Proportion		Levels[1]	
	survey	Tobit	survey	Tobit[2]
Wastes	0.274	0.027	3.70 (2.97)[3]	3.37
Fuelwood	0.866	0.856	6.18 (3.84)	5.91
Kerosene	0.098	0.075	0.80 (0.45)	0.31

[1] Fuelwood and wastes levels are in kilograms, kerosene is in litres.
[2] Expected amount conditional being above the limit $E(Y^*)$.
[3] Figures in parentheses are standard deviations.

Annual household energy used is based on the assumption that daily energy use recorded by the survey reflects an ordinary daily use throughout the year. A similar assumption was used by Sumarna and Sudiono (1973) in estimating the annual energy use by household in East Java province. This assumption, however, ignores the fact that seasonality may affect the level of energy used per year by households. Thus, the estimation results should be carefully used.

Susastro (1983) and Komarudin (1989) noted that efficiency of a traditional stove commonly used in rural areas of Indonesia, including Central Java region is relatively low. Stove efficiency ranges from 4 to 16 percent. In the present study, no adjustment is made for efficiency. Thus, energy consumed by sampled households represents a fuel as an input to produce heat.

The level of fuelwood used per household per year based on survey results and Tobit analysis are 2.71 and 2.59 cubic meters, respectively.[2] By considering that average size of household based on the survey is 5.28 persons per family, fuelwood use per capita were 0.51 and 0.49 cubic meters per year, respectively.

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[2] Conversion factor used is: 1 ton solid wood = 1.2 cubic meter roundwood (Sumarna and Sudiono, 1973 p. 17).

Table 29. The proportion of rural household by energy type in Central Java region (p*N)

Energy type	Survey	Tobit
Fuelwood	4,108,340	4,060,900
Kerosene	464,916	355,803

Table 30. Annual households energy consumption in rural areas of Central Java

Energy type	Survey		Tobit	
	Per household	Total	Per household	Total
Fuelwood(tons)	2.25	9,243,765	2.16	8,771,544
Kerosene (in 1000 litres)	0.29	134,826	0.11	39,138

In the case of fuelwood consumption, the Tobit results indicate that increasing household income by 1, 5 and 10 percent reduces the amount of fuelwood per household by 0.0037, 0.0197 and 0.0337 kilograms calculated at the mean for all samples (Table 23). On a per year basis, the average reduction are 1.35, 7.19 and 12.3 kilograms per household or 0.001, 0.007 and 0.012 tons, respectively. These reductions are relatively small. Clearly, increasing income by 1 and 5 percent will not significantly reduce the total fuelwood consumption for the entire region. For example, annual fuelwood consumption with and without increasing income is approximately 10.5 million cubic meters. Increasing income by 10 percent, however, decreases region's fuelwood consumption about 0.30 million cubic meters (Table 31). This would be equivalent to eliminating fuelwood consumption for approximately 117,005 households.

Table 31. Total fuelwood consumption if household income increase by 1, 5 and 10 percent

Total fuelwood use			
Income constant	Income increase		
	1%	5%	10%
In tons:			
8,771,544	8,767,483	8,743,118	8,519,009
In cubic meters:			
10,525,853	10,520,980	10,491,741	10,222,811

VI. CONCLUSIONS AND IMPLICATIONS

This study is aimed at addressing two objectives. The first is to present a description of rural household energy consumption. This includes the identification of type of energy, amount of use, and characteristics of energy users. The second objective is to analyze the relationship between household's economic and demographic characteristics and energy use. The effect of a household's characteristics on both the probability of using a particular type of energy and its level of use are of study interest. Study conclusions and implications are presented in this chapter.

Conclusions

Biomass energy, especially fuelwood and wastes, still play a major role as an energy source for cooking purposes in rural areas of the Central Java region. In 1983, approximately 93 percent of rural households sampled in this region used biomass energy; nearly 86 percent used fuelwood. As many as 6.5 percent of sampled households used only wastes for their cooking energy. However, the contribution of wastes as a source of energy, either as a sole energy source or in combination with other types of energy, was substantial especially in the village samples of the Bantul and Purworejo districts. In those districts, the proportion of household samples using wastes as a sole energy source or in combination with other types of energy was 42.8 percent and 93.6 percent, respectively. Fuelwood was the only biomass energy used by rural households in the Blora, Pemalang, and Temanggung districts. These differences indicate the importance of including the district as a variable in estimating rural energy use.

