AN ANALYSIS OF HOUSEHOLD DEMAND FOR FUELWOOD DURING THE WINTER SEASON IN THE KATHMANDU DISTRICT OF NEPAL

SHIDDI GANESH SHRESTHA

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The thesis attached hereto, entitled, "AN ANALYSIS OF HOUSEHOLD DEMAND FOR FUELWOOD IN THE WINTER SEASON IN THE KATHMANDU DISTRICT OF NEPAL", prepared and submitted by SHIDDI GANESH SHRESTHA in partial fulfillment of the requirements for the degree of Master of Science (Agricultural Economics) is hereby accepted.

LIBORIO S. CABANILLA
Member, Guidance Committee

Oct. 23/85
Date signed

ENRIQUETA B. TORRES
Member, Guidance Committee

Date signed

CORAZON T. ARAGON
Adviser and Chariman,
Guidance Committee

Oct. 23/85
Date signed

Accepted as partial fulfillment of the requirements for the degree of Master of Science (Agricultural Economics).

DOLORES A. RAMIREZ
Dean, Graduate School
University of the Philippines
at Los Baños

Date signed

BIOGRAPHICAL SKETCH

The author was born to Shree Madan Mohan Shrestha and Parvati Shrestha in Indrachok Shilgarhi, Doti, Seti Zone, Nepal on April 19, 1956. He completed his elementary education from the Sharada Primary School and his high school education from the Padma Public Multi Purpose High School, Shilgarhi. He passed the School Leaving Certificate (S.L.C.) examination in 1971 (second division rank). He was the President of the Nepal Children's Organization, West Zone, for four consecutive years and the President of the High School Student's Union for two terms.

In 1974, he passed the Intermediate Science of Agriculture (I. Sc. Ag.) from the Institute of Agriculture and the Animal Science, Trivuban University, Nepal (first division rank). He was also awarded a merit scholarship from 1972-74 to pursue his I. Sc. Agriculture.

In 1974, he was awarded the Colombo-Plan Scholarship to pursue his Bachelor of Science in Agriculture (B.Sc. Ag.) at the University of Agricultural Sciences in Bangalore, India. He received his B. Sc. Agri. from this university with honors in 1978. He was the vice-president of the Nepalese Student's Association for two years in Bangalore.

He worked for one year (1978/79) as a teacher and social worker in Prabhat Madhyamik Vidhyalaya, Doti, which is a remote area in

West Nepal, under the Compulsory Teaching Service program of the Agriculture and Education Ministries of HMG Nepal. In 1980, he was appointed as an Asst. Industrial Entonologist in the Sericulture Development Farm in Kavre Nepal.

In the same year, he passed the Public Service Commission Examination. Since then, he has been working as an Asst. Agriculture Development Officer in Kathmandu under the Ministry of Agriculture HMG/Nepal.

In April, 1983, he was awarded the Agricultural Development Council fellowship to pursue his Master of Science degree in Agricultural Economics at the University of the Philippines at Los Baños.

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ABSTRACT

SHRESTHA, SHIDDI G., University of the Philippines at Los Baños, October 1985. An Analysis of Household Demand for Fuelwood During the Winter Season in the Kathmandu District of Nepal. Major Professor: Dr. Corazon T. Aragon.

This study was conducted to analyze the determinants of household demand for fuelwood and to estimate own-price, cross-price, household size and income elasticities of fuelwood demand.

A total of 154 sample respondents were personally interviewed using a pre-tested questionnaire in selected rural and urban panchayats of the Kathmandu district.

Estimation of parameters was accomplished by fitting several multiple regression functions to cross-section data. Both the linear and the double-log forms were used in the estimation of fuelwood demand equations and were compared on the basis of economic and statistical criteria. The explanatory variables included in the estimation of the fuelwood demand equations were: price of fuelwood, price of electricity, price of kerosene, price of rice husk and sawdust, price of shrubs and branches, frequency of cooking meals and livestock feed, household weekly income, household size, distance of the house from the forest area, urban/rural location dummy, type of stove dummy and type of fuelwood dummies.

The linear form was selected as the best household fuelwood demand model because of its higher coefficient of determination (R^2), higher number of significant explanatory variables and the conformity of the signs of the regression coefficients of all the explanatory variables to economic expectations.

Results of the demand analysis also show that the price of fuelwood, the price of electricity, frequency of cooking meals and livestock feed, households weekly income, household size and urban/rural location dummy had significant effects on weekly household fuelwood demand. On the other hand, the prices of kerosene, shrubs and branches, the type of stove and the type of fuelwood did not have a significant effect on household fuelwood demand.

The own-price elasticity of per capita fuelwood demand was higher (-.20) than that of the per household demand (-.16). With the exception of the price of electricity, the prices of other fuel sources had insignificant effects on household fuelwood demand. The cross-price elasticity of household fuelwood demand with respect to the price of electricity was .20. The income and household size elasticities were .13 and .32, respectively.

CHAPTER I

INTRODUCTION

1.1 Statement of the Problem

The simplest form of forest energy is fuelwood. The importance of fuelwood as a primary source of energy varies widely among different parts of the world. Developed countries use more non-forest energy than developing countries (Table 1). In Nepal, approximately 92 percent of the total energy consumption came from fuelwood (Table 2). Fuelwood in this country has been used mainly for domestic or household and industrial/ commercial purposes. The domestic sector consumed a greater proportion of the total fuelwood consumption than the industiral sector.

About ninety nine percent of the whole population of this country used fuelwood (Table 3). Despite the availability of alternative fuels such as dung, biogas, kerosene and electricity, there has been a strong preference for fuelwood primarily because of its low cost. For this reason, forests in various parts of Nepal had been overexploited beyond their capacity to provide sustained yield. Presently, forests appear in

Table 1. Annual average world wood utilization (million cubic meters)

ITEM	1961-65	1966-70	1971-75	1976-80	1981-82
Industrial wood					
Developed	606	1,024	1,103	1,109	1,072
Developing	109	184	235	298	309
Total	715	1,208	1,338	1,407	1,381
Fuelwood					
Developed	123	197	171	193	249
Developing	686	1,018	1,111	1,241	1,337
Total	809	1,215	1,282	1,434	1,586
Total					
Developed	729	1,220	1,274	1,302	1,321
Developing	795	1,203	1,346	1,539	1,646
Total	1,524	2,423	2,620	2,841	2,967

Source: FAO Yearbook of Forest Products, various issues.

Table 2. Structure of energy consumption, Nepal, 1978/79.

SECTOR	FUELWOOD		VEGETABLE WASTES		ANIMAL DUNG		COAL AND COKES	
	TOE[a]	%	TOE[a]	%	TOE[a]	%	TOE[a]	%
Transportation	-	-	-	-	-	-	-	-
Domestic	2516700	95.9	52000	2.0	20000	0.8	-	-
Agricultural	-	-	-	-	-	-	-	-
Commercial and Industrial	20300	28.9	-	-	-	-	33078	47.0
Street Lighting	-	-	-	-	-	-	-	-
Others and Losses	-	-	-	-	-	-	-	-
All Uses	2537000	91.8	52000	1.9	2000	0.7	36078	1.3

Table 2. Continued

SECTOR	PETROLEUM FUELS		ELECTRICITY		TOTAL	
	TOE[a]	%	TOE[a]	%	TOE[a]	%
Transportation						
Domestic	28685	1.1	6559	0.2	2623944	100.0
Agricultural	4403	86.5	688	13.5	5001	100.0
Commercial and Industrial	10956	15.6	6013	8.5	7034	100.0
Street Lighting	-	-	175	100.0	175	100.0
Others and Losses	-	-	5000	100.0	5000	100.0
All Uses	100819	3.6	18588	0.7	27564485	100.0

[a] Tonnes of oil equivalent.

Source: APROSC (Agricultural Projects Services Center), Assessment of on going Development Program, 1982

Table 3. Fuelwood use in some developing countries.

COUNTRY	1973 GDP PER CAPUT US$	PROPORTION GDP FROM SUBSISTENCE SECTOR (%)	PROPORTION OF URBAN POPULATION (%)	PERCENTAGE OF POPULATION USING FUELWOOD (%)	FUELWOOD USE PER CAPUT M^3	FUELWOOD USE PER CAPUT 000MJ	CHARCOAL'S SHARE TO FUELWOOD CONSUMPTION
Nepal	90	69	5	99	0.53	9.3	-
Tanzania	100	30	7	99	1.80	31.2	4
Gambia	125	25	23	99	1.20	20.8	26
Thailand	200	20	15	97	1.10	19.10	45

Source: Energy Research and Development Group, 1976. Nepal: The Energy Sector. Institute of Science, Tribhuvan University, Kathmandu, Nepal.

various stages of degradation in the major ecological zones of Nepal. Hence, in this era of world energy crisis mountainous developing countries like Nepal need to carefully develop strategies which would meet their minimum domestic energy requirement without impairing the vulnerable forest ecology.

1.2 Significance of the Study

Inorder to guide government planners in formulating sound policies and programs that would help meet the fuelwood requirement of the people, an estimation of fuelwood demand is essential. For instance, the estimated demand elasticity coefficients can be used in projecting the future demand for fuelwood which would then serve as a guide in the country's reforestation program. Likewise, consumers and suppliers of fuelwood require information on the fuelwood demand situation. If for instance, there is a considerable increase in the prices of energy substitutes such as kerosene, biogas, electricity, etc., consumers will increase their fuelwood consumption. This will encourage the suppliers or sellers of fuelwood to increase their stock of fuelwood which in turn will lead to more exploitation of the forests. If policy makers would like to discourage deforestation, then they should formulate measures that would provide an adequate supply of low-cost energy substitutes.

1.3 Objectives of the Study

The general objective of this study was to analyze the household demand for fuelwood in the Kathmandu district of Nepal. Specifically, the objectives of this study were:

1. to analyze the determinants of household fuelwood demand; and
2. to estimate own-price, cross-price, household size and income elasticities of fuelwood demand.

1.4 Hypotheses of the Study

Based on the foregoing objectives of this study, the following hypotheses were formulated:

1. Household consumption of fuelwood is price inelastic;
2. The quantity of fuelwood consumed by the household is inversely related to the price of fuelwood;
3. The price of an energy substitute such as electricity, gas, etc. has a positive impact on fuelwood consumption;
4. The price of an energy complement such as shrubs, branches, etc. has a negative effect on fuelwood consumption;
5. Frequency of cooking meals and livestock feed per week is directly related to fuelwood consumption of the household;

6. Income elasticity of demand for fuelwood is inelastic;
7. Family size has a positive effect on fuelwood consumption;
8. Households residing near free access forest[1] have higher fuelwood consumption than those living far from this forest area;
9. Rural households consume more fuelwood than urban households;
10. Households using traditional stoves consume more fuelwood than those using modern stoves (close-topped stoves); and
11. Households have a higher demand for hardwood (fuelwood with high calorific value) compared to conifer or softwood.

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[1]The free access forest whereby anybody could freely cut forest trees does not exist legally. However, extraction of a head load of fuelwood (dry woods) or cutting of forest trees for household fuelwood consumption in the assigned forest area is allowed throughout the country provided that those who were given licenses will pay a nominal fee to the government. Hence "free access forest" in this study is defined in relative terms.

CHAPTER II

REVIEW OF LITERATURE

To be technically correct, demand forecasts should be expressed in price-quantity relationships either as demand schedules, curves or functions. Demand forecasts which are based only on changes in population may lead to false conclusions if the effects of other important variables affecting fuelwood demand are ignored.

So far, no study has yet been made to estimate the household demand function of fuelwood in Nepal. A limited number of studies dealt only with factors affecting fuelwood consumption of households and demand estimates were generally based on average consumption. These studies are presented below.

Earl (1975), in his study of fuelwood consumption in Nepal, reported that fuelwood consumption varied among ethnic groups. The indigenous inhabitants (the Tharu) of the Terai (plain land) were found to use more fuelwood per household than the immigrants, but because of their larger family size, their per capita consumption of fuelwood was less than those of the other ethnic groups in the Terai. He also found that in areas of scarcity and high prices, the per capita use of fuelwood was low (0.52 m^3 or 6600 MJ). He also mentioned that because fuelwood is heavy (has a relatively low calorific value of 14.7 MJ per kg. for air dry wood and 20-30 percent moisture content), it is expensive to transport them over any distance. Hence, fuelwood is mostly used within walking distance of a village (one or two days' walk in many parts of Nepal). He also stated that the demand for fuelwood falls as consumption of electricity and fossil fuels increases as a result of urbanization.

Using time series data, Banskota (1979) estimated annual fuelwood consumption in Nepal as a function of the travel time spent in the procurement of fuelwood in a given year. He concluded that total fuelwood consumption declined in absolute amount every year on account of the impact of increased travel time.

Shepherd (1970) stated that the type of stove has an effect on fuelwood consumption. Close-topped stoves economize on fuel, but most of the world's population still use very inefficient cooking facilities. Food is cooked over an openhearth, either in the open or under shelter, or in the house as in the Sherpa houses in Nepal. On the Terai in Nepal, a very basic mud stove, the "chulo", is used which has neither flue nor draught control.

Levenson (1979), in his study of six Nepalese hill villages, estimated that the average fuelwood consumption per capita per year was 686 kg. and that the average travelling time (one way) from the village to the forest fuelwood cutting site was 1.25 hours.

Bajracharya (1980) found out that firewood consumption in an eastern hill Nepali village decreased in the spring months because of grain scarcity during this period, which in turn, led to lesser cooking requirements.

To determine fuelwood consumption rates in a Nepali village, Fox (1982) used three methods of collecting data, namely: the annual recall, the daily recall and the weight survey method. He found significant differences among these methods. Using, the weight survey method, the estimated average annual per capita fuelwood consumption was $0.95 m^3$ (or 570 kg.). For the daily recall survey method, it was $1.67\ m^3$ (1002 kg.) and for the annual recall survey method, the estimated annual per capita fuelwood consumption was $1.86\ m^3$ (1116 kg.). He reported that fuelwood consumption did not vary significantly among different farm sizes. In his study, farm size was taken as a proxy for income. However, he noted that fuelwood consumption varied significantly among some caste groups. He also found significant differences in per capita fuelwood consumption among seasons and among those belonging to different family size groups.

A fuel consumption study conducted by Sycip, Gorres and Velayo and Co. (1983) in the Philippines showed differences in fuelwood consumption patterns between urban and rural households in the country. Traditional energy sources such as firewood and kerosene were more widely used in rural households. About

92 percent of the rural respondents used firewood and 52 percent used kerosene. Conversely, modern fuels, such as electricity were more readily used by urban households. The same study revealed that 63.7 percent of the 176 respondents who used firewood did not buy firewood. This probably reflects a substantial reliance on foraging and scavenging. About 25 percent estimated their acquisition cost to be less than ₱1/kg. and only 1 percent claimed that per unit cost of firewood was ₱2 or more.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Conceptual/Theoretical Framework

The quantity demanded of a certain commodity at a certain period of time is influenced by several economic and non-economic factors. Among these factors are its price, prices of related goods, population, consumers' income, tastes and preferences, seasonal and regional differences, etc. Specifically, in the analysis of fuelwood demand (Q_D), the factors that were considered to affect fuelwood demand were as follows: its own price (P_F), prices of energy substitutes (P_E), frequency of cooking meals and livestock feed (F_{CL}), household size (H), household income (HI), urbanization (D_1), type of stove used (D_2), distance of residence from the free access forest (DT) and types of fuelwood (D_3, D_4). Mathematically, this relationship can be expressed as:

$$Q_D = f\ (P_F, P_E, F_{CL}, H, HI, DT, D_1, D_2, D_3, D_4)$$

Fuelwood consumption by households may also differ by season. Since this particular study only dealt with the estimation of fuelwood demand in the winter season in Nepal, season was not included among the determinants of fuelwood demand in this study.

