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The Correlates of Household Income, Family Size, and Occupation and Increase of Wood Fuel Consumption

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ABSTRACT

As more people consumed and burned wood fuels, in addition to fossil fuel combustion, carbon dioxide concentrations continue to rise, resulting to further increase in the global temperature. The study estimates the amount of carbon dioxide emissions from wood fuel consumption in the three municipalities. There were 450 respondents randomly interviewed using structured questionnaire. Findings revealed that firewood is the main type of fuel energy used by the households for cooking. *Cocos nucifera, Acacia mangium, Sweitenia macrophylla, Gmelina arborea, Gliricidia cepium, Hevea brasilliensis, Melia dubia and Leucaena leucocephala, Elaeis quineensis, Crysophyllum caimito*, and *Sandoricum koetjape* are among the known species used as firewood and charcoal, mainly collected from their own farms. The daily consumption of wood fuel for every household ranges from 2.81 kg - 4.48 kg (about 2,484.26 kg to 8,822.22 kg annually). Carbon dioxide emissions from wood fuel is estimated to 18,247.04 kg/year. Further, regression analysis showed that CO_2 emissions from wood fuel can be determined through the following equations: CO_2 Emissions$_{firewood}$= -3.86^{-10} + 1.65*weight of firewood; CO_2 Emissions$_{charcoal}$= 4.814^{-7} + 3.667*weight of charcoal. Household's income, family size and occupation are associated with a little increase of wood fuel consumption.

Keywords **—** Forestry, carbon dioxide (CO_2) emissions, wood fuel, descriptive survey, Philippines

INTRODUCTION

Wood fuels, processed as firewood, charcoal and other solid fuels constitute a major source of energy in most countries, both developing and developed (Samir, 2017; Liyama, Neufeldt, Dobie, Njenga, Ndegwa & Jamnadass, 2014). In developing countries, more than three billion people rely on this type of solid fuel, particularly, in African (Mamo, Sjaastad, & Vedeld, 2007; Legros, Havet, Bruce & Bonjour, 2009) and other Asian countries (Démurger and Fournier, 2011; Soltani, Angelsen & Eid, 2014).

In Latin America, 83 million people rely on firewood and other biomass as their primary fuel for cooking (Bailis, Chatellier & Ghilardi, 2012). In Australia, according to the report of Driscoll, Milkovits and Freudenberger (2000), between 4.5 and 5.5 million tonnes of firewood are burned domestically each year. In South Carolina, USA, it was estimated that 39% of households burned 1.41 cords for each household (Marsinko & Wooten, 2016).

In the Philippines, the main cooking fuels used include agricultural residues, firewood, charcoal, LPG and kerosene (Samson, Stohl, Elepan & De Maio, 2002). Generally, in the rural areas, wood fuel is the backbone of the rural energy economy (Ramachandra, 2004; Veld, Narain, Gupta, Chopra & Singh, 2006). In the rural sector, the greatest use of wood fuel is among households with income lower than $100 (Department of Energy, 1995).

Since wood fuel contains carbon, burning them makes carbon dioxide gas an additional source in the atmosphere. Wood fuel consumption is closely related to accelerated land clearance and depleting the forests (Daily Independent, 2010). As more people clear vast areas of the forest, concentrations of carbon dioxide continue to rise, resulting to a very rapid warming of the world's climate (ACIAR, 2008).

The use of wood fuel is often identical with poverty. The poor majority of the people in developing countries cover most of their energy requirement in a non-commercial way, using traditional, locally available sources of energy and their own physical labor. They simply cannot afford to buy any appreciable amounts of commercial energy (GTZ, 1990). National Statistical Coordination Board (2008) reported that among the top 10 provinces with highest poverty incidence, Zamboanga del Norte was number one in 2003 and 2nd in 2006.

Hence, the study determines the amount of carbon dioxide (CO_2) emissions from burning wood fuel in this poverty-stricken province for households' need as firewood and charcoal.

