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**Development of Liquefied Petroleum Gas (LPG) and Household Woodfuel Consumption:  
Case Study of two Rural Areas in Gezira State, Sudan**

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**Abstract:** The study objectives were to: (i) investigate the level and patterns of woodfuel (WF) consumption before and after the energy development; (ii) estimate WF share in energy budget and household WF dependency; and (iii) determine the main factors influencing the household energy demand. The data were collected by interviewing 73 and 121 households from Fadasi and Alshikayrat, respectively, in the Gezira state in addition to group discussions and official interviews in 1998 and 2007. The study results revealed that the level of household WF consumption was significantly decreased in the two areas compared to the national reported level. The WF consumption was affected by liquefied petroleum gas (LPG) price and to some extends by its price. There were variations between the two study areas in terms of income, main energy source and WF dependency. The study concluded that the significant reduction in the share of WF in household energy expenditure for two periods was resulted from increment in LPG expenditure. The study recommended that introduction of valuable energy policies is necessary.

**Introduction**

Forests sector plays an important role in the national economy of the Sudan. The country's First Energy Assessment Survey revealed that biomass energy accounts for 83% of total energy consumption, followed by petroleum (16%) and hydropower (1%) (OAPEC, 2006). Energy consumption in the form of firewood and charcoal is a common type of biomass exploited in Sub-Saharan region (Byer, 1987). Up to 85% of the wood is used to meet the household's cooking requirements both in urban and rural areas (Hoek-Smit, 1991). However, the production of charcoal has caused widespread deforestation in the country (WEC/FAO, 1999; Whitney, 1981). The energy in form of woodfuel (WF) represents more than 78 % of the Sudan's total energy consumption. It seems that WF role began to diminish due to advent of petroleum products at relatively low price for the household sector. Elfadl and Elagab (2003) have recognized the

profound effect of liquefied petroleum gas (LPG) on WF consumption and expected further reduction in WF consumption, but this observation was not supported by field survey at that time. Therefore, the study aims at determining the factors influencing household's charcoal consumption both in rural and semi-urban areas of the Gezira State, Sudan.

### **Material and Methods**

**Study area:** The study was carried out in Fadasi (semi-urban area) and Alshikayrat rural area (homogenous community forest) in Gezira State, Sudan. Gezira state is located in the east-central part of the Sudan and lies between latitude 13-15° N and longitude 32-34° E. The two areas were selected to represent different settings and typical semi-urban and rural areas with different access to LPG and woodfuel source. Additionally, Gezira State, where the study areas are located, reported to be one of the most highly fuelwood consumption region in Northern Sudan (FAO, 1994).

**Data and analysis:** A total of 73 and 121 households were randomly interviewed from Fadasi and Alshikayrat, respectively, using structured questionnaire in 2007. The level of household's WF consumption before and after these energy developments was estimated. Additionally, the socioeconomic characteristics within each study area were also determined. The data from field survey were classified, coded and entered into a computer and analyzed using the Statistical Packages for Social Sciences "SPSS". Descriptive statistics, t-test for means comparison and regression analysis were applied.

### **Results and Discussion**

The results revealed that the level of household WF consumption was significantly decreased by 64.3% from 1998 to 2007 and the reduction in household fuelwood consumption for the same period was by 71%. The significant reduction of the WF share in household energy expenditure during the two periods was associated with an increase of LPG expenditure. But the woodfuel share in household energy budget by the end of 1998 was 44% and 14% in 2007. This reduction in traditional fuel share for household energy budget was synchronized with increasing in LPG share for the household energy budget from 12% to 31%. Moreover, WF dependency as a main cooking fuel decreased in the two areas from 79% to 5% in 1998 and 2007, respectively. On average basis, the annual quantity of charcoal consumed by household in rural and semi-urban areas was not exceeding 7 kg per year (Table 1). The results of the t-test for means comparison indicated that there was no significant difference ( $p > 0.05$ ) in charcoal quantity consumed by household between the two study areas (Table 2). However, there were significant differences ( $p \leq 0.000$ ) in household income and expenditure between the two study areas. The analysis of demand elasticity indicated that WF was inelastic for its own price and while high cross-and demand elasticity was detected for the LPG, this reveals that it is a substitute to WF and very

sensitive to change in price. This means that any increase in LPG price, will lead household to shift for WF. In testing the factors affecting the charcoal quantity consumed by household, the result of the regression analysis revealed that family size and expenditure on LPG have, respectively, positive and negative ( $p = 0.000$ ) effect on charcoal consumption (Table 3). This finding is similar to Ouedraogo (2006) who explained that there was a significant relationship between the use rates of firewood, charcoal and liquefied petroleum gas (LPG) and household size. Globally, various studies on the fuelwood consumption explain that there are many factors affecting the consumption of tree biomass (Curthbert and Dufoumaud, 1996). For instance, in urban Ethiopia, Mekonnen and Kohlin (2009) found that as total household expenditure increases, households increase consumption of each fuel type except for charcoal. Heltberg (2005) found in Guatemala, that wood price had a significant negative impact on firewood demand of both rural and urban sectors. Meanwhile, Zein-Elabdin (1997) found that price had a negative significant effect on the demand of charcoal in Sudan.