Figure 1 shows the winter season demand model for fuelwood. The demand model describes the relationship that exists among the variables considered in this study.

Based on economic theory, the demand for a commodity, fuelwood in this case, is inversely related to its own price. Stated in another way, quantity demanded decreases as its price increases, and vice versa.

The demand for fuelwood is inversely related to the price of complements such as shrubs and branches.

The prices of energy or fuel substitutes such as electricity and kerosene also influence the quantity of fuelwood demanded by households. If the price of an energy or fuel substitute goes up, it becomes relatively cheaper for the household to buy fuelwood, thus increasing the demand for it. In this study, only energy for cooking purposes was considered.

The demand for fuelwood increases as the frequency of cooking meals and livestock feed increases.

Household size also has a positive effect on fuelwood consumption by households. The larger the family size, the higher the fuelwood consumption.

On the other hand, the coefficient of income with respect to the quantity of fuelwood demanded by households is positive if fuelwood is a normal good and negative if it is an inferior good.

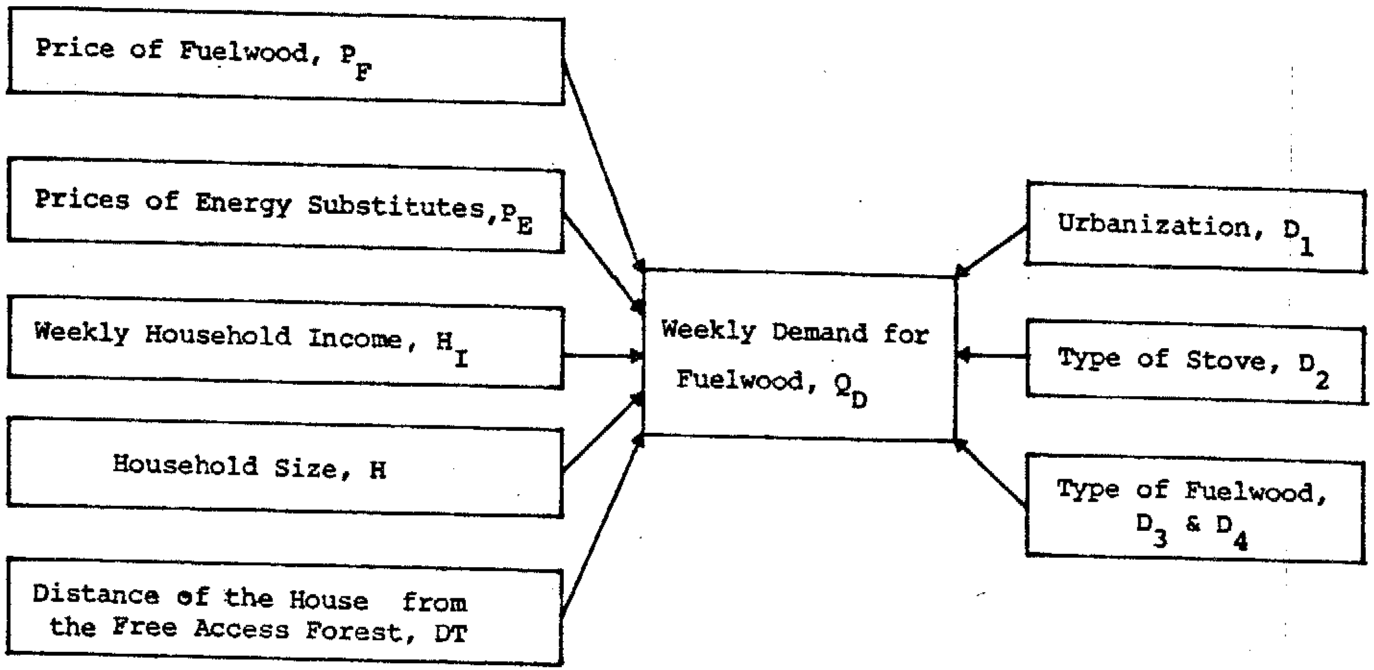

Figure 1. Theoretical Framework for the Winter Season Fuelwood Demand Model.

Another important variable affecting fuelwood demand is the distance of the house from free access forest. Households residing near this forest area are expected to have higher fuelwood consumption.

Qualitative explanatory factors such as urbanization, the type of stove used for cooking, and the type of fuelwood also influence fuelwood demand during the winter season. Urban households are expected to have lower fuelwood consumption than rural households because modern fuels such as electricity are more readily available in the urban areas.

Households using modern stoves or close-topped stoves which economize on fuel are also expected to consume less fuelwood compared to those using traditional stoves or inefficient cooking facilities.

Household consumption of fuelwood also differs by type of fuelwood due to differences in their calorific value. The quantity of hardwood required to cook the same meal is less than that of the conifers due to the high calorific value of hardwood. Assuming that both types of fuelwood have the same price, the use of hardwood by households would, therefore, lead to minimization of fuelwood expenditures. For this reason, households are expected to prefer hardwood to softwood and have, therefore, a higher demand for it compared to the latter.

3.2 Selection of the Study Area and Sampling Procedure

Kathmandu district was purposively selected from among the 75 districts of Nepal because of the wide variation in the pattern and use offuelwood in the district. To account for the influence of some government policies such as fuel pricing and forest policy as well as the influence of urban/rural location of the household and the distance of the household from the forest on fuelwood demand, purposive sampling was used in the selection of the sample panchayats.[2] The three sample panchayats which were purposively selected for this particular study were as follows: (1) Kathmandu town panchayat, representing an urban panchayat and non-forest area; (2) Jorpati, representing a rural panchayat with community or reserve forest area; and (3) Dakshinkali, representing a rural panchayat located near a free access forest.

The list of households in each panchayat was obtained from the Election Commission of Nepal. From this list, 154 sample households were randomly selected with replacement. Households which were not using fuelwood, but were in the list of randomized

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[2]A panchayat is the small political unit next to a district with a total population of 2000-4000 persons. It is further divided into nine wards in the case of a village panchayat and thirty-three wards in the case of a town panchayat.

samples were replaced by households using fuelwood in the same ward of the panchayat. The sample sizes for the rural and urban sample panchayats were determined through equal allocation method (Table 4).

3.3 Method of Data Collection

Primary data were collected through a personal interview of 154 sample households using a pre-tested interview schedule. Households were asked to give information on consumption of fuelwood and its substitutes/complements for a period of one week before the interview. Quantities of fuelwood and vegetable wastes used in cooking meals and livestock feed for a period of one week prior to date of the interview were measured by adopting the following procedure. The respondents were asked to show samples of fuelwood and vegetable wastes they used in the past week prior to the interview and these were weighed by the researcher using a spring balance. Data on household income, household size, frequency of cooking meals and livestock feed, the prices of fuelwood, electricity, kerosene, rice husk, saw dust, etc., sources of fuel and types of fuelwood were also collected during the household survey. Costs incurred in gathering and transporting fuelwood and its substitutes/complements were also obtained from households who did not buy them.

Table 4. Total number of sample households by panchayat, Kathmandu district, Nepal, 1984.

PANCHAYAT	NUMBER OF SAMPLE HOUSEHOLDS	PERCENT OF TOTAL SAMPLE HOUSEHOLDS
Rural:		
With free access forest (Dakshinkali)	38	25
With community or reserve forest (Jorpati)	39	25
Urban:		
Without forest (Kathmandu town panchayat)	77	50

Additional information included were: type of stove, the distance (one way) of the house from the forest area computed from travelling time, seasonal variation of fuelwood, kind of residence (own/rented house), ethnic group, preference for different sources of fuel, variation in fuelwood use for the past 5 years, and expenses on fuels and other necessities.

3.4 Analytical Procedures

3.4.1 Definition and Measurement of Variables

The following variables were used in the fuelwood demand analysis:

Dependent variable. The dependent variable in this study was the quantity of fuelwood consumed per capita or per household for cooking per week (Q_D) expressed in kilograms. This excludes fuelwood consumed by the household for other purposes such as lighting, ironing and heating. In most cases, however, heating and lighting were implicit in the household fuelwood consumption because after cooking, the family members usually gathered around the stove to take their meals and warm themselves. Hence, it was difficult to separate the quantity of fuelwood used for cooking from that used for heating and lighting.

Independent or explanatory variables. The following explanatory variables in fuelwood demand analysis were used in this study:

Price of fuelwood (P_F). This is the price of fuelwood expressed in NR per kilogram. There were three main sources of fuelwood with their respective pricing system namely:

(1) The Fuel Corporation of Nepal - This is a government corporation under the Ministry of Forest and Soil Conservation HMG/Nepal established with the objective of meeting the demand for fuelwood of households, private industries, the government and semi-government organizations. In addition to fuelwood, it supplies charcoal, sawdust and stoves. Out of its fifty-nine depots in the country, nine are located in Kathmandu district. The price of fuelwood charged by the corporation varies among different sectors (e.g., private industries, and for different households, etc) and among different locations of the country. The corporation sells two types of fuelwood namely, sawn wastes and roundwood with a higher price charged to the former compared to the latter type (Table 5). For fuelwood purchases of 300 kg. and below, the selling price of the corporation was NR 0.55 per kg; which was comparatively lower than that charged for a fuelwood purchase of more than 300 kg. Since the households had to

Table 5. Selling prices of fuelwood of the Fuel Corporation of Nepal, 1981 and 1984.

LOCATION	KIND OF FUELWOOD	SELLING PRICE (NR/ 100 KG.) 1981	1984	NUMBER OF DEPOTS
Kathmandu Valley	a) Roundwood	45 up to 300 kg. 56 more than 300 kg.	55 up to 300 kg. 70 more than 300 kg.	(Kathmandu-9, Lalitpur-3, Bhaktapur -2)
	b) Pieces of sawn wood	70	90	14
Hetauda	Roundwood	20	30	1
Birgunj	Roundwood	20	30	3
Chitwan	Roundwood	20	30	8
Kalaiya	Roundwood	20	30	
Gaur	Roundwood	25	30	
Janakpur	Roundwood	25	30	2
Jaleswar	Roundwood	25	30	1
Malangawa	Roundwood	25	30	1
Rajbiraj	Roundwood	30	30	2
Siraha	Roundwood	25	30	1
Biratnagar	Roundwood	22	30	
Sunsari	Roundwood	20	30	2
Jhapa	Roundwood	20	30	3
Dhankuta	Roundwood	NA	30	-
Ilam	Roundwood	25	30	1
Bhairahawa	Roundwood	25	30	4
Palpa	Roundwood	25	25	1
Pokhara	a) Roundwood	45 up to 300 kg. 56 more than 300 kg.	55 up to 300 kg. 70 more than 300 kg.	
	b) Pieces of sawn wood	NA	90	4
Kapilavastu	Roundwood	18	30	-
Nawalparari	Roundwood	18	30	-
Nepalganj	Roundwood	25	30	1
Bardiya	Roundwood	8.75	20	1
Dang	Roundwood	NA	30	-
Kailali	Roundwood	8.75	25	1
Kanchanpur	Roundwood	8.75	25	1
Surkhet	Roundwood	NA	30	1

Table 5. Continued.

LOCATION	KIND OF FUELWOOD	SELLING PRICE (NR/ 100 KG.)		NUMBER OF DEPOTS
		1981	1984	
Syngja	Roundwood	NA	40	1
Waling	Roundwood	NA	35	-

Source: Fuel Corporation of Nepal.

incur additional costs in transportation and splitting, the estimated price of fuelwood for a particular household included transportation and processing costs and the corporation price, which was based on the quantity and type of fuelwood bought by the household.

(2) Fuelwood vendors and shops - Fuelwood vendors sold splitted mixed hardwood and conifers per bundle of fuelwood. Carrying fuelwood on their back, the fuelwood vendors sold fuelwood from house to house on a per volume basis. Hence, the households did not incur transportation and processing costs when they purchased fuelwood. In this case, the price of fuelwood was the actual price of fuelwood paid to the vendors.

There were also shops selling fuelwood in small bundles. The price of fuelwood varied among shops. The price of fuelwood in this case was the actual price the households paid to the shop owners including transportation costs in some cases.

(3) Fuelwood collection by family laborers - The family laborers collected fuelwood either from the forest or from their own land. The imputed price of fuelwood was taken in this case. The imputed price of fuelwood represented the price of fuelwood that households had to pay if they were to hire laborers to collect or gather the same quantity of fuelwood. Valuation of fuelwood by the opportunity cost of family-laborers was not adopted in this study because in many parts of Nepal alternative employment opportunities were virtually nil.

Since the opportunity cost of family labor was zero, the prevailing market wage rate of hired laborers was used in imputing the wage rate of family labor, which in turn, was used in imputing the price of fuelwood collected by household members. In case the family members incurred transportation costs, these were added to the imputed cost of gathering fuelwood.

<u>Price of electricity</u> (P_E). The price of electricity per unit or kwh varied according to units of kwh consumed (Appendix Table 1). This was expressed in NR per kwh. The

Nepal Electricity Corporation is the sole agent supplying electricity to the households, government and semi-government as well as both private and government owned/operated industires of the district.

Price of kerosene (P_K). This was expressed in NR per liter. This also included transport cost incurred in purchasing kerosene. The Nepal Oil Corporation is the main distributor of kerosene in the country. The corporation sells through different private and corporation's agents. The selling price is fixed by the corporation (Appendix Table 2).

Price of rice husk and saw dust (P_{RS}). This was expressed in NR per kg. In some cases, it also included transport cost. In most cases, rice husk and saw dust were used together with fuelwood in order to economize on the use of fuelwood.

Price of shrubs and branches (P_{SB}). Shrubs and branches were collectively and locally called as 'Jhinja.' Generally, branches and shrubs were used in modern stoves called as 'Bhuse Chulo' together with rice husk and saw dust. They were also sometimes used alone or with fuelwood. The price of shurbs and branches was expressed in NR per kg. It also included transport cost in some cases.

Frequency of cooking meals and livestock feed (F_{CL}). This refers to the number of times a given household cooks meals and livestock feed per week.

Household Income (H_I). This was measured in terms of the total weekly income of all the household members from all sources (farm and non-farm) expressed in NR.

