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**Data Based Econometric Model Building for the Household  
Consumption of Non-Marketed Fuelwood**

by  
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# Data Based Econometric Model Building for the Household Consumption of Non-Marketed Fuelwood<sup>1</sup>

by  
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Fuelwood is one of the non-marketed environmental goods that need to be valued for inclusion to the conventional System of National Accounts through the Environment and Natural Resources Accounting (ENRA). However, the only available nationwide data on household consumption of non-marketed fuelwood (HCNF) is the result of the 1989 Household Energy Consumption Survey (HECS) of the then Office of Energy Affairs and the National Statistics Office. Hence, this study worked on building econometric models for the 1989 HCNF in urban area and rural area, to estimate HCNF in 1995 and 2000.

Multiple linear regression analysis, using both ordinary least squares (OLS) and Ridge regression methods of estimation, was employed. The dependent variable was the HCNF (Y), while the independent variables were as follows: urban area – magnitude of poor population (P2) and available female field labor (A); rural area – magnitude of poor families (P1), total family income (L1) and available female field labor (A).

The “best” regression models for the 1989 HCNF were found to be simple OLS linear regression models with population size (P2 or P1) as the lone factor. Its computed  $R^2$  equal to 62% and 69%, respectively, implied that the variation in the 1989 HCNF in urban area and rural area could be explained by the regression on P2 and P1.

## I. Introduction

In the early 90s, the Philippines joined the worldwide environmental and natural resources accounting (ENRA) effort to explore the possibility of modifying the conventional economic accounts. That is, by formulating a national accounting system that properly reflects the complex interactions between the economy and the environment outside ordinary markets. The national income accounting, however, relies on records of market-based transactions. Thus, among others, data on non-marketed goods such as fuelwood were needed for valuation purposes.

Delos Angeles and Bennagen (1991) noted that the contribution to the economy by the forest land-based communities engaged in fuelwood gathering is likely undermeasured because of their generally subsistence nature and the difficulty in including them in household surveys. The failure to account for non-marketed fuelwood production in the conventional System of National Accounts (SNA) has two implications in terms of accounting: 1) the gross value added (GVA) of the forestry sector is underestimated, thus, the gross national product (GNP) is also underestimated, and 2) the environmental impacts of unregulated fuelwood collection are neglected in the conventional accounts, (Bello *et. al.*, 1995).

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The only available country-level data on household consumption of non-marketed fuelwood (HCNF) is the result of the 1989 Household Energy Consumption Survey (HECS) of the Department of Energy (known then as the Office of Energy Affairs) and the National Statistics Office. The 1989 HECS was updated through the 1995 HECS. However, no data on HCNF were generated. These surveys are the only reliable information, which policy makers of the energy sector have been using to estimate the residential energy consumption (HECS, 1995).

In 2000, the DENR-hosted Environmental and Natural Resources Accounting Project Phase IV (ENRAP IV) came up with a technical paper, entitled “Accounting For Unmarketed Fuelwood Production: 1995 (With 1996-2000 Projections), which among others generated the 1995 estimate of HCNF. As of writing, said estimate is still the latest, and no survey had been conducted yet to update or even check its veracity. Thus, the author of this study, being a co-author of the said technical paper, saw the need for a follow-up study – one that would employ more appropriate statistical methods.

## **II. Objectives**

This study aimed primarily to build data based econometric models for the 1989 HCNF – one for urban area and another one for rural area. Specifically, it worked on the following:

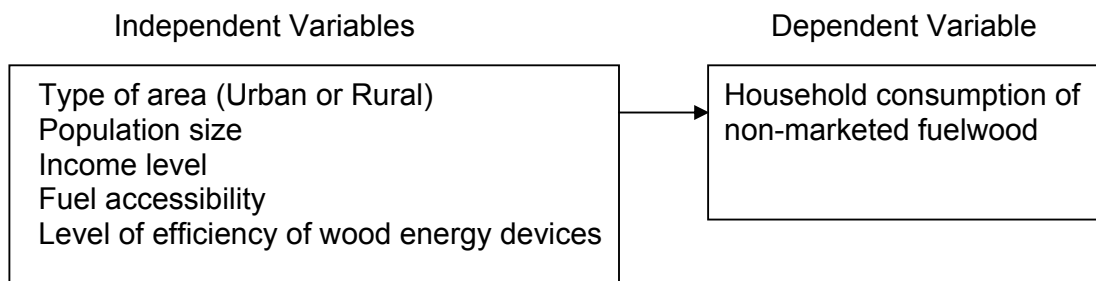
1. Identify the “best” predictor variables of HCNF among available data produced by the Philippine Statistical System;
2. Build econometric models for the 1989 HCNF using the identified “best” predictor variables, one model each for urban area and rural area;
3. Estimate the 1995 HCNF using the 1989 econometric models;
4. Compare the estimated 1995 HCNF derived through the 1989 econometric models with the results of ENRAP IV, and test the hypothesis that the true quantity of HCNF in 1995 is greater than the result of ENRAP IV;
5. Estimate the 2000 HCNF using the 1989 econometric models.

## **III. Conceptual Framework**

The level of household consumption of non-marketed fuelwood is very site-specific. It varies from country to country and from area to area within countries. Specifically, it is dependent on the type of area, such as the urban-rural area classification.

The “Regional Study on Wood Energy Today and Tomorrow in Asia” of the Food and Agriculture Organization – Regional Wood Energy Development Program (FAO-RWEDP) in 1997 discussed the specific factors that influence consumption of non-marketed fuelwood in the household sector. These are population size, income level, fuel accessibility and efficiency of wood energy devices. See Figure 1.

**Figure 1. Paradigm of the Independent and Dependent Variables on the Econometric Model Building for the Household Consumption of Non-Marketed Fuelwood**



**Population size.** A growth in population without a corresponding notable increase in the number of households moving up to higher income levels leads to greater use of non-marketed fuelwood. The amount of fuelwood consumed depends upon the number of households that falls below a threshold income level. Households that were not able to reach this income level cannot afford to buy traded fuels, including traded fuelwood and charcoal. Thus, the reason for gathering fuelwood for own use. The larger the number of households below a particular threshold income level, the larger will be the total consumption of non-marketed fuelwood in the household sector.

**Income level.** The threshold income level varies from country to country and from region to region. It has a range of values that is determined by real income earnings and not by cash income earnings alone. Real income earnings include income in kind earned by the family, which is common among rural households. Some examples of income in kind are consumption of own agricultural produce and available free time to gather fuelwood. In many places, the threshold income level may be way above the official poverty line. It is the reason why many households above poverty line cannot buy fuel even fuelwood and instead gather them. Meanwhile, the use of fuelwood in the household sector may decline even if population increases if there is a significant number of a household moving up beyond the threshold income level.

**Access constraints.** Access to fuelwood means: having physical access to the source, having the right to gather from that source and having the necessary field labor available for collection and transport. Women and children usually supply such field labor. This factor affects the level of consumption of non-marketed fuelwood as it can restrict supply and force the users to shift to alternatives – usually lower grade fuels. Restrictions on access to fuelwood can be due to limitations imposed by the location, land tenure, ownership and management of the resources. Meanwhile, user’s willingness to make extra efforts to overcome these constraints depends on the available alternatives to fuelwood, their income level and the income opportunities for fuelwood collectors.

**Efficiency of wood energy devices.** Stoves used in rural areas, which are mostly self-made by women, require no financial expenditure and are generally inefficient. Since fuelwood are mostly gathered “for free”, this further discourages efforts towards more efficient use of such wood energy devices.

#### **IV. Significance of the Study**

The subsistence production of non-marketed fuelwood is a significant household activity – an important addition to the national production figure once included in the SNA. Failure of the conventional accounts to reflect this activity could have serious consequences such as neglect of the positive value of rural labor and its contribution to environmental damages. These are some of the many concerns in the estimation of the economic values of interactions between the economy and the natural environment. Such accounting is necessary to make economic decision making more environmentally responsible and environmental targets more economically feasible.

Restrained with time and money, the estimated 1995 HCNF of ENRAP IV was left unevaluated. Thus, this study came up with data based econometric models for the 1989 HCNF, which were deemed to yield an economical but statistically sound means of evaluating such effort, and a method of estimating future value of the same. Subsequently, it would provide policy makers with a more reliable tool and basis for relevant socioeconomic planning and implementation arrangements.