FRAMEWORK

A household consumption of wood fuel can be determined by evaluating its behavioral patterns in a utility optimization structure where it maximizes wood fuel use subject to a set of economic and non-economic constraints. The household's socio-economic condition influences its wood fuel consumption decisions. This wood fuel consumption decision is affected by economic and noneconomic factors. Economic factors may include market price of fuel, household income and non-economic factors which may include a set of household characteristics such as household size and occupation. The amount of carbon dioxide emissions from wood fuel consumption depend largely on the amount of carbon present from wood fuels.

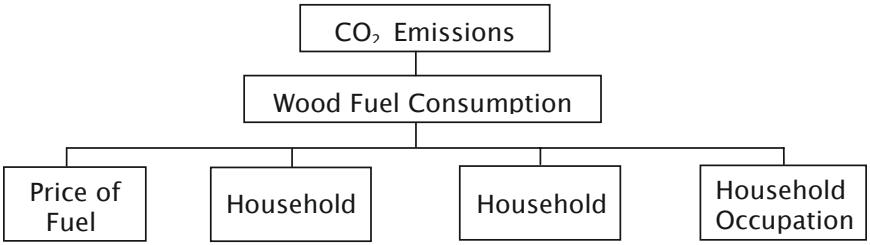

Figure 1. Conceptual Framework of the Study

METHODOLOGY

The study was conducted in the selected municipalities of the 3rd District, Zamboanga del Norte; namely Liloy, Tampilisan and Labason. The study employed questionnaire-checklist to obtain the amount of wood fuel consumption of the households. The questionnaire is composed of two (2) parts. The first part, deals with the profile of the respondents; and the second part, deals on the volume, species, and source of wood fuel consumed by the households.

The respondents were selected through purposive random sampling. Prior to data collection process, the researcher secured permission from the Municipal Mayors and Community Leaders (Barangay Captain) of the areas under study.

The respondents were explained thoroughly the purpose of the study and asked their approval prior to survey.

RESULTS AND DISCUSSION

Profile of Households that Consumed Wood Fuel

The profile of the respondents as to their occupation, monthly income, family size, ethnicity and types of fuel energy used for cooking is shown in Table 1. It can be observed that most (29.33%) of the households consuming wood fuel have meager monthly income from $100 – $199 because they are farmer/laborer (25.56%). It supports the findings of Smith, Mehta amd Maeusezahl-Feuz (2004) and Duflo, Greenstone and Hanna (2008) that 95% of the population in low income countries relies on solid fuels, including firewood and other biomass fuel to meet the basic energy needs for cooking and heating. Samson *et al.,* (2002) revealed that the greatest use of firewood is among households with income lower than $100. World Health Organization (2002) reported that the greatest use of firewood is among households with lower income (Reutlinger, 1986) as they are readily available and inexpensive. Further, about 4-7 members (69.33%) within a family are wood fuel users. This result conforms to the report of the National Statistics Office (2010) that the province of Zamboanga del Norte had an average family size of 5.09 in 2000.

Table 1. Profile of the Households that Consumed Wood Fuel

Item	Liloy		Tampilisan		Labason		Total	
A. Monthly Income	f	%	f	%	f	%	N	%
Less than $100	52	34.67	32	21.33	18	12.00	102	22.67
$100 – $200	55	36.67	35	23.33	42	28.00	132	29.33
$201 – $300	31	20.67	18	12.00	56	37.33	105	23.33
$301 – $400	10	6.67	39	26.00	27	18.00	76	16.89
$401 and Above	2	1.33	26	17.33	7	4.67	35	7.78
Total	150	100	150	100	150	100	450	100
B. Occupation	f	%	f	%	f	%	N	%
Gov't Employee	20	13.33	38	25.33	34	22.67	92	20.44
Full-time Farmer	40	26.67	49	32.67	19	12.67	108	24.00
Farmer/Laborer	50	33.33	42	28.00	43	28.67	135	30.00
Businessman	40	26.67	21	14.00	54	36.00	115	25.56
Total	150	100	150	100	150	100	450	100

C. Family Size	f	%	f	%	f	%	N	%
0 - 3	22	14.67	58	38.67	30	20.00	110	24.44
4 - 7	127	84.67	74	49.33	111	74.00	312	69.33
8 - 10	1	0.67	17	11.33	8	5.33	26	5.78
11 or more	0	0.00	1	0.67	1	0.67	2	0.44
Total	150	100	150	100	150	100	450	100