Household size (H). This included the number of people staying in the same house and sharing the same cooking facilities. Children below one year of age were excluded based on the assumption that they do not take cooked meals. For households who had guests a week prior to the household survey, an adjustment index was added to the total number of household members staying in the same house. Household size, was, therefore, estimated as follows:

$$\text{Household size} = \begin{array}{l}\text{number of household}\\ \text{members sharing the}\\ \text{same cooking faci-}\\ \text{lities}\end{array} + \frac{\begin{array}{l}\text{number of meals}\\ \text{taken by guests}\\ \text{the previous}\\ \text{week}\end{array}}{\begin{array}{l}\text{Frequency of cook-}\\ \text{ing meals per week}\end{array}}$$

Per capita weekly income (I). This was estimated by dividing weekly household income by household size.

Distance of the house from the forest area (DT). This variable was measured in terms of the time spent in walking from the respondent's house to the forest (one way). This travelling time was converted to km. by assuming an average travelling speed of 15 minutes per km.

Urban/Rural location (D_1). This was treated as a qualitative or dummy variable. In terms of location, households were classified into: (1) rural and (2) urban. This variable was assigned a value of one for an urban household and zero, otherwise. The reference group was the rural households.

Types of stove (D_2). This was also introduced qualitatively with the use of a binary or dummy variable. Households were classified by type of stove used: (1) those using traditional stoves ("Agena" or open hearth and "chulo"); and (2) those using modern or close-topped stoves. Households using modern stoves were assigned a value of one and zero, otherwise. The reference group was the traditional stove users.

Type of fuelwood (D_3). Households were classified into three groups by type of fuelwood used: (1) conifer users; (2) those using both hardwood and conifers; and (3) hardwood users. Hardwood refers to the botanical group of trees that have broad leaves while softwood or conifer refers to the botanical group of trees that have needle or scale like leaves and are evergreen for the most part (USDA, 1955). The dummy variables for the type of fuelwood were: D_3 and D_4. D_3 was assigned a value of one if the household under study was a hardwood user and zero, if otherwise. D_4 was assigned a value of one if the household under study used both hardwood and conifer and zero, if otherwise. The reference group was the conifer users. Again, to avoid the singularity problem, group 1 (conifer users) was dropped from the demand model.

The dummy variables, D_1, D_2, D_3 and D_4 were used as intercept shifters in the fuelwood demand model.

3.4.3 Analytical Tools

Both descriptive and regression analyses were employed in this study.

Descriptive analysis. Descriptive statistics like means, percentages and frequencies were used for simple comparisons. An attempt was also made to determine whether the households were using less or more fuelwood in the summer season compared to their consumption in the winter season. Existing forest policies which might also affect fuelwood consumption were also presented and reviewed in this study.

Estimation of fuelwood demand function. In estimating the household demand and per capita demand equations for fuelwood in the winter season, both the linear and the double-log functions were fitted to the data. Ordinary least squares method was utilized in the estimation of both demand models based on the following assumptions: (1) the explanatory (independent) variables are fixed and non-stochastic; (2) the variance of the disturbance term is constant; (3) the mean of the disturbance is zero; (4) the various values of the disturbance term are independent from one another.

In linear form, the household fuelwood demand function was expressed as follows:

$$Q_D = a + b_1P_F + b_2P_E + b_3P_K + b_4P_{RS} + b_5P_{SB} + b_6F_{CL} + b_7H_I + b_8H + b_9DT + b_{10}D_1 + b_{11}D_2 + b_{12}D_3 + b_{13}D_4$$

where:

Q_D = quantity of fuelwood demanded in kg/week/household

P_F = price offuelwood in NR/kg

P_E = price of electricity in NR/kwh

P_K = price of kerosene in NR/liter

P_{RS} = price of rice husk and sawdust in NR/kg

P_{SB} = price of shrubs and branches in NR/kg

F_{CL} = frequency of cooking meals and livestock feed

HI = household weekly income in NR

H = household size

DT = distance of the house from the forest area in km.

D_1 = urban/rural location dummy

D_2 = type of stove dummy

D_3 and D_4 = type of fuelwood dummies

a = constant or intercept

b_i's = regression coefficients

Using the same variables above, the double-log household fuelwood demand function was written as follows:

$$\log Q_D = \log a + b_1 \log P_F + b_2 \log P_E + b_3 \log P_K + b_4 \log P_{RS} + b_5 \log P_{SB} + b_6 F_{CL} + b_7 \log HI + b_8 \log H + b_9 \log DT + b_{10} D_1 + b_{11} D_2 + b_{12} D_3 + b_{13} D_4$$

The linear and the double-log forms of the per capita fuelwood demand functions are similar to those of the household demand, but the aggregate variables (e.g., quantity of household demand for fuelwood and household weekly income) were replaced by the per capita variables. For each form of per capita fuelwood demand, two models were estimated. In model I, household size was omitted from the per capita fuelwood demand equation while in model 2, household size was included as an explanatory variable to determine the economies of size in per capita fuelwood consumption.

In the analysis of the data, there were cases where zero observations were encountered, i.e., no consumption of fuel substitutes during the week prior to the survey. These mean that reported prices for the fuel substitutes were also zero. To remedy the latter case, the computed average price for each fuel substitute during the study period was used as an arbitrary price. This made sure that normalized values for prices were substituted for all zero price data before estimating the linear form of the fuelwood demand. Zero observation for consumption was still retained, implying that even if the sample respondents did not use these fuel substitutes, they faced the same prices as those paid by the consuming households.

In the case of the double-log form of the fuelwood demand, zero observation for quantity presented a problem since there is no log of a zero value. To solve this problem, a very small arbitrary value was chosen (e.g., .00001) which approximates zero. The log value of this arbitrary number chosen was -13.816 and this value was substituted in the double-log estimation process.

The two functional models were compared on the basis of some statistical and economic criteria. The criteria that were used in determining the most appropriate fuelwood demand model were the following:

1) R^2 (coefficient of multiple determination) - The estimated functional form should fit the data well. R^2 is a measure of goodness of fit. The form which was considered to be more apporopriate was indicated by the largest R^2. A large R^2 indicates that the estimated function has a good predictive power.

2) Significance of individual coefficients in the light of the t-test - A model with a larger number of significant terms was preferred to one which had a smaller number of significant coefficients.

3) Adequacy of the estimated function in the light of theory and *a priori* information or economic knowledge - Apart from the usual statistical test criteria, the signs of the parameters were also considered as a factor that conditions the acceptance or rejection of empirical results. The signs of the regression coefficients should be consistent with *a priori* information or knowledge.

Test of hypothesis. In order to determine the relative degree of influence of the explanatory variables on the quantity of fuelwood demanded by households for cooking, the student's t-test was used. To determine the significance of the regression coefficients, computed t-values are compared with the tabular t-values considering the degrees of freedom and the chosen level of significance. If the computed t-value was found to be greater than the critical value of the tabular t-value with n-1 degree of freedom at a specified level of significance, the explanatory variable under consideration was considered to have a significant effect on fuelwood demand, and vice versa.

Estimation of elasticity coefficients. The elasticity coefficients were estimated to determine the magnitude or degree of response of households in terms of fuelwood consumption to changes in factors affecting fuelwood demand. Likewise, the signs of the elasticity coefficients determine the direction of the effects brought about by the said factors. For this particular study, the demand elasticities that were computed were as follows: own-price, cross-price, income, and household size elasticities.

With the linear form of the fuelwood demand function, the elasticities mentioned above were then computed by multiplying the regression coefficient of the specific variable and the quotient of the mean value of that specific variable and the average quantity of the dependent variable. For example, own-price elasticity was estimated as follows: $dQ/dP \cdot \bar{P}/\bar{Q}$ or simply $b \cdot \bar{P}/\bar{Q}$. In the double-log fuelwood demand model, the regression coefficients are the elasticities themselves.

3.5 Limitations of the Study

The four major limitations of the study are as follows:

(1) The findings of this study must be taken with great caution due to the inherent limitations of the study. Obtaining accurate and reliable household information is one of the major difficulties of the study. The information provided by the households was based on memory recall which may lead to memory bias;

(2) In some cases, the households might have deliberately withheld the true information on household income because of their fear that higher taxes might be imposed after the survey;

(3) Due to time and resource limitation, it was not possible to gather data for other seasons. Hence, the study only covered the 1984 winter season. If data for other seasons were gathered, then the result could differ to some extent;

(4) Finally, the findings of the study should be interpreted only for the Kathmandu district of Nepal and cannot be applied to other districts of the country without proper scrutiny and judgement.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter is divided into three sections. The first section deals with the sample household distribution according to some selected characteristics relevant to fuelwood demand. The second section presents the average weekly per capita and per household fuelwood consumption and expenditures. The opinions of the sample households regarding the factors that affect their fuelwood consumption are also discussed in this section. Statistical comparison of two functional fuelwood demand models and the selection of the most appropriate functional model are presented in section three. The discussion about the demand elasticity estimates, the effects of quantitative and qualitative variables on fuelwood demand are also included in this section.

4.1 Sample Household Distribution

4.1.1 According to type of Fuelwood

Table 6 shows that the majority of the sample households used hardwood (43 percent). Approximately 40 percent of the total sample households used both hardwood and conifer while only 17 percent used conifer.

Table 6. Sample household distribution by type of fuelwood used, 154 sample households, selected rural and urban areas of Kathmandu district, Nepal, winter season, 1984.

PANCHAYAT	HARDWOOD USERS		CONIFER USERS		MIXED HARWOOD AND CONIFER	
	No.	%	No.	%	No.	%
Rural:						
With free access forest ((Dakshinkali)	16	42.1	9	23.7	13	34.0
With community or reserve forest (Jorpati)	9	23.1	13	33.3	17	43.6
Urban:						
Without forest (Kathmandu Town Panchayat)	41	53.2	4	5.2	32	41.6
Total	66	42.8	26	16.9	62	40.2

The same trend of fuelwood use was observed in Dakshinkali and the Kathmandu town panchayat. In Jorpati, however, the majority of the households used both conifer and hardwood (43.6 percent) whereas hardwood was not popularly used in this panchayat. This maybe attributed to the fact that fuelwood was commonly sold by vendors in the area on a per bundle basis with conifer and hardwood mixed together in a bundle. The corporation, which usually sells hardwood, does not also have a depot in this panchayat whereas it has depots in Kathmandu town panchayat.

4.1.2 According to Type of Stove

Approximately 88 percent of the sample households used traditional stoves and only 12 percent used modern stoves (Table 7). This implies that traditional stoves were commonly used in all the three sample panchayats. In Dakshinkali and Kathmandu town panchayat, there were some households who used modern stoves. However, households in Jorpati used only traditional stoves. This may be due to the fact that the improved stove program has not been extended in this panchayat whereas in Dakshinkali and in Kathmandu town panchayat, this program has already been implemented.

Table 7. Sample household distribution by type of stove used, 154 sample households, selected rural and urban areas of Kathmandu district, Nepal, winter season, 1984.

PANCHAYAT	TRADITIONAL STOVE		MODERN STOVE	
	No.	%	No.	%
Rural:				
With free access forest (Dakshinkali)	35	92.4	3	7.9
With community or reserve forest (Jorpati)	39	100	-	-
Urban:				
Without forest (Kathmandu Town Panchayat)	61	79	16	20.8
Total	135	87.7	19	12.3

4.1.3 According to Type of Residence

As shown in Table 8, the majority of the sample households in the three sample panchayats were residing in their own houses. Only 8 percent of the total sample households were residing in rented houses. Renting of houses was observed in Dakshinkali and in Kathmandu town panchayat, but in Jorpati, none of the sample households reported to be residing in rented houses.

4.1.4 According to Ethnic Group

Of the total sample households, 51 percent were Newars, 26 percent were Brahmans, 11 percent were Kshetriyas and 12 percent belonged to other ethnic groups (Table 9). In Dakshinkali and the Kathmandu town panchayat, majority of the sample households were Newars (55 and 64%, respectively) whereas in Jorpati, the majority of the sample households were Brahmans (41%).

4.2 Sources of Fuelwood

Table 10 shows the different sources of fuelwood in the sample panchayats. It can be noted that in the sample rural panchayats (Dakshinkali and Jorpati), fuelwood vendors, trees and other plants growing in their private lands were the major sources of fuelwood. This may be attributed to the fact that

Table 8. Sample household distribution by type of residence, 154 sample households, selected rural and urban areas of Kathmandu district, Nepal, winter season, 1984.

PANCHAYAT	OWN RESIDENCE		RENTED RESIDENCE	
	No.	%	No.	%
Rural:				
With free access forest (Dakshinkali)	32	84.2	6	13.6
With community or reserve forest (Jorpati)	39	100	-	-
Urban:				
Without forest (Kathmandu Town Panchayat)	70	90.9	7	9.1
Total	141	91.5	8	8.4

Table 9. Sample household distribution by ethnic group, 154 sample households, selected rural and urban areas of Kathmandu district, Nepal, winter season, 1984.

PANCHAYAT	ETHNIC GROUP							
	Brahman		Kshetriya		Newar		Other	
	No.	%	No.	%	No.	%	No.	%
Rural:								
With free access forest (Dakshinkali)	6	15.8	2	4.5	21	55.3	9	20.5
With community or reserve forest (Jorpati)	16	41.0	11	28.2	9	23.1	3	7.7
Urban:								
Without forest (Kathmandu Town Panchayat)	18	23.4	4	5.2	49	63.6	6	7.8
Total	40	26.0	17	11.0	79	51.3	18	11.6

Table 10. Sources of fuelwood of Nepalese households, 154 sample households, selected rural and urban panchayats, Kathamndu district, Nepal, winter season, 1984.

PANCHAYAT	SOURCES OF FUELWOOD											
	Forest		Fuel Corporation of Nepal (FCN)		Fuelwood Vendors		Own/Private Land		Shops		Various Sources	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Rural:												
With free access forest (Dakshinkali)	8	21.1	-	-	20	52.6	9	23.7	-	-	1	2.6
With community/ reserve forest (Jorpati)	5	12.8	6	15.4	12	30.8	9	23.1	6	15.4	1	2.5
Urban:												
Without forest (Kathmandu Town Panchayat)	-	-	30	39.0	27	35.1	2	2.6	13	16.9	5	6.4
Total	13	8.4	36	23.4	59	38.3	20	13.0	19	12.3	7	4.6

these are the most accessible sources of fuelwood among the rural households. The Fuel Corporation of Nepal (FCN) and shops were the third most common sources of fuelwood in Jorpati. Although there were no FCN depots in this panchayat, the respondents of this panchayat bought their fuelwood from the FCN depots of the neighboring Kathmandu town panchayat. There were also no FCN depots and shops selling fuelwood in Dakshinkali. Unlike Jorpati, Dakshinkali is far from the Kathmandu town panchayat. Forests ranked third as a major source of fuelwood in Dakshinkali, but they only ranked fourth in importance in Jorpati. This may be attributed to the proximity of the free access forest areas to Dakshinkali compared to the latter. The free access forest areas situated near Dakshinkali are the Dandakhel and Dakshinkali forests. On the other hand, the extraction of fuelwood in a reserve forest area (Gokarna Safari Park) and a community forest (Jogadol forest) near the vicinity of Jorpati is prohibited. For this reason, some households in Jorpati (12.8%) gathered fuelwood from the Tare Bhir forest which is far from this panchayat.