Categorization of household samples into five energy user groups (AGWA, FWAW, WOOD, KEBI, and KERO) reveals the presence of interfuel substitution. The energy options facing rural households ranged from the most inconvenient (ie., wastes) to the most convenient form of energy (ie., kerosene). In fact, household's economic and demographic characteristics relate to the type of energy they used as a primary energy source for cooking. In other words, a decision-making process within a household exists for deciding to use or not to use a particular type of energy.

Descriptive analysis of household samples (Chapter III) shows that several characteristics such as household income, education level of family head, household size, and land ownership influenced either type of energy selected by a household or its level of usage. In the case of fuelwood consumption, increasing household income increased the amount of fuelwood used by a household. However, the number of households using fuelwood decreased as household income increased.

Further analysis revealed factors linking household economic and demographic characteristics to energy-user categories and indicated that family income, education of the head of family, and family size were significantly different among energy user groups. This implies that a household may change its preference toward a particular type of energy as its economic and demographic characteristics change. As people become more market-oriented they tend to choose more convenient types of energy and use lesser amounts of biomass energy such as fuelwood and wastes.

A Tobit model linking the household choice of a particular type of energy and the amount to its economic and demographic characteristics was utilized. Tobit results, compared to the probit results, provide consistent estimates for household's probability of using a particular type of energy. Tobit results show that household income and household size altered both the probability of a household in choosing fuelwood and its amount. Dummy variables for education of the head of the household (ELES) yielded significant coefficients with negative and positive signs for kerosene and biomass energy, respectively. A household with the head of family having less education (ELES) has a higher probability of choosing fuelwood than a household head with a higher education background.

The effects of family size are positive for fuelwood and negative for kerosene, both are with significant coefficients. As family size gets larger and more labor is available, households tend to use more fuelwood and less kerosene. This implies the importance of population variable on rural energy consumption.

The Tobit decomposition following McDonald and Moffitt (1980) provides important results. The total response of a change in one explanatory variable can be broken down into two parts. The first is a response due to the change in the amount of energy used. The second is a response due to the change in proportion of households using fuelwood.

Evaluation at the mean for all samples indicates that contributions to the change in the amount of fuelwood use and the change in a number of households using fuelwood are 77 percent and 23 percent, respectively. On the other hand, among non-users ($X_iB = -0.500$), the contribution of each part is reversed, 34 percent and 66 percent, respectively. These results suggest that theoretically it is possible to alter one's decision to use or not to use fuelwood by developing policies which change levels explanatory variables. The response of each household to a change in explanatory variable is different depending on the status of household's economic and demographic characteristics.
For example, one important rural energy policy question may relate to reducing the total fuelwood consumption in order to reduce the deforestation rate. Household income is an important variable that is statistically significant in reducing the probability of selecting fuelwood as well as the level of fuelwood used.

The effect of increasing levels of explanatory variables on the probability of using a particular type of fuel and the amount are different for each type of fuel. However, increasing household income by 1 and 5 percent resulted in little reduction of the probability of using all types of energy as well as on their amounts.

As shown by Tobit results, the probability of using fuelwood is barely affected by a marginal change in income with 1 and 5 percent increases. The effects on the other types of energy are also negligible. The Tobit results indicate that the amount of fuelwood use, among fuelwood users, decreases as much as 0.0037 and 0.0197 kilograms as household income increases by 1 and 5 percent, respectively. Or, it equals 0.001 and 0.007 tons per household per year. In terms of total fuelwood use for the entire region, these increase in income by 5 percent or less may not significantly affect the total fuelwood consumption for the entire region, which remains at approximately 10.5 million cubic meters. If income increases further, for example by 10 percent, the total fuelwood consumption for entire region decreases by 0.30 million cubic meter or equivalent to eliminating fuelwood consumption by more than 117,000 households.

Limitations

Several limitations in this study are notable. First, this study focuses on demand side. A paucity of data on rural energy availability is a major constraint in providing more complete picture of rural energy status.

Estimation of demand with single equation model is very restrictive as it assumes that the decision to choose a particular type of fuel among energy alternatives is independently determined. In other words, this model does not permit the error term e_{ij} to be correlated.

