Demand of Biomass Fuels for Cooking by Rural Households in Palash Upazila of Narsingdi District

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Abstract

Cooking fuels share the largest part of primary energy consumption in the rural areas of Bangladesh. Understanding the demand situation of the cooking fuels facilitates the rural energy planning in Bangladesh. This study investigates the demand of biomass fuels for cooking through rural household and market survey in the rural areas. It adopted a cluster sampling technique to select 60 households from four villages of two unions under Palash Upazila of Narsingdi district. The major cooking fuels consumed by the households were firewood, branches, leaves-and-twigs, bamboo, rice straw, rice husk and jute stick. Price elasticity of demand of firewood was 0.317 revealing that fire wood was an inelastic market commodity in that area. It is expected that this study will be helpful for rural energy development in Bangladesh.

সারসংক্ষেপ

বাংলাদেশের গ্রামীন জনপদে রান্নার জ্বালানী মৌলিক জ্বালানী ভোগের সবচেয়ে বড় অংশ দখল করে আছে। রান্নার জ্বালানীর চাহিদা সম্পর্কে জানতে পারলে বাংলাদেশের গ্রামীন জ্বালানী পরিকল্পনায় এটি সহযোগীতা করবে। এই গবেষণাটি গ্রামীন গৃহস্থালী ও বাজার জরিপের মাধ্যমে রান্নার জন্য বায়োমাস জ্বালানীর চাহিদা নিরুপন করে। নরিসংদী জেলার পলাশ উপজেলায় দুটি ইউনিয়ন থেকে ৪ টি গ্রাম নিয়ে এই গবেষনাটি সম্পন্ন করা হয়। এটি ক্লাষ্টার নমুনায়নের মাধ্যমে ৬০ টি গৃহস্থালী নির্ধারন করে। গবেষণায় দেখা যায় রান্নার মূল জ্বালানীগুলো হলো জ্বালানী কাঠ, গাছের শাখা-প্রশাখা, পাতা ও কুঁড়ি, বাঁশ, ধানের খড়, ধানের তুষ এবং পাট কাঠি। জ্বালানী কাঠের চাহিদার মূল্য স্থিতিস্থাপকতা পাওয়া যায় ০.৩১৭, যার দ্বারা জ্বালানী কাঠকে বাজার চাহিদায় অস্থিতিস্থাপক বলে প্রতীয়মান হয়। এই গবেষণার ফলাফল বাংলাদেশের গ্রামীন জনপদে জ্বালানী উন্নয়নে কাজ করবে বলে ধারনা করা যায়।

Keywords: Firewood; Price elasticity of demand; Type of cooking fuels.

Introduction

Biomass is used as the most common primary fuel for energy purposes in domestic sectors in almost all developing countries. It plays a vital role in rural energy supply in South Asia including Bangladesh sharing a major part of the total energy consumption (Barnes et al. 2011; GOB 2008). Household energy consumption in developing countries mostly covers cooking purposes (Pokharel 2004). Energy consumption pattern throughout the world varies from country to country and region to region. Due to unavailability and scarcity of modern energy supply, almost all rural people depend on biomass to meet their daily energy demand, especially for cooking. Now, there is a severe

shortage of fuel wood in many developing countries as the natural forests and village groves are being over exploited (Balat 2009). This shortage will also be severe unless the forest cover is protected and fuel wood plantation in the country is sustainably developed (Barnes et al. 2011). Many studies report that there is a gap between demand and supply of biomass energy in many countries of the world (Akther et al. 2010b; Arnold and Persson 2003; Cooke et al. 2008). A number of studies have been found on demand and supply of rural cooking fuel in different countries throughout the world. For example, Koopmans (2005) conducted study on biomass energy demand and supply for South and South-East Asia; Berndes et al. (2003) analyzed the contribution of biomass in the future global energy supply which is a review of 17 studies. Pachauri (2004), Rao and Reddy (2007) studied the effect of income and other socio-economic factors on the fuel use by the households in India.