#### **V. Scope and Limitations**

This study focused on building econometric models for HCNF in 1989 – the only year when data on HCNF was found available through the results of the 1989 HECS. Another limitation concerned the level of disaggregation of the HCNF data. The 1989 HECS generated HCNF data only for the following geographical areas: National Capital Region (NCR), Other Urban, Rural and the Philippines. This limitation compelled the author to use auxiliary variable – the total residential fuelwood consumption in 1989 – to derive the desired regional, urban-rural breakdown of the 1989 HCNF data.

The independent variables, on one hand, were limited to indicators of the identified factors of HCNF that are currently being generated by the Philippine Statistical System in a frequent basis. Specifically, data were limited to those available for years 1989, 1995 and 2000, or a year or two closer. Meanwhile, the author failed to identify any indicator of the level of efficiency of wood energy devices. Thus, in building the econometric models for the 1989 HCNF, only the following factors were incorporated: population size, income level and fuel accessibility.

For the population size, two indicators were considered: 1) magnitude of poor families, and 2) magnitude of poor population. The former refers to the number of families while the later to the number of individuals. Both, however, concern only those whose annual per capita income falls below the annual per capita poverty thresholds. These data were available for years 1988, 1994 and 2000.

On income level, the following data were available for consideration: 1) total family income, 2) average family income, and 3) annual per capita poverty thresholds. These data were also available for years 1988, 1994 and 2000.

Fuel accessibility means having physical access to the source, having the right to gather from that source and having the necessary field labor available for collection and transport. However, for this study, only field labor was found available, and the author considered the following as its components: 1) unemployed female, and 2) female not in the labor force.

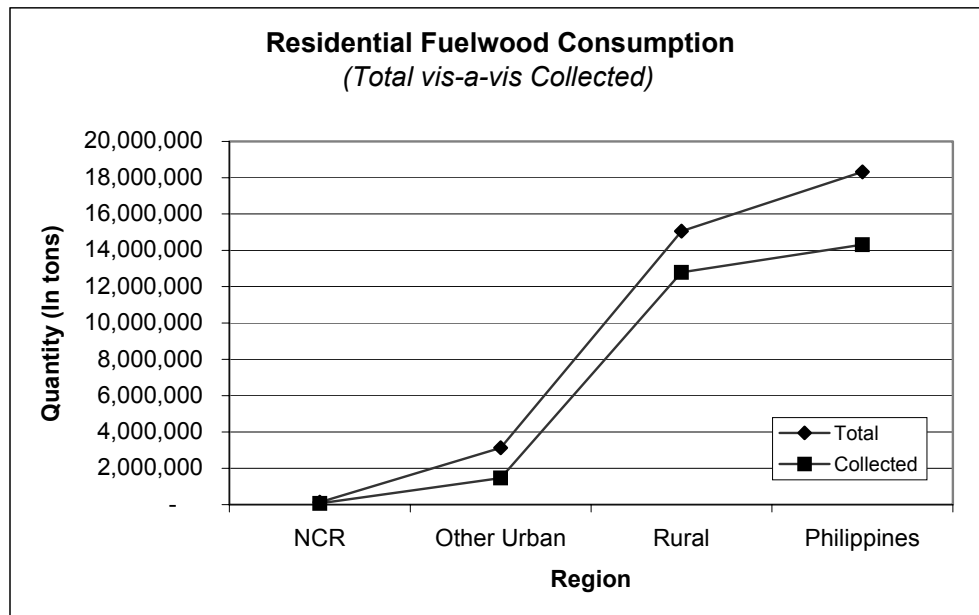
## VI. Methodology

This study used secondary type of data from the Department of Energy (DOE), National Statistics Office (NSO) and National Statistical Coordination Board (NSCB). Data selection/ gathering activity was guided by the following criteria: 1) data should be available for years 1989, 1995 and 2000, or a year or two closer; 2) data should have regional and urban-rural breakdown.

To build the econometric models for the 1989 HCNF, the multiple linear regression analysis, using both ordinary least squares (OLS) and Ridge regression methods of estimation, was employed.