This study is based on the survey data collected by Forest Products Research Institute (FPRI) of Indonesia in 1983. Although various data are available, some important information were not properly recorded. Heat content of energy used in rural areas was not measured during the survey, hence the conversion of energy use from a physical unit (kilograms) into BTU could not be done. As a result, energy input in this study is measured in kilograms for fuelwood and agricultural wastes and litres for kerosene. Important variables, such as distance to fuelwood sources which may be a better proxy than price in reflecting fuelwood scarcity were not available. Lastly, the survey only covered one period of time, hence the seasonality is not reflected by the survey data.

This study is confined to Central Java. Although the magnitude will certainly be different from region to region, however, the implications may be applicable to other region as well.

Implications

The study results indicate that both the probability and the level of a particular energy used are influenced by several explanatory variables. However, as shown by the effect of marginal change in explanatory variables, the impact is negligible in practical terms. In other words, to significantly affect overall rural energy consumption a substantial change in some explanatory variable such as income, education, and family size are crucial. Thus, if the government wants to be more successful in halting deforestation, the national economic development plan currently implemented should focus on providing more job opportunities and hence income-earning opportunities, particularly for rural people, as higher income is equated with less fuelwood use.

The nationwide education program that is currently being carried out will also positively contribute to reducing the deforestation rate as suggested by the Tobit results. Opening up the opportunity for people to obtain better education may result in decreasing demand for fuelwood, as higher education levels lower the probability of using fuelwood.

The family planning program plays a positive and significant role in altering rural energy consumption, as variable household size is significantly affect both the probability and the amount of energy use. Decreasing population which in turn is reflected by decreasing the number of household relying on fuelwood will substantially affect the total fuelwood consumption.

These solutions through increasing real income, education and family planning are long-term programs. In the mean time, fuelwood is still a basic energy necessity for most rural households, particularly in the Central Java region. Fuelwood use level per household per year based on the Tobit estimation is 0.49 cubic meters per capita per year. In other words, there must be a short-term solution for meeting basic energy needs. Implementing fuelwood production programs on private lands will be restricted by the fact that available land resources in Java, the most densely populated island, are becoming increasingly more scarce as the competition for land for different purposes such as housing and industrial sites becomes more intense. Agroforestry which integrates multiple production on a given tract of land (Wiersum, 1979) is one alternative land use practice that may be appropriate for the conditions in Central Java. This approach is appropriate since fuelwood is a basic need along with food and shelter. Solution to fuelwood problem, hence must be considered from broader perspectives (Dewees, 1989).

As implied by the low efficiency level of traditional stoves (Susastro, 1983; Komarudin, 1989), the possibility of reducing rural household's consumption of biomass energy, fuelwood in particular, through increasing its efficiency is worth pursuing. The study by Argawal (1988) noted, however, that the introduction of more efficient stoves such as Singer and Lorena in developing countries was not successful in the past. Nonetheless, increasing the efficiency of stoves should be considered in dealing with rural energy use.

Fuelwood for the major part of rural households is still a freely gathered energy source. Time devoted to collecting fuelwood might be a more appropriate indicator of the relative scarcity of fuelwood. The use of price ratio for all respondents in this study yielded a coefficient sign different than expected for fuelwood. This positive and significant coefficient of the price ratio might be caused by the aggregation of purchasers with non-purchasers. The household production model as suggested by Laarman (1987) and which is widely used in the agricultural sector for evaluating subsistence farmer behavior (Singh et al., 1986) may likely provide a richer explanation of rural household behavior related to fuelwood consumption. The household production model formally integrates the variable of time devoted to production within a household-firm in its structure. In future surveys, fuelwood collection time should be included.

Finally, further studies on demand as well as on supply are important to undertake. A repeated survey to obtain a series data is worth pursuing as it will permit evaluation of the dynamic aspects of rural energy consumption.

Appendix 1. FPRI ENERGY SURVEY 1983

The present study is based on data collected through a rural energy survey in Central Java Region conducted by the Forest Products Research Institute (FPRI), Indonesia in 1983. A description of the survey follows.

Background and objectives

Fuelwood is still a primary source of rural energy in Java. The levels of fuelwood consumption per capita ranges from 0.5 cubic meters to more than 2 cubic meters per capita per year (Hadi et al., 1979; and Sumarna and Sudiono, 1973). Several studies have reported that the growing demand for fuelwood in some areas, especially on the island of Java, are beyond supply capability. These fuelwood shortages have been associated with forest resources depletion.