In the Kathmandu town (urban) panchayat, the Fuel Corporation of Nepal was the most common source of fuelwood (39%). This may be due to the presence of many FCN depots in this urban panchayat and the low selling prices of FCN. Fuelwood vendors were the second most common sources of fuelwood of the urban households. The fuelwood vendors who sold fuelwood from house to house in this panchayat got their fuelwood supply from the neighboring Nuwakot district.

4.3 Weekly Consumption of Fuel Substitutes, Fuelwood Consumption and Expenditure

4.3.1 Consumption of Fuelwood and Its Substitutes in Rural and Urban Areas

Table 11 shows the sample households' preferences for different sources of energy in selected rural and urban panchayats of the Kathmandu district of Nepal during the 1984 winter season. It can be noted in Table 11 that the sample households generally preferred to use fuelwood for cooking (76 percent) compared to other energy sources. This was followed by electricity (11 percent), gas (8 percent) and kerosene (4 percent). They cited several seasons for preferring fuelwood to other energy sources. One of their major reasons was the lower price and/or lower cost of using fuelwood. Most households, particularly the rural households, considered fuelwood as the cheapest source of energy for cooking. About 21.4 percent of the total sample households reported that the price of fuelwood was equal to their collection cost since they merely gathered fuelwood either from the forest or from their private lands during their free time. On the other hand, the households who purchased fuelwood

Table 11. Household's preference for different types of energy, 154 sample households in selected rural and urban areas of Kathmandu district, Nepal, winter season, 1984.

PANCHAYAT	PERCENTAGE OF HOUSEHOLDS REPORTING (%)				
	Fuelwood	Electricity	Gas	Kerosene	Others
Rural:					
With free access forest (Dakshinkali)	75.0	20.5	2.3	-	2.2
With reserve/community forest (Jorpati)	92.3	5.2	-	2.5	-
Urban:					
With forest (Kathmandu Town Panchayat)	67.5	7.8	15.6	7.8	1.3
All Households	75.6	10.6	8.1	4.4	1.3

indicated that although the average price of fuelwood in terms of energy was higher (NR .3139 per MJ). than that of electricity (NR 0.2242 per MJ), the total cost of using fuelwood was still lower because its use requires simply cheaper and locally manufactured stoves while the use of electricity requires imported stoves, which are more expensive to use (Appendix Table 3). Likewise, the use of other commercial energy substitutes such as sawdusts need special and more expensive stoves, which are not manufactured in the country.

Another reason that they mentioned was the supply of fuelwood was always available unlike those of imported fuelwood substitutes such as gas and petroleum products which were sometimes not available particularly in the rural areas. Considering that these fuelwood substitutes are imported, their supply is controlled by the government and is also largely dependent upon the world market situation. Another advantage of using fuelwood that was reported by the sample households was that they could use the vegetable wastes, tree leaves and waste papers found in their surroundings or yards along with fuelwood for cooking purposes whereas they could not do this if they used other energy sources such as kerosene, gas and electricity. Some rural households also mentioned that they kept few branches of firewood burning throughout the day inorder to save their expenses on matches.

Tables 12 and 13 present the average weekly household and per capita consumption of fuelwood during the 1984 winter season in the sample rural and urban panchayats, respectively. Among the three sample panchayats, Dakshinkali had the highest weekly fuelwood consumption per household (59.84 kg.) and per capita (8.96 kg.). This may be explained by the availability of fuelwood in this rural panchayat and its lower price because of the proximity of free access forest areas in this panchayat. On the other hand, although the average weekly fuelwood consumption of the urban households in the Kathmandu town panchayat (37.79 kg.) was slightly higher than that of the rural households in Jorpati (36.46 kg.) the differences in their mean levels of fuelwood consumption per household was statistically insignificant. As mentioned earlier, the extraction of fuelwood from reserve and community forest areas situated near the vicinity of Jorpati is prohibited by the government. Hence, the supply of fuelwood in this rural panchayat is scarce and its average price was higher than the prevailing price in Dakshinkali (Table 14).

A comparison of the average weekly per capita fuelwood consumption between Jorpati residents and those of the

Table 12. Results of statistical tests to determine if there are significant differences in mean weekly fuelwood consumption per household between panchayats, Kathmandu district, Nepal, winter season, 1984.

PANCHAYAT	NO. OF SAMPLE HOUSEHOLDS	MEAN HOUSEHOLD FUELWOOD CONSUMPTION (KG)	DIFFERENCE (KG)	COMPUTED T-VALUE
Rural 1: Dakshinkali	38	59.84	23.38*	3.20
Rural 2: Jorpati	39	36.46		
Rural 1: Dakshinkali	38	59.84	22.05*	3.64
Urban: Kathmandu Town Panchayat	77	37.79		
Rural 2: Jorpati	39	36.46	-1.33^{ns}	-0.23
Urban: Kathmandu Town Panchayat	77	37.79		
Rural 1 & 2: Dakshinkali and Jorpati	77	48.00	10.21*	5.07
Urban: Kathmandu Town Panchayat	77	37.79		

* - significant at 5% level of significance

ns - not significant at 5% level of significance

Table 13. Results of statistical tests to determine if there are significant differences in mean weekly per capita fuelwood consumption between panchayats, Kathmandu district, Nepal, winter season, 1984.

PANCHAYAT	NO. OF SAMPLE HOUSEHOLDS	MEAN PER CAPITA FUELWOOD CONSUMPTION (KG)	DIFFERENCE (KG)	COMPUTED T-VALUE
Rural 1: Dakshinkali	38	8.96	3.81*	3.98
Rural 2: Jorpati	39	5.15		
Rural 1: Dakshinkali	38	8.96	3.92*	5.15
Urban: Kathmandu Town Panchayat	77	5.04		
Rural 2: Jorpati	39	5.15	0.11^{ns}	0.61
Urban: Kathmandu Town Panchayat	77	5.04		
Rural 1 & 2: Dakshinkali and Jorpati	77	7.03	1.99*	3.14
Urban: Kathmandu Town Panchayat	77	5.04		

* - significant at 5% level of significance

ns - not significant at 5% level of significance

Table 14. Weekly household and per capita consumption of fuelwood and fuel substitutes 154 sample households, selected rural and urban areas of Kathmandu district, Nepal. winter season, 1984.

PANCHAYAT	NUMBER OF SAMPLE HOUSEHOLDS	AVERAGE HOUSE-HOLD SIZE	FUELWOOD CONSUMPTION (kg)		AVERAGE PRICE (NR/KG)
			Per Household	Per Capita	
Rural:					
With free access forest(Dakshinkali)	38	7	59.84	8.96	0.67
With community/ reserve forest(Jorpati)	39	7	36.46	5.15	1.33
Urban:					
Without forest (Kathmandu Town Panchayat)	77	9	37.79	5.04	1.00
All Households (Total/Mean)	154	8	46.8	6.0	1.00

Table 14. continued.

PANCHAYAT	CONSUMPTION IN ENERGY VALUE					
	Fuelwood			Fuel Substitutes		
	Per Household		Per Capita (MJ)	Per Household		Per Capita (MJ)
	Total (MJ)	Percent		Total	Percent	
Rural:						
With free access forest(Dakshinkali)	6576.8	94	956.8	432.5	6	60.9
With community/ reserve forest (Jorpati)	3087.9	83	431.0	634.0	17	90.5
Urban:						
Without forest (Kathmandu Town Panchayat)	4358.2	98	580.5	94.4	2	11.8
All Households (Total/Mean)	4583.8	92	635.5	314.5	8	43.85

Kathmandu town panchayat also showed that there was no significant difference in their mean per capita fuelwood consumption levels (Table 13).

To compare mean weekly per household and per capita fuelwood consumption between urban and rural panchayats, data gathered from the two rural panchayats (Dakshinkali and Jorpati) were pooled. As expected, the rural households had, on the average, a higher weekly fuelwood consumption per household (48 kg.) than the urban households (37.79 kg.). Likewise, they also had a higher weekly fuelwood consumption per capita (7.03 kg.) than the latter (5.04 kg.).

Table 14 also shows the average weekly consumption of fuelwood and fuel substitutes in terms of energy value. The energy conversion factors are presented in Appendix A. Considering all the sample households, the average weekly consumption of fuelwood and fuel substitutes per household during the 1984 winter season was 4583.8 and 314.5 MJ, respectively. These figures indicate that fuelwood substitutes supplied only 8 percent of the total energy consumption of each household for cooking while 92 percent came from fuelwood. This was consistent with the research findings of APROSC (1982) which revealed that 91 percent of the total energy consumption was supplied by fuelwood.

Based on a survey of fuelwood users in Kathmandu town panchayat in this particular study, 98 percent of their total energy consumption for cooking was derived from fuelwood and only 2 percent was supplied by fuel substitutes. The sample urban households did not use agricultural wastes as cheap fuelwood substitutes because of their non-availability in this urban panchayat. Moreover, the use of commercial fuel substitutes like gas and electricity was low because they were more expensive to use compared to fuelwood.

In the rural panchayats (Dakshinkali and Jorpati), the use of agricultural wastes and cowdung as fuel substitutes was commonly practiced because of their abundant supply. In Dakshinkali, 6 percent of the total household energy consumption came from fuel substitutes and 94 percent from fuelwood. This substitution was more prevalent in Jorpati, where 17 percent of the total household energy consumption was derived from fuel substitutes and 83 percent from fuelwood. This may be explained by the scarcity of fuelwood and its higher price in this panchayat, as well as, the policy of the government which prohibits the exploitation of community and reserve forests.[3] In terms of energy value, Jorpati, therefore, had

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[3]According to Forest Act 1978 amendment.

the highest weekly mean per capita consumption of fuel substitutes (90.5 MJ) and the lowest weekly mean per capita consumption of fuelwood (634 MJ) among the three sample panchayats.

The total weekly energy used for cooking per capita (both from fuelwood and its substitutes) was, on the average, 679.3 MJ. According to Shepherd (1979), the energy requirement to have a modest standard of living in Nepal is 577 MJ. In his study, he estimated that the average weekly per capita energy consumption for the country was 83 MJ. This figure was far below the one estimated in this study 679.3 MJ for the Kathmandu district. The energy consumption estimates of Shepherd might have been undervalued because he considered only two cooked meals per day and excluded in his computation the fuels used for cooking tea-ffin, livestock feed and for heating. It is a traditional Nepalese custom that all the family members gather around the stove especially in the evenings while cooking or taking their meals. The purpose of this gathering is not only to keep themselves warm, but also to interact with each other and discuss major household decisions on various aspects. Hence, for these reasons it is difficult to separate the energy used for cooking meals from that used for heating or for family entertainment. In addition, a large percentage of the Nepalese population (95%) are found in the rural areas and they greatly depend on agriculture for their livelihood. Some of these rural households also raise livestock for which they cook feeds either by using fuelwood or fuel substitutes. Hence, failure to capture these factors will definitely underestimate the energy consumption for cooking.

4.3.2 Weekly Household and Per Capita Consumption of Fuelwood by Type of Stove

Table 15 shows the average weekly consumption by type of stove in the three sample panchayats. Traditional stoves ("Agenda" or openhearth and "chulo") were widely used in both the rural panchayats (Dakshinkali and Jorpati), as well as, in the urban panchayat (Kathmandu town). In Jorpati, none of the sample households used modern stoves (closed-topped) while in Dakshinkali only three (3) sample households (8%) used modern stoves. In the Kathmandu town panchayat, only 21 percent of the sample household used modern stoves. Considering all the sample households, 88 percent were traditional stove users while 12 percent were modern stove users.

Generally, the modern or close-topped stoves economize on fuelwood compared to the traditional stoves, other factors held constant. However, since the households using modern stoves had a higher frequency of cooking meals and livestock feed per week compared to those using traditional stoves, the

Table 15. Weekly household and per capita consumption of fuelwood by type of stove, 154 sample households, selected rural and urban areas, Kathmandu district, Nepal, winter season, 1984.

PANCHAYAT	TRADITIONAL STOVE					
	Number of Sample Households	Average Household Size	Average Frequency of Cooking per Week	Average Weekly Household Income	Weekly Fuelwood Consumption (kg)	
					Per Household	Per Capita
Rural:						
With free access forest(Dakshinkali)	35	7.0	26.5	372.7	60.8	8.7
With community or reserve forest (Jorpati)	39	6.8	26.2	362.5	36.5	5.4
Urban:						
Without forest (Kathmandu Town Panchayat)	61	7.5	23.3	757.6	37.0	5.5
All Households (Total/Mean)	135	7.1	25.3	497.6	43.0	6.02

Table 15. continued.

PANCHAYAT	MODERN STOVE					
	Number of Households	Average Household Size	Average Frequency of Cooking per Week	Average Weekly Household Income	Weekly Fuelwood Consumption(kg) Per Household	Weekly Fuelwood Consumption(kg) Per Capita
Rural:						
With free access forest(Dakshinkali)	3	7.8	25.7	306.3	49.0	6.3
With community or reserve forest (Jorpati)	-	-	-	-	-	-
Urban:						
Without forest (Kathmandu Town Panchayat)	16	10.1	26.6	1373.3	45.6	4.5
All Households(Total/Mean)	19	8.9	26.1	839.8	46.1	5.29

average weekly fuelwood consumption per household and per capita were not significantly different between the two groups of households (Table 15 and 16). The average weekly fuelwood consumption per household of traditional stove users was 43.0 kg. while for modern stove users, it was 46.1 kg. On the other hand, per capita weekly consumption of fuelwood of traditional stove users was 6.02 kg., on the average, whereas modern stove users used 5.29 kg. per capita.

4.3.3 Weekly Household and Per Capita Consumption of Fuelwood by Ethnic Group

The average weekly household and per capita consumption of fuelwood by ethnic group in selected rural and urban panchayats of the Kathmandu district of Nepal during the 1984 winter season are presented in Table 17. The ethnic groupings were as follows: (1) Kshetriyas; (2) Brahmans; (3) Newars; and (4) other ethnic groups such as the Lamas, Magans, etc. The classification of these ethnic groups was based on the observed differences in their style of living, food habits and customs.

As shown in Table 17, the Kshetriyas and other ethnic groups had higher weekly fuelwood consumption per household and per capita than the Brahmans and the Newars. This maybe due to the fact that they customarily eat more meat than

Table 16. Results of statistical tests to determine if there are significant differences in mean weekly fuelwood consumption per household and per capita between modern stove users and traditional stove users, 154 sample households, Kathmandu district, Nepal, winter season, 1984.

ITEM	NUMBER OR SAMPLE HOUSEHOLDS	AVERAGE WEEKLY FUELWOOD CONSUMPTION (KG)	DIFFERENCE (KG)	COMPUTED T-VALUE
Per Household:				
Modern Stove	19	46.1	3.1^{ns}	0.4
Traditional Stove	135	43.0		
Per Capita:				
Modern Stove	19	5.29	-0.7^{ns}	-0.7
Traditional Stove	135	6.02		

^{ns} Means not significant at 5% level of significance.