The major sources of energy in Bangladesh are biomass fuel, natural gas, oil and coal (Ahmed et al. 2013; Huda et al. 2014). Despite many studies on rural biomass energy sources, supply and demand crossing various socio-economic factors in many parts of Bangladesh (e.g. Akther et al. 2010a; Akther et al. 2010b; Alam et al. 1999; Bala et al. 1989; Hassan et al. 2011; Jashimuddin et al. 2006; Kennes et al. 1984; Miah et al. 2003; Miah et al. 2009; Miah et al. 2010; Miah et al. 2011a; Miah et al. 2011b; Sarker and Islam 1998), demand situation of cooking fuel visualizing by elasticity measurement in Narsingdi region is unexplored. Akther et al. (2010a) studied domestic fuel use in the Meghna floodplain area of Bangladesh; Akther et al. (2010b) studied fuelwood shortage situation in the Old Brahmaputra downstream zone in Bangladesh. Although both the study sites (Akther et al. 2010a; Akther et al. 2010b) are in Narsingdi District of Bangladesh, these studies did not scaled up the demand situation in relation to price elasticity. The present study accentuates the demand situation of cooking fuels with the increase and decrease of the price on the basis of economic nature of these fuels. Likewise, it will shorten the present knowledge dearth on price-demand sensitivity of cooking fuels in Bangladesh.

Materials and Methods

The study was conducted during June 2012 through December 2012 in Palash Upazila of Narsingdi district in Bangladesh.

Description of the study area

The study was conducted at Palash Upazila of Narsingdi district. The Upazila occupies an area of 94.43 km². It is located between 23°53' and 24°03' North latitudes and between 90°34' and 90°43' East longitudes (Figure 1). It consists of 4 Union Parishads (UP) , 55 Mauza and 78 villages (BBS 2012). The UP are Danga, Charsindur, Gazaria and Jinardi. The total population of the Upazila is 212,612 where male and female shares by almost 50% (BBS 2012). The total number of households in this Upazila is 46,780 with the population density 2251 km-1 having an annual growth rate of 1.16. Average literacy of the Upazila is 59% including male 60% and female 57% (BBS 2012). Narsingdi district enjoys a subtropical climate having temperature ranging from 12.7ºC to 36ºC with average rainfall 2376 mm.

Sampling

The sampling technique conducted for the study was multistage cluster sampling. The sequence of selection was from Upazila to Union, from Union to village and then households and corresponding markets. Out of 4 Unions of Palash Upazila, 2 Unions (Gazaria and Jinardi) and 2 villages from each union (Dorichor and Gazaria from Gazaria Union, Mazerchar and Parulia from Jinardi Union) were selected randomly (Figure 1). Finally, 15 households from each village having a total of 60 households were selected randomly. From the offices of the respective UP, the list of the villages and households were obtained. Using the randomization tool of a statistical package, the villages and corresponding households were selected for the study. After selecting the unions, villages and households, we received the help of the ward members and key persons in the village to locate the households and data collection.

Data collection and analysis

A semi-structured questionnaire was prepared for primary data collection from each of the household. Before going to collect final data, a reconnaissance survey was carried out to observe the overall situation of the study area. Through reconnaissance survey, it was observed that pipeline-gas supply was not available and most of the households were Semi-Pucca in those areas. To facilitate and enrich the study, the relevant statistical data and information about the study area were collected from the UP office. The collected data were compiled and analyzed by the statistical package SPSS statistics 17.0 and Microsoft Excel, 2007.

The study involved household and market survey. The household survey was carried out through personal visits to the households for several times during June 2012 through December 2012. The cooking fuels were identified on the basis of the determination of the price of the fuels and total quantity bought per month for each household and the responses of the households to buy these fuels at different hypothetical prices. Four hypothetical prices were assumed for this survey. They were price1, price2, price3 and price4.While price1 and price2 were derived through the reduction of present market-price at 20%. On the other hand, price3 and price4 were derived through the increase of market-price at 20%.