The species, source and volume of wood fuel consumed by the households are shown in Table 2a & 2b. The respondents used firewood composed of different species (39.11%), followed by coconut (*Cocos nucifera*) (19.11%) and rubber (*Hevea brasilliensis*) (22.22%). It indicates that the choice of firewood species depend on its availability in the vicinity. Findings of the study consistent with the reports of Driscoll, Milkovits and Freudenberger (2000) which disclosed that species available locally are likely to be used as wood fuel. Generally, households collected firewood in their own farms (43.11%). The results implies that households in the rural areas are dependent on gathering firewood because of its availability nearby. The findings concurred with the account of Ramachandra (2004) and Veld *et al.* (2006) which revealed that most of the households in the rural areas are dependent on gathering firewood from their own land or other farms nearby.

Table 2a. Species, Source and Volume of Firewood Consumed by the Households

	Liloy		Tampilisan		Labason		Total	
A. Species of wood used as firewood	f	%	f	%	f	%	N	%
Ipil-ipil (*Leucaena leucocephala*)	0	0.00	0	0.00	1	0.67	1	0.22
Kakawate (*Gliricidia sepium*)	0	0.00	0	0.00	0	0.00	0	0.00
Mahogany (*Sweitenia macrophylla*)	2	1.33	0	0.00	0	0.00	2	0.44
Mangium (*Acacia mangium*)	0	0.00	1	0.67	0	0.00	1	0.22
Gmelina *Gmelina arborea*)	5	3.33	0	0.00	0	0.00	5	1.11
Rubber (Hevea brasiliensis)	0	0.00	100	66.67	0	0.00	100	22.22
Coconut (*Cocos nucifera*)	28	18.67	0	0.00	58	38.67	86	19.11
Different species	79	52.67	43	28.67	54	36.00	176	39.11
Do not know	0	0.00	1	0.67	6	4.00	7	1.56
None firewood users	36	24.00	5	3.33	31	20.67	72	16.00
Total	150	100	150	100	150	100	450	100

B. Source of firewood	f	%	f	%	f	%	N	%
Own farm	88	58.67	69	46.00	37	24.67	194	43.11
Neighboring farms	23	15.33	59	39.33	28	18.67	110	24.44
Natural forest	0	0.00	0	0.00	1	0.67	1	0.22
Market	3	2.00	15	10.00	52	34.67	70	15.56
Own & neighboring farms	0	0.00	2	1.33	1	0.67	3	0.67
None firewood users	36	24.00	5	3.33	31	20.67	72	16.00
Total	150	100	150	100	150	100	450	100
C. Volume of firewood/month	f	%	f	%	f	%	N	%
1-10 bundles	1	0.67	9	6.00	2	1.33	12	2.67
11-20 bundles	64	42.67	16	10.67	95	63.33	175	38.89
21-30 bundles	48	32.00	38	25.33	19	12.67	105	23.33
31 & above	1	0.67	82	54.67	3	2.00	86	19.11
None firewood users	36	24.00	5	3.33	31	20.67	72	16.00
Total	150	100	150	100	150	100	450	100

Table 2b. Species, Source and Volume of Charcoal Consumed by the Households

	Liloy		Tampilisan		Labason		Total	
A. Species of charcoal	f	%	f	%	f	%	N	%
Ipil-ipil (*Leucaena leucocephala*)	0	0.00	0	0.00	0	0.00	0	0.00
Mahogany (*Swietenia macrophylla*)	0	0.00	0	0.00	0	0.00	0	0.00
Mangium (*Acacia mangium*)	0	0.00	1	0.67	0	0.00	1	0.22
Gmelina (*Gmelina arborea*)	0	0.00	3	2.00	0	0.00	3	0.67
Rubber (*Gmelina arborea*)	0	0.00	1	0.67	0	0.00	1	0.22
Coconut (*Cocos nucifera*)	36	24.00	3	2.00	32	21.33	71	15.78
Different species	0	0.00	3	2.00	0	0.00	3	0.67
Do not know	0	0.00	5	3.33	0	0.00	5	1.11
None charcoal users	114	76.00	134	89.33	118	78.67	366	81.33
Total	150	100	150	100	150	100	450	100
B. Source of charcoal	f	%	f	%	f	%	N	%
Own farm	0	0	0	0	1	0.66	1	0.22
Neighboring farms	0	0	0	0	0	0	0	0
Natural forest	0	0	1	0.67	0	0	1	0.22
Market	36	24	15	10	31	20.67	82	18.22
Own & neighboring farms	0	0	0	0	0	0	0	0
None charcoal users	114	76	134	89.33	118	78.67	366	81.33
Total	150	100	150	100	150	100	450	100