Lack of reliable data and information regarding rural energy patterns is a hindrance to development of a sound rural energy program. To fulfill the needs for more information, a study on fuelwood consumption by rural households in Java was conducted.

There were three survey objectives. First was to estimate the levels of fuelwood and other types of energy consumed by rural household. The second was to analyze the effects of economic and demographic factors on energy consumption. The final objective was to identify the relative contribution of each type of energy in meeting rural energy demands.

Survey implementations

Field work was carried out in January and February of 1983. As many as 24 field workers were trained prior to the survey execution. In the actual field work, enumerators were supervised by the field coordinators. Each district was controlled by one field coordinator.

Survey locations

Surveys were conducted in Central Java Region. This region is comprised of two provinces, Central Java and Yogyakarta. The survey covered six districts, namely Banyumas, Blora, Pemalang, Purworejo, Temanggung, and Bantul in the province of Jogyakarta.

Two counties in each district were randomly selected, and in each selected county three villages were selected at random. The selection of districts, counties and villages was done prior to the field work. In each village, 25 households were randomly selected to be survey respondents. Therefore, the total number of households selected in this survey for the entire region was 750 households.

The selection of households was undertaken in the field based on the household list provided by the provincial village offices. Households were selected at random. Samples results selected is presented in Table 4 page 43.

<u>Energy use measurements</u>

Energy use levels both for cooking and lighting by household samples were recorded through direct measurement during three consecutive days of visiting. From the three visits, surveyors recorded two observations, each observation represented the energy use per day by each respective household.

The calculated daily energy consumption level was the average of these two observations. Questionnaires used in the survey are presented in the questionnaire section. Energy consumed was recorded separately for each type of energy use (e.g., energy for cooking and type of fuel).

The measurement unit used for fuelwood and other biomass energies was a unit of weight (in kilograms) and for kerosene it was a unit of volume (in litres).

Fuelwood and biomass energy consumed were weighed and recorded separately. This separation was based on the evidence that the heat content of a fuelwood species, on the average, is higher than that of other biomass energies such as agricultural wastes (Direktorat Jenderal Ketenagaan, 1982).

Heat content of fuelwood and other biomass energies depends among other factors on the wood species and its moisture content. For a given wood species, the drier the wood is, the higher the heat content. Unfortunately, the moisture content of wood and biomass energy used by households was not measured during the survey. In order to reduce variation of calorific values among wood and other biomass substances, respondents were asked to use 'ready to burn' fuelwood. By this, it is meant that the varieties of fuelwood used by households were similar in the degree of their air-dry condition which decreased the variation in calorific value between different wood species.

Economic and demographic factors

Important economic factors in a demand study are income and price of goods. In this survey income was defined as the annual total income received by a household. It consists of income earned by the household head and by other household members for a common use. Regularly received monetary additions from other family members or relatives who did not live in the same household were added to the household's total income.

Income from agricultural production was calculated based on revenues received minus costs required in production activities. Productivity of agricultural land was estimated based on data published by The Biro Pusat Statistik (Central Bureau of Statistics). Cost items were based on respondents' recollections.

Prices of fuelwood and kerosene recorded were based on price levels prevailing in the market place in each corresponding village. Price information was mostly obtained from respondents, fuelwood traders and kerosene retailers. Both income and prices were measured in Rupiah (Rps), the Indonesian currency.

Recorded demographic factors included information regarding the head of a household such as age, education, and occupation; further information about a household included that of household composition, size, education of family members and land ownership.

Educational background was recorded in categories such as; (1) an uneducated, (2) graduated from an elementary school, (3) graduated from a junior high school, (4) graduated from a senior high school, and (5) graduated from a college or university.

Survey limitations

To derive a useful reference from a sample using statistical techniques, reliable data are needed. Unfortunately, not all questionnaires collected had accurate information. Hence, to select reliable questionnaires, data screening processes were carried out. As a result of data screening, the number of questionnaires considered as reliable was 732 out of 750 Questionnaires. Only 18 questionnaires were dropped for various reasons; some were incomplete, inconsistent, or not answered (Buharman, 1988).

Being 'incomplete' meant important data was not recorded. For example, only one of two observations which were supposed to have been reported was recorded. 'Inconsistency' meant data recorded was vague and enumerator could not provide a reasonable explanation. Non-response was simply the result of failure to interview a potential respondent. For example, a household sample, for some reason or other, was not available for interviewing during the survey period.