Table 17. Weekly household and per capita consumption of fuelwood by ethnic group, 154 sample households, selected rural and urban areas, Kathmandu district, Nepal, winter season, 1984.

PANCHAYAT/ETHNIC GROUP	NUMBER OF SAMPLE HOUSEHOLD	AVERAGE HOUSE-HOLD SIZE	AVERAGE FREQUENCY OF COOKING	AVERAGE WEEKLY INCOME (NR)	WEEKLY FUELWOOD CONSUMPTION (KG)	
					Per Household	Per Capita
Rural 1: Dakshinkali (With free access forest)						
Kshetriya	2	5.0	26.0	261.5	87.5	17.5
Brahman	6	10.4	35.1	572.8	71.8	6.9
Newar	21	7.1	24.4	408.1	57.1	8.0
Others	9	5.4	25.7	159.6	52.2	9.6
Rural 2: Jorpati (With community/ reserve forest)						
Kshetriya	10	6.5	25.5	348.5	42.5	6.5
Brahman	16	7.4	28.9	382.8	33.8	4.6
Newar	10	6.2	22.6	344.1	29.7	4.8
Others	3	6.3	25.7	360.3	49.0	7.7

Table 17. continued.

PANCHAYAT/ETHNIC GROUP	NUMBER OF SAMPLE HOUSEHOLD	AVERAGE HOUSE-HOLD SIZE	AVERAGE FREQUENCY OF COOKING	AVERAGE WEEKLY INCOME (NR)	WEEKLY FUELWOOD CONSUMPTION (KG)	
					Per Household	Per Capita
Urban: Kathmandu Town Panchayat (without forest)						
Kshetriya	4	9.0	32.0	1117.0	61.8	6.9
Brahman	18	7.6	23.8	1135.8	40.8	5.4
Newar	49	8.2	23.3	614.0	31.3	3.8
Others	6	6.8	25.2	556.2	62.5	9.1
All Sample Panchayats						
Kshetriya	16	6.9	27.2	529.75	54.25	7.16
Brahman	40	7.9	27.5	750.15	42.65	5.72
Newar	80	7.7	23.5	526.2	39.14	5.20
Others	18	6.0	25.5	325.25	54.55	8.9

vegetable dishes compared to the latter. The Brahmans, who are mostly composed of priests, are basically vegetarians. Although the Brahmans cooked meals more frequently than the Kshetriyas and other ethnic groups, their weekly fuelwood consumption per household was lower than the latter because cooking of vegetable dishes is faster and requires less fuelwood compared to meat dishes. Among the four ethnic groups, the Newars, who are considered to be the natives or the indigenous people of Kathmandu, had the lowest weekly fuelwood consumption per household and per capita. This might be attributed to the fact that they had low-income and had the lowest frequency of cooking among the four ethnic groups in the Kathmandu district. Due to their low average weekly household income, the Newars might have reduced their frequency of cooking and might have tried to eat more vegetables which are abundant and cheap in Kathmandu, as well as, relatively faster to cook compared to meat. As shown in Tables 18 and 19, the Kshetriyas and the other ethnic groups had significantly higher weekly fuelwood consumption per household and per capita than the Brahmans and the Newars. However, the average weekly fuelwood consumption per household and per capita were not significantly different between the Brahmans and the Newars because both ethnic groups ate more vegetables than meat.

Table 18. Results of statistical tests to determine if there are significant differences in mean weekly fuelwood consumption per household among ethnic groups, 154 sample households, Kathmandu district, Nepal, winter season, 1984.

ETHNIC GROUP	NUMBER OF SAMPLE HOUSEHOLDS	AVERAGE WEEKLY FUELWOOD CONSUMPTION PER HOUSEHOLD (KG)	DIFFERENCE (KG)	COMPUTED T-VALUE
Brahmans	40	42.65	-11.60*	-1.67
Kshetriyas	16	54.25		
Brahmans	40	42.65	3.5^{ns}	0.62
Newars	80	39.14		
Brahmans	40	42.65	-11.91*	-1.68
Others	18	54.56		
Kshetriyas	16	54.25	15.11*	1.70
Newars	80	39.14		
Kshetriyas	16	54.25	-0.30^{ns}	-0.02
Others	18	54.55		
Newars	80	39.14	-15.41*	-2.06
Others	18	54.55		

* Means significant at 5% level of significance.

^{ns} Means not significant at 5% level of significance.

Table 19. Results of statistical tests to determine if there are significant differences in mean weekly fuelwood consumption per capita among ethnic groups, 154 sample households, Kathmandu district, Nepal, winter season, 1984.

ETHNIC GROUP	NUMBER OF SAMPLE HOUSEHOLDS	AVERAGE FUELWOOD CONSUMPTION PER CAPITA (KG)	DIFFERENCE (KG)	COMPUTED T-VALUE
Brahmans	40	5.72	-1.44*	-1.71
Kshetriyas	16	7.16		
Brahmans	40	5.72	0.52[ns]	0.80
Newars	80	5.20		
Brahmans	40	5.72	3.18*	2.96
Others	18	8.90		
Kshetriyas	16	7.16	1.95*	1.84
Newars	80	5.20		
Kshetriyas	16	7.16	-1.74[ns]	-0.94
Others	18	8.90		
Newars	80	5.20	-3.70*	-3.90
Others	18	8.90		

* Means significant at 5% level of significance.

ns Means not significant at 5% level.

4.3.5 Weekly Fuelwood Expenditure

Table 20 shows that 22 percent of the 154 sample households who used fuelwood in the Kathmandu district did not buy fuelwood while 78 percent bought fuelwood. On the average, the sample households collected 46.67 kg. of fuelwood per household or 6.44 kg. per capita per week and purchased 42.42 kg. of fuelwood per household or 5.23 kg. per capita per week. The sample rural panchayats (Dakshinkali and Jorpati) had higher collection of fuelwood per household and per capita than the sample urban panchayat (Kathmandu town) because of their accessibility to forest areas. In terms of purchases of fuelwood, Dakshinkali households had the highest quantity of purchases, followed by households in the Kathmandu town panchayat and lastly, by the Jorpati households.

As presented in Table 21 the sample households who purchased fuelwood generally had a higher average weekly household income (NR 599.46) than those who did not buy fuelwood (NR 343.52). The latter merely gathered fuelwood from the forest or from their own private lands without incurring any cost in transporting and in collecting fuelwood since the family members themselves did the gathering of fuelwood during their leisure time. However, if the labor spent by the household members

Table 20. Quantities of fuelwood collected and purchased weekly by fuelwood users, 154 sample households, selected rural and urban panchayats, Kathmandu district, Nepal, winter season, 1984.

PANCHAYAT	FUELWOOD PER HOUSEHOLD				QUANTITY OF FUELWOOD PER CAPITA (KG)	
	Collected		Purchased		Collected	Purchased
	Qty. (kg)	%	Qty. (kg)	%		
Rural:						
With free access forest (Dakshinkali)	53.29 (17)	44.7	64.81 (21)	55.3	7.10 (17)	7.22 (21)
With community/reserve forest (Jorpati)	45.21 (14)	35.9	31.56 (25)	64.1	6.36 (14)	4.77 (25)
Urban:						
Without forest (Kathmandu Town Panchayat)	16.00 (3)	3.9	39.74 (74)	96.1	2.18 (3)	4.93 (74)
All Households	46.67 (34)	22.1	42.42 (120)	77.9	6.44 (34)	5.23 (120)

Figures in the parentheses are the number of sample households reporting.

Table 21. Weekly income per capita and per household of fuelwood users, 154 sample households, selected rural and urban panchayats of Kathmandu district, Nepal, winter season, 1984.

PANCHAYAT	WEEKLY INCOME OF THOSE WHO DID NOT BUY FUELWOOD (NR)		WEEKLY INCOME OF THOSE WHO PURCHASED FUELWOOD (NR)	
	Per Household	Per Capita	Per Household	Per Capita
Rural:				
With free access forest(Dakshinkali)	269.95 (17)	35.96	532.49 (21)	59.36
With community/reserve forest(Jorpati)	411.36 (14)	57.84	309.82 (25)	46.82
Urban:				
Without forest(Kathmandu Town Panchayat)	443.88 (3)	60.53	716.32 (74)	88.94
All Households	343.52 (34)	47.14	599.46 (120)	74.99

Figures in parentheses are the number of sample households reporting.

in collecting fuelwood would be valued, their imputed collection cost would be NR 0.62, NR 1.03 and NR 0.87 per kilogram in Dakshinkali, Jorpati and the Kathmandu town panchayat, respectively (Table 22). On the other hand, the households who purchased fuelwood spent, on the average, NR 0.72, NR 1.54 and NR 1.00 per kilogram of fuelwood in the same order of mention. Dakshinkali households had the lowest collection and purchase costs because of the accessibility of this rural panchayat to free access forest areas. Considering all the sample households in the three sample panchayats, the average expenditure per kilogram of fuelwood purchased by the sample households (NR 1.06) was generally higher than the imputed cost per kilogram of fuelwood collected by those households who did not buy fuelwood (NR 0.81).

Comparing the weekly fuelwood expenditures among households in the three sample panchayats, it can be noted that the households in Jorpati had the highest average fuelwood expenditure (NR 48.60) inspite of the fact that they had the lowest quantity of fuelwood purchased (Tables 20 and 23). This may be attributed to the very high price of fuelwood in the area (NR 1.54/kg.), which was double the prevailing price in Dakshinkali (NR 0.72/kg.), the sample panchayat which reported the highest purchases of fuelwood (64.81 kg/household). As expected, the households in the sample rural panchayats (Dakshinkali and Jorpati) had a higher

Table 22. Weekly fuelwood expenditure per kilogram, 154 sample households, selected rural and urban panchayats of Kathmandu district, Nepal, winter season, 1984.

PANCHAYAT	FUELWOOD EXPENDITURES: Collection Cost of Those Who Gathered Fuelwood from the Forest — Actual Cost (NR/kg)	FUELWOOD EXPENDITURES: Collection Cost of Those Who Gathered Fuelwood from the Forest — Actual Cost Plus Imputed Labor Cost (NR/kg)	FUELWOOD EXPENDITURES: Purchase Cost (NR/kg)
Rural:			
With free access forest (Dakshinkali)	0	0.62	0.72
With community/reserve forest(Jorpati)	0	1.03	1.54
Urban:			
Without forest(Kathmandu Town Panchayat)	0	0.87	1.00
All Households	0	0.81	1.06

Table 23. Weekly per capita and per household fuelwood expenditures of the sample households who purchased fuelwood, 120 sample households, selected rural and urban panchayats of Kathmandu district, Nepal, winter season, 1984.

PANCHAYAT	NUMBER OF SAMPLE HOUSEHOLDS REPORTING	FUELWOOD PURCHASED (KG)		FUELWOOD EXPENDITURE (NR)		WEEKLY INCOME (NR)		PERCENT OF WEEKLY INCOME (%)	
		Per House-hold	Per Cap-ita	Per House-hold	Per Cap-ita	Per House-hold	Per Capita	Per Household	Per Capita
Rural:									
With free access forest(Dakshinkali)	21	64.81	7.22	46.66	5.20	523.49	59.36	8.91	8.76
With community/ reserve forest (Jorpati)	25	31.56	4.77	48.60	7.35	309.82	46.82	15.68	15.70
Urban:									
Without forest (Kathmandu Town Panchayat)	74	39.74	4.93	39.74	4.93	716.32	88.94	5.54	5.54
All Households	120	42.42	5.23	44.97	5.54	599.46	74.99	7.50	7.39

average fuelwood expenditure per household than the households in the sample urban panchayat (Kathmandu town). This indicates that fuelwood was more widely used in the rural areas.

As shown in Table 23, fuelwood expenditure, on the average, represented approximately 9 to 16 percent of the household weekly income in the rural panchayats and only 6 percent of the household weekly income in the sample urban panchayat. Considering all the sample households fuelwood expenditure comprised approximately only 8 percent of the household weekly income.

4.3.5 Estimated Per Capita Consumption of Fuelwood and Fuel Substitutes for the 1984 Winter Season

Table 24 shows the estimated per capita consumption values for fuelwood and fuel substitutes in selected rural and urban areas of the Kathmandu district of Nepal for the 1984 winter season. To estimate the per capita consumption of fuelwood throughout the winter season, the weekly per capita consumption of fuelwood was multiplied by the total number of weeks (26 weeks) in the winter season. In this study the winter season was considered to be of six months duration (September to February).

In the 1984 winter season, the estimated or extrapolated fuelwood consumption per capita was 157.04 kg. (Table 24).

Table 24. Estimated per capita consumption of fuelwood and fuel substitutes for the entire winter season, 154 sample households, selected rural and urban areas of Kathmandu district, Nepal, 1984.

PANCHAYAT	WEEKLY PER CAPITA FUELWOOD CONSUMPTION (KG)	PER CAPITA FUELWOOD CONSUMPTION FOR THE 1984 WINTER SEASON[a]	PER CAPITA ENERGY CONSUMPTION FOR THE 1984 WINTER SEASON (MJ)		
			Fuelwood	Fuel Substitutes	Total
Rural:					
With free access forest (Dakshinkali)	8.96	232.96	24876.8	1583.4	26360.2
With community/ reserve forest (Jorpati)	5.15	133.90	11206.0	2353.0	13559.0
Urban:					
Without forest (Kathmandu Town Panchayat)	5.04	131.04	15093.0	306.8	15399.8
All Households	6.04	157.04	16523.0	1130.0	17653.0

[a] This was estimated by multiplying per capita consumption per week by the total number of weeks during the winter season (26 weeks). The winter season in this study is considered to be of six months duration (September to February).

Dakshinkali had the highest fuelwood consumption per capita (232.96 kg), followed by Jorpati with 133.90 kg. and lastly, by the Kathmandu Town Panchayat with 131.04 kg. A separate study conducted by APROSC (1983) in selected urban areas of Nepal reported that the annual per capita consumption was 280 kg. Assuming that the fuelwood consumption during the winter and the summer seasons would be the same, then the annual fuelwood consumption in the Kathmandu town panchayat would be 262.08 kg. If the annual per capita consumption estimated in this study for the Kathmandu town panchayat approximates APROSC's estimated fuelwood consumption value, then this implies that the fuelwood consumption estimated for the winter season in this study represents a large percentage (almost 50%) of the annual fuelwood consumption in the area.

In terms of energy value, the estimated per capita fuelwood consumption for the 1984 winter season was 16.523 MJ. Dakshinkali ranked first in terms of fuelwood consumption converted into its energy value (24,876.8 MJ), followed by the Kathmandu town panchayat (15,093.0MJ) and lastly, by Jorpati with 11,206 MJ. It can be noted that there was a change in ranking between Kathmandu town panchayat and Jorpati when fuelwood was converted into its energy value. This may be explained by the fact that more households used hardwood in the Kathmandu town panchayat than in Jorpati. As explained earlier, hardwood has a higher energy or calorific value than softwood or conifers.