C. Volume of charcoal/month	f	%	f	%	f	%	N	%
less than 1 sack	3	2	4	2.67	1	0.67	8	1.78
1-1 ½ sack	31	20.67	3	2	22	14.67	56	12.44
2-2 ½ sacks	2	1.33	6	4	9	6	17	3.78
3-3 ½ sacks	0	0	2	1.33	0	0	2	0.44
4 sacks & above	0	0	1	0.67	0	0	1	0.22
None charcoal users	114	76	134	89.33	118	78.67	366	81.33
Total	150	100	150	100	150	100	450	100

Even in Metro Manila area, about 78% of the households collected the firewood and 22% purchased it (DOE, 1995). Sun Star (2006) reported that of the total number of firewood users in Cebu, 52% are bought, while 48% are gathered. About 11-20 bundles (38.89%) of firewood are consumed by the households every month, and each bundle has an average weight of 8 kg.

On the other hand, coconut (*Cocos nucifera*) shell is the species used for making charcoal. However, *kakawate* (*Gliricidia sepium*), caimito (*Crysophyllum caimito*), mahogany (*Sweitenia macrophylla*), santol (*Sandoricum koetjape*), ipil-ipil (*Leucaena leucocephala*), rubber (*Hevea brasiliensis*) and agoho (*Elaeis quineensis*) are among the tree species used for charcoal production. The result is comparative to the findings of Driscoll et al. (2000) which disclosed that species available locally are likely to be used as wood fuel for making firewood and charcoal. The volume of charcoal consumed by the households ranging from 1-1 ½ sack per month. Charcoal made from coconut shell was chiefly bought in the market. The households, basically, purchased it because they do not have the time to make their own charcoal. DOE (1995) revealed that most of the urban centers in the Philippines, 99.5% of the charcoal consumed was purchased. In 2007, 42.6% of the population (more than 1 million of households) is still using charcoal for cooking. Additionally, the population does not use charcoal for ironing anymore, this means that 99% of the charcoal consumed is considered for cooking purposes (O.D.D., 2007). Further, it is observed that prices of charcoal made from coconut shell and wood of different tree species have varying prices. According to the users, charcoal made of coconut shell is costly, compared to other wood species due to its higher BTU (British thermal unit) value.

Nix (2010) reported that wood heating potential can be determined by its wood density and the amount of energy it can produce, usually measured in British Thermal Units or BTUs. This is also related to the findings of Hong

and Slatick (1994) which says that the amount of heat emitted during coal combustion depends largely on the amounts of carbon, hydrogen, and oxygen present in the coal and to a lesser extent, sulfur content. Since carbon is the major component of coal, then it is the principal source of heat. It implies that dry-wood density would matter the amount of heat during combustion as basis for heat sustainability. As observed, coconut (*Cocos nucifera*) shell is heavier than most of the wood tree species used as charcoal.

Wood Fuel Consumption Rate and CO_2 emissions for a Household

The estimated consumption rate of wood fuel for every household is indicated in Table 3. It shows that the daily consumption rate of firewood and charcoal ranges from 1.24 kg - 3.03 kg and 1.12 - 1.45 kg, respectively. The amount of CO_2 emissions from wood fuel consumption for every household is estimated to 5,827.14 kg annually. These figures are closer to the reports of Objectif Développement Durable (2007) of the firewood consumption in Panay Island which have an average weekly consumption of 21 kg per week, while charcoal users consumed 5.25 kg per week. In 1995, Metro Manila had an average annual consumption of firewood at 294.37 kg (DOE, 1995).