Data on distance to fuelwood sources was actually intended to be used as a proxy for a relative scarcity of fuelwood, since the largest part of the fuelwood is freely collected. However, the distance to a fuelwood source had been largely misinterpreted by the field workers due to unclear explanations during survey training. Instead of recording the distance to fuelwood source, enumerators had recorded the distance to the particular energy source (biomass, kerosene) which the respective household happened to be using. As a result, the available data on distance does not reflect the data to a fuelwood source in particular. As a result, the distance variable cannot be used to test the hypothesis that fuelwood use will decrease as the distance to wood sources increases.

Available data summaries contain other information concerning household samples such as household income, price of energy, age and education of the household head, family size, and land possession. These data summaries are used in this present energy study.

<u>Variables summary</u>

The mean and standard deviations of economic factors such as income and energy prices and demographic factors such as household size, land ownership, and age of the head of household are presented in Table A1. The distribution of household samples based on the education of the head of family is presented in Table A2. Distance to fuelwood and agricultural waste sources is presented in Table A3.

Table A1. Summary of variables for the region (N = 732)

Variable	Unit	Mean	Std.Dev.
Household income	(1000Rps/mo)	50.71	66.89
Family size	(N)	5.28	2.16
Land ownership	(hectares)	0.55	0.81
Age of head of household	(years)	48.93	12.34
Fuelwood price	(Rps/kg)	13.05	3.61
Kerosene price	(Rps/litres)	131.08	9.24

Table A2. Households samples by education (N=732)

Education level	N	%
Without a formal education	190	25.9
Elementary school	429	58.6
Middle school	80	10.9
High school	31	4.2
College or university	2	0.4

Table A3. Distance to energy source

Energy type	Mean	Sd	Max.	Min.
Agricultural wastes	0.17	0.27	1.20	0.00
Fuelwood	0.75	1.68	17.5	0.00

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FORM DP. 01 : RESPONDENT'S IDENTITY

Village :........... Enumerator: ....
County :........... Date :...........
District :...........

No.	Description	Family's head	Husband/wife
1.	N a m e		
2.	S e x		
3.	Age (years)		
4.	Education		
5.	Primary job		
6.	Secondary job		
7.	No. of family member		
8.	Land ownership (Ha) a. Dryfield b. Ricefield c. Homegarden d. Other garden c. Others		

Note:

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FORM DP. 02 : HOUSEHOLD MEMBERS

Village : ....
County : ....
District : ....

Enumerator: ....
Date : ....

No.	N a m e	Status	Sex	Age	Educ.	Occupation

Note:

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FORM DP. 03 : FUELWOOD SOURCE

Village : .... Enumerator: ....
County : .... Date : ....
District : ....

No.	Description	Energy 1	2	3	Note
1.	Type of energy				
2.	Source of energy				
3.	Frequency of collection				
4.	Amount per collection				
5.	Location of source				
6	Distance to source				
7.	Frequency of purchasing				
8.	Amount per purchasing				
9.	Price per unit (Rps)				

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FORM DP. 04 and 05: FUELWOOD CONSUMPTION

Village :............... **Enumerator:** ....
County :............... **Date** : ....
District :...............

No. of observation	Description	Measurement	Note
	Amount of stock	.... kg	
	Before using	.... kg	
	Amount added (+)	.... kg	
	Amount taken (-)	.... kg	
	After using	.... kg	
	Amount used	.... kg	

Cooking frequency between two visits : ......
Number of people eating between two visits:.......

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FORM DP. 06 AND 07 :KEROSENE CONSUMPTION

Village :...............   Enumerator:............
County :...............   Date :............
District :...............

No. of observation	Type of usage	Description	Measurement	Notes
	Cooking	Stock amount	. ...kg	
		Before using	..........kg	
		Amount added	..........kg	
		Amount taken	..........kg	
		After using	............kg	
		Amount used	..........kg	

Frequency of cooking between two visits :......
Number of people eating between two visits :......

	Lighting	Before using	..........kg	
		After using	..........kg	
		Amount used	..........kg	

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FORM DP. 09 : INCOME END EXPENDITURE

Village : .... Enumerator: ....
County : .... Date : ....
District : ....