Regarding consumption of fuel substitutes (converted into energy value), Jorpati had the highest per capita consumption of fuel substitute during the 1984 winter season with 2353 MJ, followed by Dakshinkali with 1583.4 MJ and finally, by the Kathmandu town panchayat with 306.8 MJ. Consdering all the sample households, the average per capita consumption of fuel substitutes during the 1984 winter season was 1130 MJ.

Comparing the total consumption of energy (both from fuelwood and fuel substitutes) for the 1984 winter season among the three sample panchayats, Dakshinkali had the highest energy consumption, 26,460.2 MJ, followed by the Kathmandu town panchayat. On the other hand, Jorpati had the lowest energy consumption (67,559.0 MJ) among the three sample panchayats. The higher average energy consumption (from fuelwood and fuel substitutes as energy sources) in Dakshinkali compared to those in Jorpati and the Kathmandu town panchayat might be attributed to the availability of greater quantities of fuelwood (especially the hardwood) and agricultural wastes in this rural panchayat.

4.3.6 Opinions of the Sample Households Regarding Seasonal Variatiion in Fuelwood Consumption

The classification of season for this particular study was based in two's distinct weather conditions in the study area. These are: 1) summer (March-August) and 2) winter (September-February). In order to find out if there are seasonal variations in fuelwood consumption, the sample households were asked to give their opinions regarding this matter.

As shown in Table 25, majority of the sample households (71 percent) reported that they consume more fuelwood during the winter season because of the cold climate. Since the weather condition and water are cold during winter, it takes a longer time to cook food and boil water during this period. For this reason, more fuelwood is needed for cooking. In addition, they reported that the households usually use more fuelwood for heating and for producing wine during the winter season.

On the contrary, about 15 percent of the 154 sample respondents mentioned that their fuelwood consumption was higher during summer.

The major reason cited by the respondents who reported that their fuelwood consumption was higher during the summer months was the large number of agricultural laborers they had to feed during this period. These agricultural laborers are employed every summer for transplanting operations. Hence, a large quantity of fuelwood is usually used for cooking food for the hired laborers. Moreover, they noted that fuelwood is generally wet during summer and it produces more smoke than heat. For this reason, they have to use more fuelwood for cooking during summer.

Table 25. Opinions of the sample households regarding seasonal variation in fuelwood consumption, 154 sample households, rural and urban panchayats of the Kathmandu district, Nepal, winter season, 1984.

PANCHAYAT	PERCENTAGE OF HOUSEHOLDS REPORTING(%)		
	More Fuelwood Consumption During Winter	More Fuelwood Consumption During Summer	No Difference in Fuelwood Consumption Between Summer and Winter
Rural:			
With free access forest (Dakshinkali)	56.8	27.3	15.9
With community/reserve forest(Jorpati)	66.7	17.9	15.4
Urban:			
Without forest (Kathmandu Town Panchayat)	80.5	6.5	13.0
All Households	70.6	15.0	14.4

About 14 percent of the sample respondents indicated that there was no difference in fuelwood consumption between the winter and summer seasons. They explained that a large quantity of fuelwood was used during winter for heating. Likewise they also need a large quantity of fuelwood during summer to cook food for the agricultural laborers, whom they hired for rice farming operations. Hence, they did not observe any difference in fuelwood consumption between these seasons.

4.3.7 Opinions of the Sample Households Regarding the Trend in Fuelwood Consumption

Table 26 shows that the majority of the sample respondents (52%) mentioned that fuelwood consumption has been decreasing for the past 10 years. They cited the following reasons for the decline in fuelwood consumption: 1) increasing trend in the price of fuelwood; 2) scarcity or decreasing supply of fuelwood; and 3) strict government regulation on fuelwood extraction from the forests.

About 27 percent of the sample respondents reported that fuelwood consumption showed an increasing trend while 21 percent indicated that there has been no change in fuelwood consumption for the past 10 years.

Table 26. Opinions of the sample households regarding the trend in fuelwood consumption, 154 sample households, selected rural and urban panchayats of Kathmandu district, Nepal, winter season, 1984.

PANCHAYAT	PERCENTAGE OF SAMPLE RESPONDENTS REPORTING (%)		
	Increasing Trend	Decreasing Trend	No change
Rural:			
With free access forest (Dakshinkali)	21	53	26
With community/reserve forest (Jorpati)	21	49	30
Urban:			
Without forest (Kathmandu Town Panchayat)	32	55	13
All Households	27	52	21

4.4 Empirical Results of Fuelwood Demand Analysis

The empirical results of the fuelwood demand analysis are presented and interpreted in this section. Linear and double-log forms of fuelwood demand equations were estimated. Estimation of parameters was accomplished by fitting several multiple regression functions to cross-section data. The linear and double-log forms were compared on the basis of economic and statistical criteria. As mentioned earlier in Chapter 3, the underlying criteria considered in selecting the best model were: 1) the coefficient of determination (R^2); 2) the number of variables which were significant; 3) theoretical soundness; and 4) magnitude of the regression coefficients. However, only the best household and per capita fuelwood demand models were further analyzed and discussed.

4.4.1 Estimates of Household Fuelwood Demand

Table 27 presents the estimated linear and double-log household demand functions for fuelwood in the Kathmandu district of Nepal for the winter season. The regression coefficients of the explanatory variables from the linear equations are the absolute changes in fuelwood consumption per unit change in the explanatory variable. On the other hand, the regression coefficients of the independent variables derived from the double log equations are already the elasticities or the relative changes expressed in percentage change in fuelwood consumption resulting from a one percent change in the explanatory variable.

As shown in Table 27, all the estimated household demand models had a poor fit as evident from their low coefficients of determination (R^2 = .27 to .38). The estimated R^2 values indicate that 27 to 38 percent of the variation in household fuelwood consumption was explained by the variation of the included independent variables. An examination of their F-values shows that the overall estimated equations were all highly significant. Relatively better results, however, were obtained in the estimated linear demand equations than those in the double-log form. The linear equations are superior to the double-log equations owing to their higher coefficients of determination, higher number of significant explanatory variables and the conformity of the signs of the regression coefficients of all the explanatory variables to economic expectations.

It can be noted that although linear model 1, which is the complete model, appears to have a higher coefficients of determination (R^2 = .38) than linear model 2 (R^2 = .35), some explanatory variables were found to be highly correlated with each other (e.g., r = 0.71 for distance of the house from the forest and urban/rural location dummy as shown in Appendix Table 4). Due to the multicollinearity problem in

Table 27. Estimated household fuelwood demand equations, 154 sample households, Kathmandu district, Nepal, winter season, 1984.

EQUATION	INTERCEPT	PRICE OF FUELWOOD (P_F)	PRICE OF ELECTRICITY (P_E)	PRICE OF KEROSENE (P_K)	PRICE OF RICE HUSK & SAWDUST (P_{RS})	PRICE OF SHRUBS AND BRANCHES (P_{SB})	FREQUENCY OF COOKING MEALS AND FEEDS FCL)
Linear Models:							
(1)	60.82	-6.00*	16.24*	-6.04^{ns}	3.99^{ns}	-1.21^{ns}	.54*
		(-1.70)	(1.85)	(- .57)	(.66)	(- .51)	(1.68)
(2)	15.97	-6.99**	15.75*	$- .78^{ns}$	4.99^{ns}	-1.64^{ns}	.60*
		(-1.95)	(1.75)	(- .07)	(.81)	(- .68)	(1.83)
Double-log Models:							
(1)	2.05	$- .20^{ns}$	$.47^{ns}$	$.24^{ns}$	$.20^{ns}$	$- .01^{ns}$	$.007^{ns}$
		(-1.54)	(1.36)	(.13)	(1.84)	(- .87)	(.17)
(2)	-.536	- .27**	$.47^{ns}$	1.52^{ns}	$.20^{ns}$	- .11	$.07^{ns}$
		(-2.13)	(1.35)	(.84)	(1.80)	(-.93)	(.16)

Figures in parentheses are t-values.

***,**,* means significant at 1%, 5% and 10% level of significance, respectively.

ns means not significant at 10% level of significance.

Table 27. continued.

EQUATION	INTERCEPT	HOUSEHOLD WEEKLY INCOME (HI)	HOUSEHOLD SIZE (H)	DISTANCE OF THE HOUSE FROM THE FOREST (DT)	URBAN/RURAL LOCATION DUMMY (DI)	TYPE OF STOVE DUMMY (D2)	TYPE OF FUELWOOD DUMMIES (D3)	(D4)	F VALUE	R^2
Linear Models:										
(1)	60.82	.01*** (3.17)	1.83*** (2.77)	-1.37*** (-2.64)	-28.90*** (-3.35)	-7.20ns (- .99)	3.83ns (.57)	-.58ns (-.09)	6.51***	.38
(2)	15.97	.01*** (3.13)	1.80*** (2.67)		-14.14** (- 2.10)	-7.68ns (-1.04)	2.41ns (.35)	-.39ns (-.06)	6.21***	.35
Double-log Models:										
(1)	2.05	.11ns (1.13)	.50*** (2.82)	- .16** (-2.00)	- 2.39** (-2.19)	.03ns (.15)	.27ns (1.49)	.16ns (.94)	4.47***	.29
(2)	-.536	.11ns (1.12)	.48*** (2.71)		- .24ns (-1.25)	.01ns (.06)	.26ns (1.44)	.17ns (1.01)	4.84***	.27

Figures in parentheses are t-values.
***,**,* means significant at 1%, 5% and 10% level of significance, respectively.
ns means not significant at 10% level of significance.

linear model 1, another regression model (linear model 2) was estimated with distance of the house from the forest omitted in the second model. Dropping of one variable in linear model 2 did not lead to any significant difference from the previous specification except that the effect of the price of fuelwood on fuelwood consumption became more significant. It can be noted that the coefficient of determination was only slightly changed by the elimination of one regressor and the signs of all the estimated parameters conformed to expectations. Hence, linear model 2 was chosen as the best household fuelwood demand function. Since linear model 2 was chosen as the best household fuelwood demand model, only the coefficients of this model were further analyzed and discussed.

Among the 12 explanatory variables included in linear model 2, the price of fuelwood, the price of electricity, frequency of cooking meals and livestock feed, household weekly income, household size and urban/rural location dummy were found to have significant effects on weekly household fuelwood demand.

The regression coefficient of the price of fuelwood was significant at 5 percent level and had the expected sign. The negative regression coefficient of the price of fuelwood connotes that the quantity of fuelwood demanded per household would decrease by 6.99 kg weekly with a NR 1.00/kg increase in the price of fuelwood, holding other variables constant.

The positive regression coefficients of the price of electricity and the prices of rice husk and sawdust indicate that electricity, rice husk and sawdust are substitutes of fuelwood for cooking. The coefficient of the price of electricity was positive and significant at 10 percent level only. The estimated regression coefficient of the price of electricity indicates that if the price of electricity would increase by NR 1.00/kwh, household fuelwood consumption would increase by 15.75 kg weekly, other variables in the model remaining constant. Although bearing the expected sign, the prices of rice husk and sawdust were not found to be important determinants of household fuelwood demand as indicated by their insignificant regression coefficients.

The prices of kerosene, shrubs and branches had also insignificant effects on household fuelwood demand. The negative signs of the regression coefficients of the price of kerosene and the price of shrubs and branches were also consistent with a priori expectations and indicates that kerosene, branches and shrubs are complements of fuelwood. When fuelwood was used for cooking, many households in the Kathmandu district poured kerosene and added small branches for faster burning or ignition.

As expected, the regression coefficient of frequency of cooking meals and feeds was positive, but was significant at 10 percent level only. The positive regression coefficient (.60) of the frequency of cooking meals and livestock feed denotes that higher frequency of cooking meals and livestock feed would increase weekly household fuelwood consumption, other variables remaining the same.

Household weekly income increased weekly household fuelwood consumption significantly as shown by its highly significant regression coefficient (1% level). The positive regression coefficient of weekly household income of .01 implies that weekly household fuelwood demand would increase by .01 kg per household per week if the weekly household income would increase by NR 1.00.

Likewise, the regression coefficient of household size was highly significant at 1% level and positive implying that the larger the family size, the higher will be the household fuelwood consumption. Its positive regression coefficient of 1.80 denotes that an additional family member would increase fuelwood consumption per household by 1.80 kg per week. Some important qualitative variables (e.g., location, type of stove and type of fuelwood) were also introduced in the demand model through the use of zero-one dummy or binary variables in order to know their effect on household fuelwood demand. These binary variables were used as intercept shifters.

The location dummy variable was included in the demand model to test whether there were intercept differences between rural and urban households. The regression coefficient of the urban/rural location dummy variable (D_1) was negative as expected and significant at 5 percent level implying that urban households had lower household fuelwood consumption compared to the rural households, other factors remaining the same. This is consistent with the findings in the descriptive or tabular analysis presented in the previous section. The higher household fuelwood consumption of the rural households was due to their accessibility to forest areas.

The regression coefficient of the type of stove dummy variable (D_2) was also negative, but insignificant. Its negative sign implies that traditional stove users had more fuelwood consumption than modern stove users, other factors held constant. Since traditional stoves do not have flue nor draft control, heat is not conserved in the stove, thus requiring the use of more fuelwood. The difference in the fuelwood consumption of traditional and modern stove users was not statistically significant.

Regarding the dummy variables for type of fuelwood, the regression coefficients were insignificant. Contrary to expectations, the type of fuelwood did not have a significant effect on household fuelwood demand. The regression coefficient of hardwood dummy variable (D_3) was positive which means that households using hardwood had higher fuelwood consumption than those using conifers, other factors remaining the same. A possible explanation for this positive coefficient maybe the multiple uses of hardwood.

Hardwood is not only used for cooking, but it also provides additional income to the households. Hardwood generates energy which is ten times more than softwood and yields charcoal which could be used for smoking tobacco in "chilam" (a kind of traditional device used for smoking tobacco), for room heating in "makkal" (a kind of pot made up of metal or clay) and for pressing or ironing clothes. Some households were, therefore, found selling charcoal obtained after cooking their meals using hardwood. Although the household fuelwood consumption of hardwood users was higher than those of the conifer users, the difference in their weekly fuelwood consumption was not statistically significant. Likewise, there was no significant difference in household fuelwood consumption between pure conifer users and those using mixed conifers and hardwood.

4.4.2 Estimates of Per Capita Fuelwood Demand

Several alternative models of specification were tested to estimate the winter season per capita fuelwood demand in the Kathmandu district (Table 28). It can be noted that although all the estimated per capita fuelwood demand equations were significant as indicated by their high F-values, they generally gave unsatisfactory results. Lower coefficients of determination were obtained for the per capita demand equations compared to

Table 28. Estimated per capita fuelwood demand equations, 154 sample households, Kathmandu district, Nepal, winter season, 1984.