To determine the relationship between total income and cooking fuel use of the household, each household was brought under five income groups. The groups were selected purposively on the basis of total income per month of the household. The income groups were ≤9500 tk month-1, 9501-13500 tk month-1, 13501-20000 tk month-1, 20001-45000 tk month-1, ≥45001 tk month-1.The relationship also was shown for the house-types classified as Kacha , Pucca and Semi-Pucca.

From the analysis, it was found that only fire wood (58%) was used as the market commodity as the largest scale among the other cooking fuels. So, price elasticity of demand was considered only for fire wood. From the dataset, the cases incorporating fire wood as a market commodity were abstracted only for elasticity measurement. For elasticity measurement, 5 prices and quantity demanded scenarios were used. To create these scenarios, the present market price was used as a pivotal point resulting to prices lower and two prices upper than the present price. With these changes, the corresponding quantity demanded was recorded. For calculating price elasticity of demand, the midpoint method (Mankiw 2012) was used between two point, as (Q_1, P_1) and (Q_2, P_2).

$$\text{Price elasticity of demand} \quad \frac{\frac{(Q_2 - Q_1)}{(Q_2 + Q_1)}}{2} \quad ((P_2 - P_1))/((P_2 + P_1)/2))$$

Where, Q_2= Quantity demanded 2, Q_1= Quantity demanded 1, P1 = Price 1, P2= Price 2
For specifying the elasticity, the corresponding price as 'mode' figure was analyzed for each scenario. And then, stem-and–leaf plot was generated for showing the 'mode' price and the corresponding elasticity.

To find out an elasticity of firewood for the whole study area, we calculated dQ/Q and dP/P and plotted dQ/Q (Y-axis) against dP/P (X-axis). After that we calculated the slope [(dQ/Q)/ (dP/P)], which determined the price elasticity estimate for the firewood in the market.

The study was conducted under the academic research program designed by the authors themselves. However, after fulfilling the purpose of academic needs, the study and analysis was furthered to accomplish the full objectives of this study. The present paper is one of the series of the studies of this kind.

Results and Discussions

Socio-economic profile of the households

The average family size and number of income earners found in the selected households were 6±2 and 3±1, respectively (Table 1). Among the four villages, the highest average family size was found in Parulia and the lowest in Dorichar, Gazaria and Mazerchar. Average income of the households in these villages was 29191.7±3846.7 tk month-1. The highest average income (43200.0±11653 tk month-1) was found in Dorichar and the lowest (18933.3±3227.1 tk month-1) was in Mazerchar. The households of the study areas possessed 521.03±75.85 m² homestead size and 3470.52±858.89 m² agricultural lands on average.

Table 1: Socio-demographic profile of the households in Palash Upazila, Narsingdi.

Village	Homestead size (m^2 homestead^{-1})	Homestead size (m^2 homestead^{-1})	Agricultural land (m^2 household^{-1})
Dorichar	43200.0±11653.0*	524.74±149.09	5943.49±2374.46
Gazaria	29166.7±6360.5	825.56±245.99	5391.77±2261.04
Mazherchar	18933.3±3227.1	277.88±42.28	631.31±267.09
Parulia	25466.7±6344.0	455.95±36.30	1915.51±405.91
Mean	29191.7±3846.7	521.03±75.85	3470.52±858.89

*Figure indicates standard error of means.

Palash Upazila, situated on the bank of Sitalakhya River, is blessed with numerous small and large scale industries. These have provided significant numbers of employment to the local people. The population census 2011 have recorded 6177 people employed in the industries including 6016 jobs in the government and non-government services in Palash Upazila (BBS 2012). In addition to this, foreign remittance was found an important source of income in many households in this Upazila (pers.comm.). Thus the present high income of the households can be explained. In contrast to this, household income revealed for Raipura and Belabo Upazila under Narsingdi district was lower than this Upazila (Akther et al. 2010a; Akther et al. 2010b). Having a total number of households 46,780, with the population density 2251 km-1, Palash Upazila is experiencing a huge fragmentation of homestead and agricultural lands (BBS 2012). The tendency of rapid urbanization is also squeezing the homestead and agricultural lands in this Upazila. Thus the lower size of homestead and agricultural lands can be explained.