	Activities	Amount (Rps.)	Note
Expend.	1. Consumption		
	a. Food		
	b. Clothes/housing		
	c. Education		
	d. Health care		
	c. Others		
	2. Production costs (e.g. farm inputs)		
	3. Savings		
	Total		
Income	1. Agricultural		
	a. Rice		
	b. Dryland		
	c. Homegarden		
	d. fish pond		
	2. Trader		
	3. Government employees/ army		
	4. Home industry		
	5. Other sources		
	Total		

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FORM DP. 10 : FUELWOOD TRADER

Village :.............. Enumerator :.............
County :.............. Date :.............
District :..............

No.	Description	Note
1.	Trader's name	
2.	Address/location	
3.	Amount purchased	
4.	Price per unit	
5.	Frequency of purchasing	
6.	Source of fuelwood	
7.	Amount sold per day	
8.	Selling price	
9.	Type of consumer *)	
10.	Consumer origin **)	

Notes : *) Household/home industry/rural industry
**) Within village or outside vilage

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FORM DS. 01 : LAND USE PATTERN

Village :.............
County :.............
District :.............

Enumerator : ....
Date : ....

No.	Land use	Area (ha)	Percentage (%)	Note
1.	Rice field			
	a. irrigated			
	b. non-irrigated			
2.	Dry-field			
3.	Homegarden			
4.	Estate			
5.	Forest land			
6.	Bare land			
7.	Lake/swamp			
8.	Fish ponds			
9.	Others			
	Total			

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FORM DS. 02 : TYPE OF OCCUPATION

Village :..............   Enumerator :...........
County :..............   Date :...........
District :..............

No.	Description	Number	%	Note
1.	Farmers (owners)			
2.	Farm workers			
3.	Laborers			
4.	Private employee			
5.	Govt. employees/Army			
6.	Traders			
7.	Others			
	Total			

Appendix 2. The probit

Decision to use fuelwood

Economic theory explains that consumption decisions among individual households are driven by a rational behavior assumption where individuals maximize utility subject to a budget constraint. Total utility gained by an individual is derived from a bundle of commodities that are actually chosen from the set of alternative bundles of commodities available. In explaining how utility is derived from consuming energy, first, it must be assumed that energy utility is weakly separable from the utility of other goods. Being weakly separable means that the demand for heating is independent of prices and quantities of non-heating items (Deaton and Muellbauer, 1980). Following Skog (1986), if the utility from heating for cooking and from non-heating products are written as $U_1(q_1)$ and $U_2(q_2)$, respectively, then total utility (U) can be written as:

$$U = U\ (U_1(q_1),\ U_2(q_2)) \tag{1}$$

where:

$U_1(q_1)$ = utility from heating for cooking and,

$U_2(q_2)$ = utility from non-heating items.

From the previous description of the energy user in the Central Java region it was clear that an individual household faces a range of alternative fuels from the least convenient form of energy (e.g., agricultural wastes) to a more convenient form of energy (e.g., kerosene). Different users will make decisions based on individual utility. By holding the assumption that an individual behaves rationally a household may choose one particular fuel or a combination of fuels that provides more utility. In other words, a decision to choose a particular type of energy contains an element of probability.

To explain the probability of choosing a particular type of fuel, such as fuelwood, first it is assumed that the utility gained by a household from consuming this energy contains both fixed and random components (Skog, 1986). To simplify, let us assume that a household faces the use of two types of energy, fuelwood and non-fuelwood. The utility obtained from using fuelwood by household **n** is expressed as:

$$U_{1n} = \bar{U}_1 + e_{1n} \qquad (2)$$

Similarly, the utility derived from consuming non-fuelwood by household **n**, is written as:

$$U_{2n} = \bar{U}_2 + e_{2n} \qquad (3)$$

where:

$\bar{U}_1$ and $\bar{U}_2$ = representative consumer utility, and

e_{1n} and e_{2n} = random components.

$\bar{U}_1$ and $\bar{U}_2$, which are representative consumer utilities, can be expressed in the following utility relation (Hardie and Hassan, 1986):

$$U_{in} = u_i\ (X'B),\ i = 1 \text{ or } 2 \qquad (4)$$

where, X is a vector of economic and demographic characteristics of a household. B is a vector of coefficients expressing relationship between utility and the associated characteristics.