EQUATION	INTERCEPT	PRICE OF FUELWOOD (P_F)	PRICE OF ELECTRICITY (P_E)	PRICE OF KEROSENE (P_K)	PRICE OF RICE HUSK & SAWDUST (P_{RS})	PRICE OF SHRUBS & BRANCHES (P_{SB})	FREQUENCY OF COOKING MEALS AND FEEDS (FCL)	PER CAPITA WEEKLY INCOME (I)
Linear Models:								
(1)	2.51	-.90*	.30*	.97ns	.91ns	.82ns	-.02ns	.01ns
		(-1.81)	(.27)	(.65)	(1.07)	(.25)	(-.38)	(1.46)
(2)	5.48	-.95**	1.78ns	.58ns	1.08ns	-.05ns	-.01ns	.01*
		(-1.97)	(1.48)	(.40)	(1.31)	(-.15)	(-.15)	(1.69)
(3)	-6.22	-1.08**	.19ns	2.00ns	1.10ns	-.0004ns	-.01ns	.01ns
		(-2.11)	(.16)	(1.31)	(1.24)	(-.001)	(-.13)	(1.47)
(4)	-3.09	-1.14**	1.69ns	1.58ns	1.28ns	-.13ns	.004ns	.01*
		(-2.27)	(1.35)	(1.06)	(1.48)	(-.40)	(.10)	(1.69)
Double-log Models:								
(1)	.63	-.18ns	.07ns	.42ns	.21*	-.06ns	.04ns	.10ns
		(-1.40)	(.22)	(.22)	(1.88)	(-.57)	(1.02)	(1.03)
(2)	2.04	-.20ns	.47ns	.24ns	.20ns	-.10ns	.01ns	.10ns
		(-1.54)	(1.36)	(.13)	(1.83)	(-.87)	(.17)	(1.13)
(3)	-2.18	-.26**	.05ns	1.79ns	.20*	-.07ns	.04ns	.10ns
		(-2.00)	(.17)	(.97)	(1.84)	(-.63)	(1.03)	(1.02)
(4)	- .54	-.27**	.47ns	1.51ns	.20*	-.11ns	.01ns	.10ns
		(-2.13)	(1.35)	(.84)	(1.80)	(-.93)	(.16)	(1.12)

Figures in parentheses are t-values.
***,**,* means significant at 1%, 5% and 10% level of significance, respectively
ns means not significant at 10% level of significance.

EQUATION	INTERCEPT	HOUSEHOLD SIZE (H)	DISTANCE OF THE HOUSE FROM THE FOREST (DT)	URBAN/RURAL LOCATION DUMMY (D1)	TYPE OF STOVE (D2)	TYPE OF FUELWOOD DUMMIES (D3)	(D4)	F VALUE	R^2
Linear Models:									
(1)	2.51		-.26*** (-3.60)	-4.74*** (-3.93)	-.33ns (-.33)	1.50ns (1.58)	.62ns (.67)	3.43***	.23
(2)	5.48)	-.24*** (-2.95)	-.26ns (-3.66)	-4.39*** (-3.72)	-.41*** (-.42)	1.41ns (1.52)	.79 (.88)	4.01***	.27
(3)	-6.22			-1.93** (-2.01)	-.44ns (-.41)	1.23ns (1.25)	.65ns (67)	2.36***	.15
(4)	-3.09	-.24*** (-2.88)		-1.61* (-1.71)	-.51ns (-.50)	1.14ns (1.18)	.83ns (.88)	2.97***	.20
Double-log Models:									
(1)	.63		-.17** (-2.09)	-2.50** (-2.24)	.02ns (.09)	.28ns (1.56)	.16ns (.88)	2.75***	.19
(2)	2.04	-.40*** (-2.68)	-.16** (-2.00)	-2.39** (-2.19)	.03ns (.15)	.27ns (1.49)	.16ns (.93)	3.21***	.23
(3)	-2.18			- .21ns (-1.07)	-.0002 (-.001)	.28ns (1.51)	.17ns (.95)	2.55***	.16
(4)	- .54	-.41*** (-2.75)		-.24ns (-1.25)	.01ns (.06)	.26ns (1.44)	.18ns (1.01)	3.07***	.21

Figures in parentheses are t-values.
***,**,* means significant at 1%,5% and 10% level of significance, respectively.
ns means not significant at 10% level of significance.

those in the household demand models. In addition, illogical signs of the regression coefficients of some of the explanatory variables were also observed in the per capita demand models.

Multicollinearity problem was encountered in models 1 and 2, both in the linear and double-log functional forms. A high correlation between distance of the house from the forest and urban/rural location dummy variable ($r = 0.71$) was noted (Appendix Table 5). In order to improve the results, model 3 (without household size) and model 4 (with household size) using both linear and double-log forms were estimated with distance of the house from the forest deleted from these models. This led to a decrease in R^2, but the effect of the price of fuelwood on per capita fuelwood demand became more significant.

Linear model 4 was selected as the best per capita fuelwood demand model. Although double-log model 4 provided a better fit to the data ($R^2 = .21$) than linear model 4 ($R^2 = .20$), the sign of the regression coefficient for the type of stove dummy variable in the former model turned out to be illogical or contrary to expectations. In both models, however, the price of kerosene was not consistent with _a priori_ expectations.

The discussion below focused on linear model 4, the best per capita fuelwood demand function.

The price of fuelwood appeared to have a significant and negative effect on weekly per capita fuelwood demand. The interpretation of the fuelwood price coefficient is that holding other variables constant, an increase in the price of fuelwood by NR 1.00/kg will result in a decrease in per capita fuelwood consumption by 1.14 kg per week.

The same equation shows that both per capita weekly income and household size had significant effects on weekly per capita fuelwood consumption indicating as per capita income increases, fuelwood consumption per capita would also increase. The negative and significant regression coefficient of household size implies economies in per capita fuelwood consumption in large households.

The regression coefficient of the urban/rural location dummy variable (D_1) was significant at 10 percent level only and negative in linear model 4, indicating that weekly per capita fuelwood consumption was lower in urban areas than in rural areas.

Although bearing the expected signs, the frequency of cooking meals and livestock feed, the type of stove, the type of fuelwood and the prices of electricity, rice husk, sawdust, shrubs and branches had no significant effects on weekly per capita fuelwood demand. Similarly, the regression coefficient of the price of kerosene was not significant.

4.4.3 Fuelwood Demand Elasticity

Own-price elasticity of demand. As shown in Table 29, own-price elasticity of household fuelwood demand is -.16 and is, therefore, inelastic. This is mainly attributed to the fact that for the majority of the households in Nepal, fuelwood is an essential good because it is the most reliable source of energy for them. The own-price elasticity coefficient of -.16 indicates that a one percent increase in the price of fuelwood would cause a 0.16 percent decrease in the quantity of fuelwood demanded per household per week.

On the other hand, the own-price elasticity of per capita fuelwood demand is -.19 and is also inelastic, implying that a one percent change in the price of fuelwood will bring about a .19 percent decrease in the quantity of fuelwood demanded per capita per week.

Cross-price elasticity of demand. This shows the response of the demand for fuelwood in relation to changes in price of other related commodities. Cross price elasticity measures the extent to which commodities are related to each other. Substitutes have positive cross-price elasticities while complements have negative cross-price elasticities.

In Table 29, only the cross-price elasticity of household demand with respect to the price of electricity was presented since the prices of other fuel sources such as rice husk, sawdust, kerosene, shrubs and branches were found to have insignificant effects on household fuelwood demand.

The households' responsiveness to the price of electricity was apparent from the significant cross-price elasticity of fuel-wood demand with respect to the price of electricity. Cross price elasticity of fuelwood demand with respect to the price of electricity was positive indicating that fuelwood and electricity are substitutes. The cross-price elasticity coefficient is 0.20, which implies that a one percent increase in the price of electricity will increase the household fuelwood demand by 0.20 percent per week. This finding suggests that if the Nepalese government wants to discourage the use of fuelwood in order to minimize deforestation, low-cost electricity shoudd be provided. This would be one of the most effective ways of reducing deforestation because the supply and price of electricity are entirely controlled by the government in Nepal.

Income elasticity of demand. This can be defined as the responsiveness of the quantity of fuelwood used by households to income changes.

Table 29. Elasticity estimates of fuelwood demand from the selected household and per capita models, Kathmandu district, Nepal, winter season, 1984.

ITEM	HOUSEHOLD FUELWOOD DEMAND[1]	PER CAPITA FUELWOOD DEMAND[2]
Own-price elasticity	-.16	-.19
Cross-price elasticity with respect to electricity	.20	-
Income elasticity	.13	-
Household size elasticity	.32	-

[1]Cross-price elasticities were not computed for insignificant regression coefficients (e.g., prices of kerosene, rice husk, sawdust, shrubs and branches).

[2]Cross-price elasticities, income elasticity and household size elasticities were not computed because of insignificant regression coefficients of household size, income prices of kerosene, rice husk, sawdust, shrubs and branches.

The income elasticity coefficient is 0.13 indicating that fuelwood is a normal good and that household fuelwood demand would increase by 0.13 percent if there is a one percent increase in household weekly income. A comparison of the elasticity coefficients shows that household fuelwood demand is more responsive to changes in the prices of electricity and fuelwood than to changes in income.

Household size elasticity. The household size elasticity shows the responsiveness of fuelwood demanded to the change in household size. The household size elasticity coefficient is 0.32. This figure means that if household size would increase by one percent, household fuelwood demand would increase by 0.32 percent per week.

CHAPTER V

SUMMARY, CONCLUSION AND IMPLICATIONS

5.1 Summary and Conclusion

This study attempted to analyze the determinants of household demand for fuelwood and also to estimate own-price, cross-price, household size and income elasticities of fuelwood demand in selected rural and urban panchayats of the Kathmandu district of Nepal using cross-section data gathered during the 1984 winter season.

The three sample panchayats which were purposively selected for this particular study were: (1) the Kathmandu town panchayat, representing an urban panchayat and non-forest area; (2) Jorpati, representing a rural panchayat with community or reserve forest area; and (3) Dakshinkali, representing a rural panchayat located near a free access forest. The sample sizes for the rural and urban sample panchayats were determined through equal allocation method. A total of 154 households, which were randomly selected with replacement were personally interviewed using a pre-tested questionnaire.

Both descriptive and regression analyses were employed in this study. To estimate the household and per capita demand equations for fuelwood in the winter season, both the linear and the double-log functions were fitted to the data. Ordinary least squares method was utilized in the estimation of the fuelwood demand models. The explanatory variables included in the estimation of the fuelwood demand equations were: price of fuelwood, price of electricity, price of kerosene, price of rice husk and sawdust, price of shrubs and branches, frequency of cooking meals and livestock feed, household weekly income, household size, distance of the house from the forest area, urban/rural location dummy, type of stove dummy and type of fuelwood dummies. The two functional models were compared on the basis of some statistical and economic criteria.

The results of the study showed that the majority of the sample households used hardwood (43 percent) while 40 percent used both hardwood and conifers. Only 17 percent used conifers or softwood. Traditional stoves were commonly used in all the sample panchayats in the Kathmandu district (88 percent). Of the total sample households, 51 percent were Newars, 26 percent were Brahmans, 11 percent were Kshetriyas and 12 percent belonged to other ethnic groups.

The sample households generally preferred to use fuelwood for cooking (76 percent) compared to other energy sources. This was followed by electricity (11 percent), gas (8 percent) and kerosene (4 percent). The major reasons for their preference for fuelwood were as follows: its lower cost and its available supply. They also mentioned that the use of fuelwood requires simple stoves whereas the commercial energy sources need special stoves which are not locally manufactured and are, therefore, more expensive to use.

A comparison of the mean weekly per household and per capita fuelwood consumption between urban and rural panchayats showed that the rural households had, on the average, a higher weekly fuelwood consumption per household (48 kg) than the urban households (37.79 kg). Likewise, they also had a higher weekly fuelwood consumption per capita (7.03 kg) than the latter (5.04 kg). This may be attributed to the accessibility of the rural panchayats to forest areas.

In the rural panchayats, the use of agricultural wastes and cowdung as fuel substitutes was commonly practiced because of their abundant supply in these areas. On the other hand, the sample urban households did not use agricultural wastes as cheap fuelwood substitutes because of their non-availability in the urban sample panchayat.

A comparison of fuelwood consumption among ethnic groups also revealed that the Kshetriyas and other ethnic groups such as the Lamas and the Magars had a higher average weekly fuelwood consumption per household and per capita than the Brahmans and the Newars. This may be due to the fact that they customarily eat more meat than vegetable dishes compared to the latter.

The results of the study also showed that the majority of the sample households bought fuelwood (78 percent) while 22 percent did not buy fuelwood. On the average, the sample households collected 46.47 kg of fuelwood per household or 6.44 kg per capita per week and purchased 42.42 kg of fuelwood per household or 5.23 kg per capita per week. The sample rural panchayats had higher collection of fuelwood per capita than the sample urban panchayat because of their accessibility to forest areas. The sample households who purchased fuelwood generally had a higher average weekly household income (NR 599.46) than those who did not buy fuelwood (NR 343.42). On the average, fuelwood expenditure represented approximately 9 to 16 percent of the household weekly income in the rural panchayats and only 6 percent of the household weekly income in the sample urban panchayat.

Majority of the sample households (71 percent) reported that they consume more fuelwood during the winter season because of the cold climate. They explained that due to the cold weather condition, it takes a longer time to cook food and boil water during this period. For this reason, more fuelwood is needed for cooking. In addition, they reported that the households usually use more fuelwood for heating and for producing wine during the winter season.

Results of the demand analysis showed that the linear model is the best household fuelwood demand equation because of its better fit (higher coefficient of determination), higher number of significant explanatory variables and the conformity of the signs of the regression coefficients of all the explanatory variables to economic expectations.

The study also revealed that the price of fuelwood, the price of electricity,frequency of cooking meals and livestock feed, household weekly income, household size and urban/rural location dummy had significant effects on weekly household fuelwood demand. On the other hand, the prices of kerosene, shrubs and branches, the type of stove and the types of fuelwood did not have a significant effect on household fuelwood demand.

The study has also indicated that the quantity of fuelwood demanded by the households was more responsive to changes in the price of fuelwood and the price of electricity than to changes in income. The estimated own-price elasticity of household demand for fuelwood was -.16 while the cross-price elasticity with respect to the price of electricity was .20 implying that fuelwood and electricity are substitutes. The coefficient of the income elasticity of demand was .13, which was lower than the price elasticity coefficients.

5.2 Policy Implications

Based on the foregoing empirical results of this study, there are three important measures that can be adopted by the government in order to decrease fuelwood consumption and thereby reduce the incidence of deforestation. One of these measures would be the strict enforcement of government policies which prohibit the extraction of fuelwood, particularly those that pertain to big logging concessions. This policy measure will, in turn, make fuelwood scarce and increase the price of fuelwood. With the increase in the cost of fuelwood, consumers will reduce their consumption of fuelwood and will be forced to use alternative or cheaper sources of energy. At the same time, the government should formulate measures that would provide adequate supply of low-cost energy substitutes such as electricity, and should also subsidize the cost of imported electric stoves. Nepal has untapped sources of hydroelectric power which can be utilized in order to facilitate substitution of fuelwood for electricity in the future.