Cooking fuels used by the households

The main types of cooking fuels consumed by the households were firewood, branches and twigs, bamboo, rice straw, rice husk and jute stick. All of the households of Pucca and semi-Pucca types consumed firewood with the percentage of 41 and 52, respectively (Table 2). More than 90% Semi-Pucca households consumed branches and jute sticks. More than two-third of the Kacha households consumed firewood, leaves-and-twigs and jute stick, while half of that type of households consumed bamboo and rice husk. The type of biomass fuels consumed by the households in the present study site resembles to the fuel types, except cowdung, consumed by the households of Raipura and Belabo Upazila of Narsingdi district (Akther et al. 2010a; Akther et al. 2010b). In Raipura Upazila, leaves-and-twigs was found as the dominant biomass fuel for cooking (Akther et al. 2010a). The dominance of the biomass fuel use was measured by ranking of frequency of uses of each type of fuel weighted by the amount consumed (Akther et al. 2010a).

The present study did not examine the dominance as we aimed at deliberately finding the elasticity of firewood. Akther et al. (2010b) found that cowdung as a cooking fuel was consumed by the households in Belabo Upazila of Narsingdi district, as the adaptation technique at the face of biomass fuel crisis. The socio-economic profile of the present study site shows a comparatively higher income per month. It also shows a buying capacity of the households, especially living in the Pucca and Semi-Pucca houses, to buy firewood from the market. The squeezing trend of agricultural and homestead lands, and urbanization might influence the households of the present study area not to consume cowdung.

Table 2. Consumption of biomass fuels for cooking by the rural household-types in Palash Upazila, Narsingdi.

Biomass fuels	Type of house		
	Kacha	*Pucca*	*Semi-Pucca*
Firewood	7(88)	41(100)	52(100)
Branches	45(9)	4(50)	51(91)
Leaves-and-twigs	48(85)	4(50)	48(73)
Bamboo	46(58)	6(50)	49(53)
Rice straw	64(27)	0(0)	36(13)
Rice husk	48(50)	4(25)	48(43)
Jute stick	42(92)	7(100)	51(97)

Note: Figures without parenthesis indicate percentage of specific fuel among the fuels; figures with parenthesis indicate percentage of fuel within house types.

The highest percentage of firewood (52%) was consumed by the Semi-Pucca type household and the least (7%) by the Kacha (Table 2). More than 90% of the households of income group ≤9500 tk month-1 consumed firewood, branches, leaves-and-twigs and jute sticks for cooking (Table 3). More than 80% of the households of income group 9501 – 13500 tk month-1 consumed firewood, branches, leaves-and-twigs, and jute stick. The income group 13501-20000 tk month-1 at more than 80% consumed firewood and jute stick. All of the households of income group 20001- 45000 tk month-1 consumed fire wood, branches and jute stick.

Table 3. Consumption of biomass fuels for cooking by the income groups in Palash Upazila, Narsingdi.

Biomass fuels	Income group (tk month^{-1}household^{-1})				
	≤9500.0	9501.0 - 13500.0	13501.0 - 20000.0	20001.0 - 45000.0	45001.0+
Firewood	10(92)	23(83)	26(92)	21(100)	20(100)
Branches	25(92)	18(100)	17(69)	21(100)	19(83)
Leaves-and-twigs	41(92)	29(92)	20(69)	7(73)	3(58)
Bamboo	25(42)	22(58)	21(54)	15(45)	17(75)
Rice straw	32(25)	27(25)	19(15)	18(18)	4(8)
Rice husk	33(50)	28(50)	19(38)	15(36)	5(50)
Jute stick	29(100)	21(92)	20(85)	19(100)	11(100)

Note: Figures without parenthesis indicate percentage of specific fuel among the fuels; figures with parenthesis indicate percentage of fuel within income groups.