As a rational actor, a given household **n** will choose fuelwood if:

$$U_{1n} > U_{2n} \qquad (5)$$

or

$$\bar{U}_1 + e_{1n} > \bar{U}_2 + e_{2n}. \qquad (6)$$

This inequality can be rewritten as follows:

$$\bar{U}_1 - \bar{U}_2 > -e_{1n} + e_{2n} \qquad (7)$$

Since e_{1n} and e_{2n} are random variables, the probability that an individual household **n** will choose fuelwood may be written as:

$$P_{1n} = \text{Prob}\ (\ \bar{U}_1 - \bar{U}_2 > -e_{1n} + e_{2n}\ ) \qquad (8)$$

To derive a probability function, equation (8) is rewritten as follows:

$$P_{1n} = \text{Prob}\ (\bar{U}_1 - \bar{U}_2 > -e_{1n} + e_{2n}\ ) = F(X'B) \qquad (9)$$

where:

P_{1n} = Probability of household **n** choosing fuelwood, and

F = the cumulative distribution of $(-e_{1n} + e_{2n})$.

To develop an empirical model based on equation (8), an assumption about the distribution of $(-e_{1n} + e_{2n})$ must be made. In this study, we assume that both e_{n1} and e_{n2} are normally distributed, therefore $(-e_{1n} + e_{2n})$ also has a normal distribution and hence a probit function is developed. Skog (1986) noted a necessary condition for e_{1n} and e_{2n} to be normally distributed in that all relevant variables must be included to represent terms U_1 and U_2 and a proper functional form must be chosen.

Since we assume that e_{1n} and e_{2n} are normally distributed, then, P_{1n} (or to be more general P_i) in equation (9) is represented by the following cumulative normal distribution:

$$P_i = \int_{-\infty}^{X'B} \frac{1}{\sqrt{2\pi}} e^{(-x^2/2)} dx \tag{11}$$

where:

P_i = probability of a household to select energy i (i= 1, 2; 1 = fuelwood, 2 = non-fuelwood)

Parameters of X'B are estimated by a maximum likelihood procedure. A micro computer version of Time Series Processor (TSP) which provides probit estimation used in the present study (Lilien, 1987). For Tobit estimation, TSP mainframe version 4.1 is used in this study.

Appendix 3. Comparison between Probit Models with and without district dummy variables

Variable	Model I	Model II
C	-16.3617	-12.6910
INCOME	-0.0078**	-0.0064**
AGE	-0.0028	-0.0031
EDUC	-0.4320**	-0.4449**
SIZE	0.2116**	0.2124**
LAND	0.1928*	0.2082**
PRIWOO	-0.0202	0.0324*
PRIKER	0.1416**	0.1061**
RBA	0.2132	-
RBT	-0.4985*	-
RBL	0.2652	-
RPM	0.3667	-
RPW	-0.5881	-
Log likelihood	-213.4222	-222.4163

$X^2 = 2[-213.42 - (-222.42)] = 17.98$

$X^2_{(5,\ 01)} = 15.09$

$X^2_{(5,\ 05)} = 11.07$

Fail to reject that Region = 0

Appendix 2. (continued)

Variable	Model IV	Model V
C	-9.7823	-14.1231
INCOME	-0.0053**	-0.0069**
AGE	-0.0033	-0.0032
EDUC	-	-
SIZE	0.2094**	0.2124**
LAND	0.1921*	0.1898*
PRIWOO	0.0336*	-0.1679
PRIKER	0.0967**	0.1412**
PRIRAT	-	-
NOED	-2.1485	-2.5328
ELEM	-2.5519	-2.9770
MIDE	-3.5304	-3.9916
HIGH	-3.2876	-3.6169
RBA	-	0.0870
RBT	-	-0.6757**
RBL	-	0.2288
RPM	-	0.3897
RPW	-	-0.6454
Log likelihood	-215.8683	-205.0763

X^2 = 21.57

X^2 table (0.1)= 15.09

Fail to reject that Region = 0

Appendix 2. (continued)