Finally, another measure that can be adopted by the government to reduce the use of fuelwood would be to subsidize "Bhuse Chulo" (dust stove). The use of this stove has several advantages. It economizes on the use of fuelwood thereby decreasing deforestation. It also minimizes heat loss, produces less smoke thereby avoiding health hazards and utilizes sawdust which are readily available in the urban areas as well as, rice husk and other kinds of vegetable wastes such as shrubs, branches, corn cobb and stalk, rice and wheat straw, which are in abundant supply in the rural areas. A major constraint to the adoption of this stove, however, is its high cost. The construction materials of this stove are all imported. Hence, the use of this stove might be less appealing to rural households, as well as, to the low-income urban households who commonly use fuelwood as a source of energy for cooking and lighting.

5.3 Recommendations for Further Study

Since this study covers only the winter season, a similar study should be undertaken for the summer season in the same district. The empirical results for both the winter and the dry seasons will be very useful in projecting annual fuelwood demand in the study area.

Finally, inasmuch as related studies along this line of research are still limited and considering that this research provides a good perspective of household fuelwood demand in the Kathmandu district of Nepal, it is recommended that similar studies should be conducted in other districts in the country.

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Appendix Table 1. Selling price of electricity of the Nepal Electricity Corporation, 1984.

ITEM	SELLING PRICE NR TO HOUSEHOLDS
25 kwh per month	11.00
26 to 100 kwh per month	0.66 per kwh
101 to 300 kwh per month	0.80 per kwh
301 and above per month	0.90 per kwh

Source: Nepal Electricity Corporation.

Appendix Table 2. Selling prices of kerosene of the Nepal Oil Corporation, 1973 to 1984.

YEAR	SELLING PRICE NR/LITER
1973	1.19
1974	1.30
1975	1.54
1976	2.00
1977	NA
1978	2.50
1979	NA
1980	3.10
1981	4.25
1982	4.90
1983	4.90
1984	5.90

Source: Nepal Oil Corporation.

Appendix Table 3. Prices of fuels in terms of their energy value.

FUEL	UNIT	HEAT VALUE MJ	END USE EFFICIENCY %	NET USEFUL ENERGY MJ	AVERAGE PRICE PER UNIT[a]	PRICE PER MJ
Fuelwood	kg	31.9[b]	10	3.2	1.0044	0.3139
Electricity	kwh	3.6	70	2.5	0.5606	0.2242
Kerosene	liter	36.5	30	10.9	6.0697	0.5568

[a] Based on this study.

[b] Computed based on the use of hardwood, conifer, and mixed hardwood and conifer in this study.

Appendix Table 4. Correlation matrix of all the variables used in the analysis of household demand for fuelwood, Kathmandu district, Nepal, winter season, 1984.

	PRICE OF FUELWOOD PF	PRICE OF ELECTRICITY PE	PRICE OF KEROSENE PK	PRICE OF RICE HUSK AND SAW DUST PRS	PRICE OF SHRUBS AND BRANCHES PSB	WEEKLY HOUSEHOLD INCOME HI	HOUSEHOLD SIZE H
PF	1.00000						
PE	-.01224	1.00000					
PK	-.24751	-.14404	1.00000				
PRS	-.17003	-.02515	.18406	1.00000			
PSB	.10187	.06762	-.36114	.10091	1.00000		
HI	-.02354	.24788	-.22369	-.08193	.18398	1.00000	
H	-.03369	.48899	-.15494	.00689	-.00542	.49866	1.00000
FCL	-.03525	.19370	.21998	.09104	-.20791	.08584	.12811
DT	.12909	-.15432	.19093	.04892	-.39918	-.18799	-.12951
D1	-.00717	.22204	-.49840	-.16687	.62397	.27672	.18027
D2	-.02847	.27961	-.14555	-.11047	.06604	.33746	.16716
D3	-.11752	-.04539	-.19359	-.10601	.10418	.00638	-.08569
D4	.06253	.12505	-.05066	.00593	-.02730	.09781	.17485
QD	-.18481	.27831	.09249	.10826	-.18315	.33541	.41187

	FREQUENCY OF COOKING MEALS AND FEEDS	DISTANCE OF THE HOUSE FROM THE FOREST	URBAN/RURAL LOCATION DUMMY	TYPE OF STOVE DUMMY	TYPE OF FUEL-WOOD DUMMIES		QUANTITY OF FUEL-WOOD PER HOUSE-HOLD
	FCL	DT	D1	D2	D3	D4	QD
PF							
PE							
PK							
PRS							
PSB							
HI							
H							
FCL	1.00000						
DT	.08424	1.00000					
D1	-.20502	-.71106	1.00000				
D2	.08123	-.17670	.25668	1.00000			
D3	.05040	-.06382	.20995	-.00570	1.00000		
D4	-.12366	-.07041	.02649	.09464	-.71094	1.00000	
QD	.28438	-.02979	-.16110	.06238	-.01787	.01648	1.00000

demand for fuelwood, Kathmandu district, Nepal, winter season, 1984.

	PRICE OF FUELWOOD PF	PRICE OF ELEC-TRICITY PE	PRICE OF KEROSENE PK	PRICE OF RICE HUSK AND SAW DUST PRS	PRICE OF SHRUBS AND BRANCHES PSB	PER CAPITA WEEKLY INCOME I
PF	1.00000					
PE	-.01224	1.00000				
PK	-.24751	-.14404	1.00000			
PRS	-.17003	-.02515	.18406	1.00000		
PSB	.10187	.06762	-.36114	.10091	1.00000	
I	-.00581	.09597	-.27196	-.13643	.26551	1.00000
H	-.03369	.48899	-.15494	.00689	-.00542	.12059
FCL	-.03525	.19370	.21998	.09104	-.20791	-.00930
DT	.12909	-.15432	.19093	.04892	-.39918	-.22858
DI	-.00717	.22204	-.49840	-.16687	.62397	.33867
D2	-.02847	.27961	-.14555	-.11047	.06604	.33902
D3	-.11752	-.04539	-.19359	-.10601	.10418	.06940
D4	.06253	.12505	-.05066	.00593	-.02730	.03581
QD	-.23914	-.05567	.24481	.16897	-.15537	.00197

	HOUSEHOLD SIZE	FREQUENCY OF COOKING MEALS AND FEEDS	DISTANCE OF THE HOUSE THE FOREST	URBAN/RURAL LOCATION DUMMY	TYPE OF STOVE DUMMY	TYPE OF FUELWOOD DUMMIES		QUANTITY OF FUEL-WOOD PER CAPITA
	H	FCL	DT	D1	D2	D3	D4	QD
PF								
PE								
PK								
PRS								
PSB								
I								
H	1.00000							
FCL	.12811	1.00000						
DT	-.12951	.08424	1.00000					
D1	.18027	-.20502	-.71106	1.00000				
D2	.16716	.08123	-.17670	.25668	1.00000			
D3	-.08569	.05040	-.06382	.20995	-.00570	1.00000		
D4	.17485	-.12366	.07041	.02648	.09464	-.71094	1.00000	
QD	-.22423	.07880	-.04129	-.24713	-.06964	.03810	-.04800	1.00000

Appendix Table 6. Price structure of fuelwood brought by the Fuel Corporation of Nepal to Kathmandu, 1984.

ITEM	NR/100 KG
Production cost at field level (splitting etc.)	1.90
Loading and unloading truck	1.60
Average transport cost to Kathmandu	35.42
Depots handling costs	1.50
Government royalty	4.03
Total Production Costs	48.90
Additional splitting costs	6.00

Source: Fuel Corporation of Nepal.

YEAR	KATHMANDU VALLEY (m.t.)	REST OF THE COUNTRY (m.t.)	EXPORT (m.t.)	TOTAL (m.t.)
1965-66	1620.8	NA	460000	1620.8
1966-67	10868.5	1099.9	600000	11968.4
1967-68	8199.6	3041.7	800000	11241.3
1968-69	12548.5	350.8	760000	12899.3
1969-70	6024.1	2353.0	620000	8377.1
1970-71	13817.8	4589.0	440000	18406.8
1971-72	6298.5	4281.5	820000	10580.0
1972-73	11494.3	7356.5	820000	18850.8
1973-74	8720.7	9720.0	820000	18440.7
1974-75	21010.0	14572.5	820000	35582.5
1975-76	25880.4	107752.5	820000	133632.9
1976-77	38558.9	184689.1	520000	223248.3
1977-78	28830.3	161154.0	500000	159984.3
1978-79	35000.0	240757.6	1805.7	277563.3
1979-80	18778.0	209137.2	11520.0	239435.2
1980-81	26057.1	235466.4	8862.0	270385.5
1981-82	39949.5	1867779.1	-	226728.6
1982-83	35464.0	117612.9	-	153076.9
1983-84	35943.5	89905.1	-	125848.6
1984-85	23959.1	49519.3	-	73478.4

Sources: 1965-77 data were taken from Sharma, E. R. and D. B. Amatya. 1978. Degradation of forest resources in Nepal. Nepal Journal of Forestry 1, No. 4, (January-June, 1978).
1978-1985 data were taken from Fuel Corporation of Nepal.

Appendix Table 8. Mean values used in the computation of elasticity coefficients in the analysis of household and per capita demand for fuelwood, Kathmandu district, Nepal, winter season, 1984.

VARIABLES	UNIT	MEAN
Price of fuelwood	NR/kg	1.0044
Price of electricity	NR/kwh	0.5606
Price of kerosene	NR/liter	6.0697
Price of rice husk and saw dust	NR/kg	0.7959
Price of shrubs and branches	NR/kg	1.5315
Weekly household income	NR	562.5455
Household size	Number	7.7387
Quantity of fuelwood per household	Kg	42.8961
Quantity of fuelwood per capita	Kg	6.0361

Appendix Table 9. Sample household distribution according to frequency of cooking livestock feed, 154 sample households, selected rural and urban areas of Kathmandu district, Nepal, winter season, 1984.

PANCHAYAT	NO. OF SAMPLE HOUSEHOLDS		LIVESTOCK POPULATION				SAMPLE HOUSEHOLDS WITH LIVESTOCK					
	With Livestock	Without Livestock	Buffalo	Cattle	Goat	Others	Separate feed and meal cooking		Feed Cooking included in meal cooking		Did not cook feeds	
							No.	%	No.	%	No.	%
Rural:												
With free access forest (Dakshinkali)	21	17	15	44	25	6	8	21	13	34	0	0
With community/ reserve forest (Jorpati)	23	16	7	51	23	5	18	46	4	10	1	3
Urban:												
Without forest (Kathmandu Town Panchayat)	8	69	4	12	9	16	4	5	4	5	0	0
All Households	52	102	26	107	57	27	30	19	21	14	1	1

Appendix Table 10. Summary of results of annual per capita fuelwood consumption in Nepal from various studies.

SOURCE/ RESEARCHERS	YEAR	QUANTITY m^3	kg	REMARKS
1. Clark	1970	0.20	120	Average for Nepal based on consumption figure for India (Nationwide)
2. Earl	1973	0.85	638	Tharu village in Bardia (Terai)
		0.05	713	Tahru random sample in Bardia (Terai)
		0.52	390	Hill people in hills (Hills)
3. Sinden	1971	2.55	-	Tharu village in Bardia (Terai)
Butkas	1972	1.09	-	Tharu villages in Bardia (Terai)
		1.40	-	Hill people living in Bardia (Terai)
		1.34	-	Indian immigrants in Bardia (Terai)
4. FAO year book	1970	0.57	-	Nationwide based on Forest Department returns
5. Robbe	1954:3	0.10	60	Nationwide
6. World Bank	1974	0.33	198	Nationwide
7. Donner	1972: 354	0.57	342	Nationwide
8. Krasowski	1979	00.71	425	Nationwide
9. Energy Research Group	1975: 15	0.91	546	Nationwide
10. Schmid	1969: 77	1.00	600	Nationwide

Appendix Table 10. continued.

SOURCE/ RESEARCHERS	YEAR	QUANTITY m^3	kg	REMARKS
11. World Bank Annex 10:1	1978))	1.00	600	Nationwide
12. FAO/World Bank Annex: 1:3	1979)			
13. Hirshbrunner	1969	1.23	738	Central hills
14. Howartch	1976	1.35	810	Central hills
15. Chitrakar et.al.	1974	1.53	918	Central hills
16. Kawakital	1979: 36	1.55	928	Western hills
17. Reiger et.al.	1976: 152	3.33- 6.97	2000 4000	Nationwide
18. Fox, J.	1982	1.07	639	Nareswar Panchayat, Gorkha district (Hills)
19. Shrestha, S. G.	1985	-	466	Rural area of Kathmandu district (Hills)
			268	Semi-urban area of Kathmandu district (Hills)
			262	Urban area of Kathmandu district (Hills)
			314	Kathmandu district (Hills)

Sources:

1-5 Earl, D. 1975. Forest energy and economic development. Oxford: Clarendon Press.

6-17 Donovan D., and D. Bajracharya. September, 1980. "Energy research in rural Nepal: Past experience and future focus" in Energy Analysis in Rural Regions: Studies in Indonesia, Nepal and the Philippines. East West Resource System Institute, East West Centre, Honolulu, Hawaii, pp. 2-18.

18 Fox, J. 1982. Fuelwood consumption rates in a Nepal village: methodologies and conclusions, Ph.D. dissertation, University of Wisconsin, Madison, U.S.A.

APPENDIX A

ENERGY CONVERSION FACTORS

Cal (calorie)	=	4.19 J (joules)
k cal (kilocalorie)	=	4.19 kJ (kilojoules)
1000 k cal	=	4.19 MJ (megajoules)
BTU (British Thermal Unit)	=	1050 J
2.77 10^{-7} kwh (kilowatt hour)	=	1 J
1 kwh	=	864 cal
	=	1.34 horsepower-hour
1000 kwh	=	0.125 tonnes coal equivalent

CALORIFIC VALUE (CV)	MJ per kilogram
Charcoal	29.7
Coal	28.9
Wood (oven dry)	19.7
Wood (air dry)	14.7
Cow dung (dry)	16.7
Peat (dry)	16.7
Wheat straw	17.6
Barley straw	18.0
Bean straw	18.0
Gasoline	44.1
Kerosene	20.0 MJ/gallon
Electricity	3.6 MJ/kilowatt hr.

coal equivalent (CE): 1 ton coal = 289000 MJ
= $2.3m^3$ air dry wood (density 0.88)
= 6.9×10^6 k cal
= 5.6 barrels of oil
= 8000 kilowatt-hour

WOOD AIR-DRY DENSITY			MJ per m^3
301 lb/cu ft.	=	0.48 per cc (conifers)	7,000
50 "	=	0.80 per cc (hardwoods)	118,000
70 "	=	1.12 per cc (dense hardwoods)	165.000
1 cubic meter	=	35.31 cubic ft.	
	=	725 kg (general),750 (non-conifers)	
1 tonne	=	1.38 m^3 (general), $1.33m^3$ (non-conifer)	
1 cord	=	128 $ft.^3$ (Stacked), $2.12m^3$ (Solid)	

Calorie is the quantity of heat required to raise the temperature of 1 gram of water through 1°C.

Coal equivalent is energy equivalent of 1 tonne of coal.

Kilowatt-hour (=1unit) is the quantity of energy furnished in one hour by a current with power or rate of expenditure of energy of one kilowatt.