In 2007, Metro Manila, Cebu and Iloilo marked an average annual consumption rate of charcoal at 156 kg, 232.96 kg and 273 kg, respectively. Comparatively, it can be noted that charcoal consumption of these big cities is quite lower because LPG and electricity are commonly used as principal cooking fuel (DOE, 1995). Nonetheless, the result is closer to the reports of some authorities in rural areas of subtropical countries.

Rijal and Yoshida (2002) stated that the rate of firewood consumption in the rural households in Nepal ranges from 235-1,130 kg/capita/year. World Bank (2003) estimated daily firewood consumption in Northern Himalayan region of India ranges from 1.2 kg in town to 2 kg in rural areas. GTZ (1990) also recounted that a family of five members in Sudan consumed roughly 2.5 kg – 3 kg of charcoal daily. However, in the cooler regions, the daily firewood demand varies between 20 kg in the winter and 14 kg in the summer. This figure is higher compared to the results of this study since firewood is used not only for cooking but also for heating the fireplace (Zhou, Wu, Q. Chen & S. Chen, 2008).

Table 3. Estimated Consumption Rate of Wood Fuel and CO_2 Emissions for Every Household in the Three Municipalities

Municipality	Firewood Consumption/ Household/day	Charcoal Consumption/ Household/day	Consumption of Wood Fuel/ Household/year (kg)	CO_2 Emissions/ House-hold (kg/year)
Liloy	1.69	1.12	1,011.60	2,484.26
Tampilisan	3.03	1.45	1,612.80	8,822.22
Labason	1.24	1.28	907.20	6,940.56
Total	5.96	3.85	3,531.6	18,247.04

Mathematical Equation Models between Wood Fuel Consumption and its Carbon Dioxide Emissions. Table 4 reflects the results of linear regression analysis between wood fuel consumption and its carbon dioxide emissions. It exhibited that the model of relationship between wood fuel consumption and the amount of CO_2 emissions is observed linear. The equations pointed out that the variation in the amount of carbon dioxide emissions due to firewood and charcoal consumption is explained by linear equation model, R^2= .86 and .75, respectively, with p= <.05.

Table 4. Mathematical Equation Models between Wood Fuel Consumption and CO_2 Emissions

Woodfuel	Relative Equation Model	R^2	P Value
Firewood	CO^2 Emissions = -3.866^{-10} + 1.650*weight of firewood	.86	0.02*
Charcoal	CO^2 Emissions = 4.814^{-7} + 3.667*weight of charcoal	.75	0.04*

* = Significant at .05

Relationship between Wood Fuel Consumption and Characteristics of the Households

Table 5 reflects the results of the stepwise multiple linear regression analysis on the predictors of wood fuel consumption. Among the independent variables, three came out as best predictors of wood fuel consumption. These variables are monthly income, family size and occupation of the respondents. These levels are

statistically significant at p=.05. It explained that 49% of the monthly income, 52 percent of the family size and 53% of the occupation of the respondents significantly influenced their consumption of wood fuel.

Table 5. Relationship Between Wood Fuel Consumption and Characteristics of the Households

Factors	R	R^2
Monthly Income	0.70	0.49
Family Size	0.72	0.52
Occupation	0.73	0.53

Reutlinger (1986) disclosed that households' income determined the amount of fuels consumed. Macauley, Naimuddin, Agarwal and Dunkerley (1989) reported that the total energy consumption increases with household income. Demurger and Fournier (2011) also found out that household members found to have significant impact on firewood consumption. Alvarez, Palma and Tay (2004) revealed that fuel consumption patterns may be affected by education level or occupation of household members. Results of an informal interview with respondents disclosed that as their income increases they tend to use modern fuels such as LPG, electric, rice cooker, etc., either in substitution of or complement with wood fuel.

CONCLUSIONS

Households in the three municipalities of Zamboanga del Norte are wood fuel users because it is the cheapest type of fuel energy that their income may warrant since they are farmer/laborer. By burning these wood fuels, substantial amount of CO^2 is emitted to the environment which may contribute additional source in the atmosphere.

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