Variable	Model VI	Model VII
C	2.7527	4.7197
INCOME	-0.0048**	-0.0061**
AGE	-0.0034	-0.0037
EDUC	-	-
SIZE	0.2048**	0.2009**
LAND	0.1783*	0.1596*
PRIWOO	-	-
PRIKER	-	-
PRIRAT	2.1485	-6.4157
NOED	-2.0080	-2.2380
ELEM	-2.3511	-2.6618
MIDE	-3.4480	-3.7398
HIGH	-3.2169	-3.4465
RBA	-	-0.3838
RBT	-	-0.9309
RBL	-	-0.3893
RPM	-	-0.3125
RPW	-	-1.4312
Log likelihood	-226.1167	-209.7044

X^2 = 32.84

X^2 table (0.1) = 15.09

Fail to reject that Region = 0

Appendix 2. (continued)

Variable	Model VIII	Model IX
C	1.4298	-0.3191
INCOME	-0.0063**	-0.0049**
AGE	-0.0032	-0.0033
EDUC	-	-
SIZE	0.1869**	0.1929**
LAND	0.1633*	0.1780*
PRIWOO	-	-
PRIKER	-	-
PRIRAT	-6.7945*	2.1652
NOED	-	-
ELEM	0.7791**	0.4648**
MIDE	-0.3803	-0.2975
HIGH	-	-
RBA	-0.3783	-
RBT	-0.8358**	-
RBL	-0.3205	-
RPM	-0.1960	-
RPW	-1.4064**	-
Log likelihood	-213.5377	-229.1264

$X^2 = 31.16$

X^2 table (0.1) = 15.09

Fail to reject that Region = 0

Appendix 2. (continued)

Variable	Model X	Model XI
C	-12.1272**	-17.4977
INCOME	-0.0054**	-0.0072**
AGE	-0.0030	-0.0028
EDUC	-	-
SIZE	0.1948**	0.1978**
LAND	0.1910*	0.1938*
PRIWOO	0.0354*	-0.0188
PRIKER	0.0902**	0.1404**
PRIRAT	-	-
NOED	-	-
ELEM	0.7693**	0.6490*
MIDE	-0.2964	-0.4525
HIGH	-	-
RBA	-	0.0854
RBT	-	-0.5831**
RBL	-	0.3003
RBM	-	0.4939
RPW	-	-0.6172
Log likelihood	-219.1249	-208.8885

$X^2 = 20.46$

X^2 Table (0.01) = 15.09

Fail to reject that Region = 0

Appendix 4. The results of the probit estimations

Variable	Type of Energy		
	Wastes	Fuelwood	Kerosene
CONSTANT	-4.9870**	1.2801*	-0.8310
INCOME	-0.0027$ [1] (0.0031)	-0.0062** (0.0013) [2]	0.0061** (0.0015)
PRIRAT		-6.7425 (3.8776)	16.8107** (4.7115)
AGE	-0.0027 (0.0070)	-0.0033 (0.0024)	-0.0004 (0.0049)
SIZE	-0.0388 (0.0492)	0.1841** (0.0393)	-0.1803** (0.0578)
LAND	0.6376** (0.1358)	0.1512 (0.0875)	-0.3576** (0.1180)
ELES	0.9607** (0.2673)	1.0458** (0.1731)	-2.0669** (0.2310)
RBA	3.6942** (1.5533)	-0.3008 (0.2906)	-0.5673* (0.3225)
RBL	-0.0705 (2.2476)	-0.2836 (0.3092)	-0.0278 (0.3251)
RBT	4.1972** (1.5567)	-0.7665** (0.2684)	-1.5039** (0.4240)
RPM	-0.1618 (2.1860)	-0.2151 (0.3101)	0.0478 (0.3100)
RPW	5.9537** (1.5660)	-1.3773 (0.3104)	-0.0975 (0.4201)
Loglikelihood=	-162.29	-214.41	-103.57
X^2	24.56	84.85	45.26

1 ** , * and $ are significant at 1, 5 and 10 percent level, respectively.
2 Values in parentheses are standard deviations.

Appendix 5. Correlation matrix

	X_1	X_2	X_3	X_4	X_5	X_6	X_7
X_1	1	-0.035	0.383	0.460	0.425	0.171	-0.052
X_2		1	-0.109	-0.085	0.036	-0.005	-0.053
X_3			1	0.099	0.104	0.094	-0.159
X_4				1	0.182	0.089	0.062
X_5					1	-0.014	0.005
X_6						1	-0.255
X_7							1

X_1 = households income
X_2 = age of the head of household
X_3 = education
X_4 = family size
X_5 = land ownership
X_6 = fuelwood price
X_7 = kerosene price

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