**Table 1 Household socio-economic characteristics of rural and semi-urban areas in Gezira state, Sudan**

Variable	Parameter	Area	
		Fadasi (semi-urban)	Alshikayrat (rural)
Family size	Mean	6.8	7.6
	SD	3.0	2.6
	Min	2	2
	Max	15	19
Age of HH head	Mean	55.5	52.9
	SD	13.3	11.8
	Min	27	25
	Max	86	85
Education level of HH head	Illiterate (%)	5	15
	Basic and quranic school (%)	33	50
	Secondary education (%)	36	29
	Graduate (%)	26	7
Total income (SDG)	Mean	67356.16	45119.83
	SD	54139.06	28114.43
	Min	9000.00	15000.00
	Max	300000.00	150000.00
Total expenses (SDG)	Mean	58287.67	42714.88
	SD	27786.63	24649.44
	Min	18000	10000
	Max	150000	150000
Quantity of charcoal consumed	Mean	6.18	6.95
	SD	10.44	7.30
	Min	0.00	0.00
	Max	60.00	35.00

SD = standard deviation; SDG = Sudanese pound; sample size (73 and 121 respondents for Fadasi and Alshikayrat, respectively).

**Table 2 T-test for equality of means of some economic variables in rural and semi-urban areas in Gezira state, Sudan**

Variable tested	t-value	sig.	Mean difference	SE	95% CI of the difference	
					Lower	Upper
Total income	-3.76	0.000	-22236.33	5915.28	-33903.61	-10569.05
Total expense	-4.06	0.000	-15572.80	3834.00	-23134.96	-8010.63
Q	0.60	0.549	0.77	1.28	-1.75	3.28

SE = standard error of the difference; Q = quantity (kg/year) of charcoal consumed by household; sample size (73 and 121 respondents for Fadasi and Alshikayrat, respectively).

**Table 3 Testing the significance of factors affecting quantity of charcoal consumption in and semi-urban areas in Gezira state, Sudan**

Variable	Fadasi (semi-urban)			Alshikayrat (rural)		
	Coefficient	t-value	p-value	B (SE)	t-value	p-value
Constant	6.53(4.36)	1.497	0.139	0.55(4.50)	0.123	0.903
Family size	1.31(0.32)	4.060	0.000	0.57(0.30)	1.916	0.058
Age	0.09(0.07)	1.184	0.241	-0.05(0.06)	-0.846	0.399
Education level:						
Illiterate	3.78(3.71)	1.021	0.311	4.57(3.33)	1.375	0.172
Basic	1.00(2.51)	0.399	0.691	5.08(2.88)	1.760	0.081
Secondary	-0.25(1.96)	-0.125	0.901	5.79(2.97)	1.947	0.054
Graduate	0.00*			0.00*		
Income	2.15E-5(1.60E-5)	1.342	0.184	2.60E-5(2.65E-5)	0.979	0.330
Expense in firewood	0.01(0.01)	1.404	0.165	0.002(0.005)	0.430	0.668
Expense in LPG	-0.01(0.001)	-8.507	0.000	-0.001(0.001)	-0.608	0.544

In parentheses are standard errors of the estimates; LPG = liquidized petroleum gas; sample size (73 and 121 respondents for Fadasi and Alshikayrat, respectively).

\*. This parameter is set to zero because it is redundant.

### Conclusions and Outlook

Against the experience of many developing countries rural areas of Sudan has succeeded in shifting from dependency on traditional fuel to modern fuel which enhanced by the recent petroleum discovery. The shift is obvious even in areas with easy access to forest resources. The study support the presumption that LPG price reduction policy and charcoal price policy, have succeeded in reducing WF consumption, but in the long run other policy options might be necessary, specifically under the expected price of LPG increase in future. However, due to its positive effect on deforestation, the price reduction policy for LPG in association with policies that increase the cost of WF obtaining were recommended in easy access areas to forest resources. Other factors facilitating the acceptance of LPG as a main household energy source need to be investigated in order to promote its use and reduce human pressure on forest resources.

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