It is evident that the use of firewood increased with the increase of monthly income from ≤ 9500.0 to 13501.0 - 20000.0 tk month-1household-1 from 10% to 26%. But it was around 20% in the groups 20001.0 - 45000.0 and 45001.0+. The other fuels' usages decreased with the increase of income per month of the households. Among the fuels, firewood was used as the highest quantity, 132 kg month-1 household-1 followed by leaves-and-twigs 119-, branches 87-, bamboo 19-, jute stick 15-, rice husk 5- and rice straw 3 kg month-1 household-1 (Figure 2).

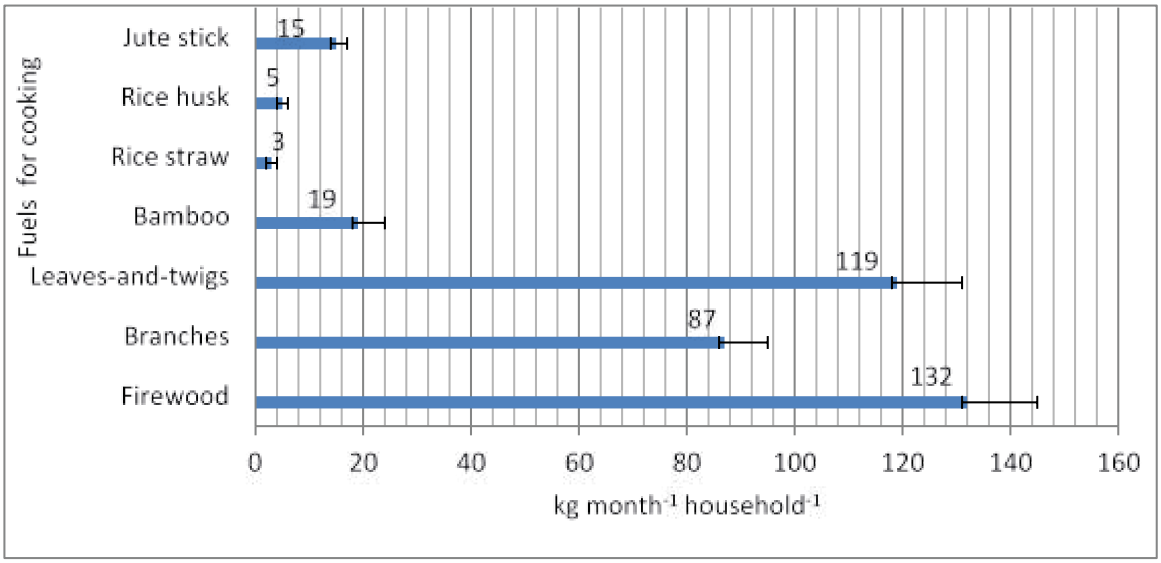


Figure 2: Consumption of cooking fuels at varying income groups and house-types in Palash

Upazila, Narsingdi.

Among the biomass fuels, only firewood was only found as the market commodity. The study found that 58% of the firewood consumed by the households was bought from the local market. The other biomass fuels were collected from the households' own and neighbors' resources. Most of the Pucca and Semi-Pucca households bought firewood from the market while a few Kacha households bought a scanty of firewoods from market. However, some of the Pucca households used LPG (Liquefied Petroleum Gas) along with firewoods and other biomass fuels. The reasons for consuming firewood by the comparatively higher-income households are simplicity of use and better burning capacity (Akther et al. 2010a; van Ruijven et al. 2008). Households' income, the major driving force, influences households' shifting of fuel use through the energy ladder in many developing countries including Bangladesh (Akther et al. 2010c; Gupta and Köhlin 2006; Heltberg 2004; Joon et al. 2009; Rao and Reddy 2007; Wijayatunga and Attalage 2002). Energy ladder follows cleanliness, convenience, efficiency and cost getting momentum with the increase of income. The concept of energy ladder incorporates three stages of fuel transitions. Dependence- on biomass fuels is the first step, on kerosene, coal is the second, and on LPG, electricity is the third one (Davis 1998; Leach 1992). Akther et al. (2010c) concluded that Bangladesh is still at the first step of the energy ladder getting place at the first half of the EKC (Environmental Kuznets Curve). However, this is clear in the present study that the households had a transition between the biomass fuels towards more cleanliness and ease.

Price elasticity of demand of firewood

The modes of 5 tk kg-1 , 4 tk kg-1, 3.2 tk kg-1 , 6 tk kg-1 elasticity was found 0 where maximum frequencies were 15, 14, 14 and 15 (Figure 3). In all the cases, it was observed that firewood was an inelastic market commodity. Increase and decrease of price could not keep effect on the consumption of firewood in the rural areas of the study area though economic value of a commodity depends on its price.

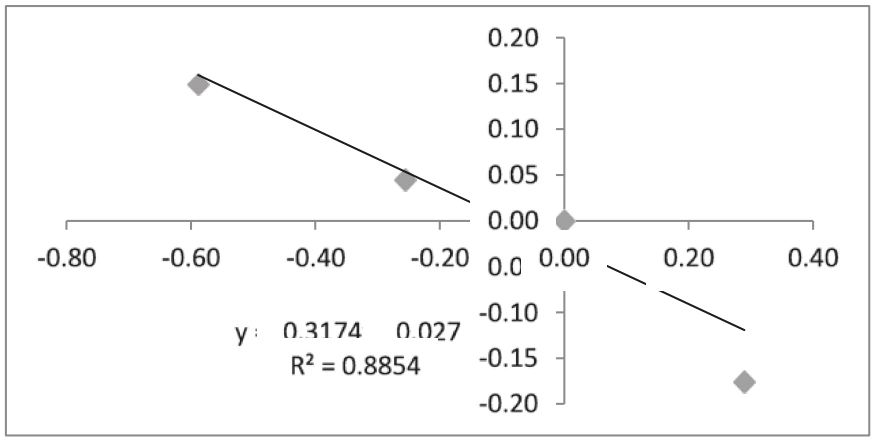
Price elasticity of demand Stem-and-Leaf Plot for present market price, 5.0 tk kg^{-1} Frequency Stem & Leaf 2.00 -1 . 88 3.00 -1 . 222 2.00 -0 . 69 .00 -0 . 15.00 0 . 000000000000000 .00 0 . 1.00 1 . 0 1.00 Extremes (>=1.3) Stem width: 1.00 Each leaf: 1 case(s)	Price elasticity of demand Stem-and-Leaf Plot for market price, 4 tk kg^{-1} Frequency Stem & Leaf 1.00 -3 . 0 .00 -2 . .00 -2 . 5.00 -1 . 88888 2.00 -1 . 02 2.00 -0 . 68 14.00 -0 . 00000000000000 Stem width: 1.00 Each leaf: 1 case(s)
Plot A	Plot B

Price elasticity of demand Stem-and-Leaf Plot for		Price elasticity of demand Stem-and-Leaf Plot for	
firewood market price, 3.2 tk kg^{-1}		firewood market price, 6 tk kg^{-1}	
Frequency	Stem & Leaf	Frequency	Stem & Leaf
5.00	-1.00000	2.00	-3.66
5.00	-0.66666	.00	-3.00
14.00	-0.00000000012334	.00	-2.00
		3.00	-2.22
Stem width:1.00		2.00	-1.55
Each leaf:1 case(s)		1.00	-1.20
		.00	-0.00
		15.00	-0.00
		Stem width:1.00	
		Each leaf:1 case(s)	
Plot C		Plot D	

Figure 3: Stem-and-leaf plots including A, B, C and D mentioning price elasticity of demand of firewood for cooking by mode calculation in the rural areas of Palash Upazila, Narsingdi.

Hossain (1992) conducted a study in 1985 in Bogra and Chittagong district to find the own price elasticity of firewood. He found the price elasticity -1.51 showing a negative relationship between price and quantity demanded. But the cross elasticity, income elasticity and household size elasticity were found 0.37, 0.39 and 0.27, respectively. The study maintained the usual rule of 'law of demand' and gave evidence that firewood in 1985 in those districts was not 'necessity market commodity'. However, the present study finds firewood a necessary market commodity in Palash Upazila of Narsingdi. The households in Mozabique also shows an inelastic demand of firewood evident by the coefficient -0.41 (Arthur et al. 2012).

It was observed that with the increase of price of firewood there was little change of quantity demanded. In this study, elasticity of firewood was 0.317 incorporating all the prices and households' demands (Figure 4) meaning that firewood was an inelastic market commodity in the rural areas of Palash Upazila of Narsingdi District.



A linear demand function model was constructed as presented in the figure 5 to show the relationship between price of firewood (tk kg-1) and quantity demanded of firewood. The linear price demand function of firewood for cooking was found as y= -0.104x+19.47 (R^2=0.94), where x denotes quantity demanded (kg month-1household-1) and y denotes price (tk kg-1) of firewood.

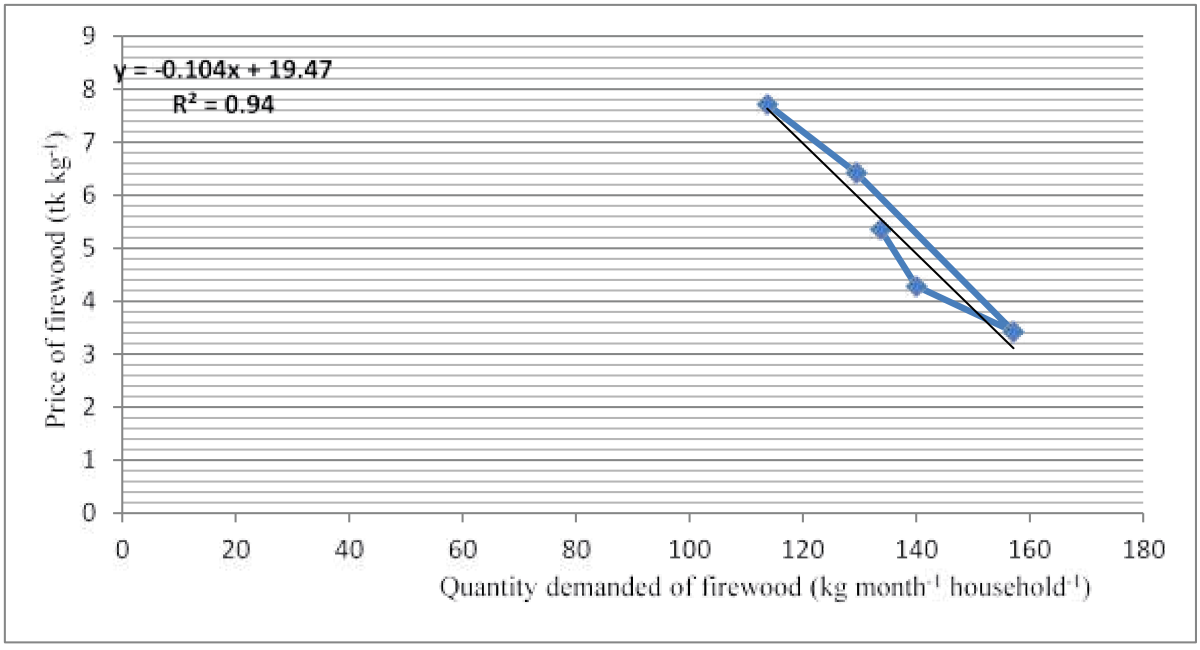


Figure 5. Linear demand functions for the firewood for cooking used in Palash Upazila, Narsingdi.

Conclusion

Consumption of biomass fuels was related with the determinants, such as house-type and total income of the households. Firewood was preferred by the Pucca, Semi-pucca and high-income households in comparison to Kacha and low income ones. Firewood was an inelastic market commodity. The study confirms that firewood was one of the essential commodities in the rural areas of Palash Upazila of Narsingdi, Bangladesh. This study will be baseline information for the energy policy makers to formulate an efficient rural energy policy.

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