The variable of interest was the household consumption of non-marketed fuelwood (HCNF) in 1989, thus, the result of the 1989 HECS on residential consumption of collected fuelwood or simply COLLECTED was used as the dependent variable (Y) of this study. But, since the 1989 HECS had generated data on COLLECTED for selected region/ area only, the author extrapolated its required regional, urban-rural breakdown. Given the regional, urban-rural data on the total residential fuelwood consumption or simply TOTAL, and considering that COLLECTED and TOTAL are highly linearly correlated at a coefficient equal to 0.996 (Figure 2), the regional proportions of the TOTAL were used as weights to derive the regional, urban-rural data on COLLECTED. Table 1 presents the data on TOTAL and COLLECTED in 1989.

**Figure 2. Total vis-à-vis Collected Residential Fuelwood Consumption, 1989**



**Table 1. Annual Total Residential Fuelwood Consumption, 1989**

Region/ Area	Total	Collected	Purchased
	<i>(In Tons)</i>		
Philippines	18,316,900	14,316,390	4,000,510
NCR	131,610	65,270	66,340
Other Urban	3,126,820	1,463,470	1,663,350
Rural	15,058,470	12,787,650	2,270,820

Source: 1989 Household Energy Consumption Survey.

This study started with six (6) independent variables (Table 2), which underwent iterative process of identification of the “best” predictor variables using scatter plots and correlation coefficients. For urban area, outliers in x space were examined. Data points with high leverage (i.e. with leverage value greater than  $2p/n$ , where  $p$  is the number of independent variables and  $n$  as the number of cases) and with Cook’s distance greater than one (1) were considered influential, thus flagged from the data set. These data points were of the NCR and Region VI. See Table 3 – final set of independent variables, and Table 4 – the 1989 data of the dependent and the independent variables of this study.

**Table 2. Initial Set of Independent Variables**

Factor	Independent Variable	Notation	Source
Population size	Magnitude of poor families	P1	NSCB
	Magnitude of poor population	P2	NSCB
Income level	Total family income	L1	NSO
	Average family income	L2	NSO
	Annual per capita poverty thresholds	L3	NSCB
Fuel Accessibility	Available female field labor (female population, 15 years and older, who are unemployed and not in the labor force)	A	NSO

**Table 3. Final Set of Independent Variables**

Area	Independent Variable
Urban	<ul style="list-style-type: none"> <li>• Magnitude of poor population (P2)</li> <li>• Available female field labor (female population, 15 years and older, who are unemployed and not in the labor force) (A)</li> </ul>
Rural	<ul style="list-style-type: none"> <li>• Magnitude of poor families (P1)</li> <li>• Total family income (L1)</li> <li>• Available female field labor (female population, 15 years and older, who are unemployed and not in the labor force) (A)</li> </ul>

This study used the “all possible regressions procedure” to select the “best” regression for the 1989 HCNF. This procedure is simple and practical to apply when the number of independent variables is not large, say less than 5. It is very direct and applies equally well to both collinear and noncollinear data. It clearly gives an analyst the maximum amount of information available concerning the nature of relationships between dependent (Y) and independent variables.

The “all possible regressions procedure” was done through SPSS version

10.0 for Windows. For each possible regression equation, collinearity statistics – tolerance and variance inflation factor (VIF) – were generated and examined to rule out multicollinearity or the problem of collinear data. There is a problem of collinear data if tolerance value is close to zero or VIF is equal to or greater than 10.

**Table 4. Data of the Dependent Variable (Y) and Independent Variables, Urban-Rural, 1989**

Region	Independent Variable	Dependent Variables				
		Urban		Rural		
	Y	P2	A	P1	L1	A
	(Ton)	(Count)	(Count)	(Count)	(Peso)	(Count)
CAR	23,560	122,181	47	68,147	4,716,497	115
I	144,440	360,993	167	222,336	14,827,841	476
II	53,366	152,186	59	150,105	11,471,757	342
III	95,405	667,877	477	187,240	22,232,870	730
IV	182,479	819,370	579	387,730	26,022,037	902
V	127,231	433,181	155	325,796	13,012,223	461
VI	-	-	-	370,422	17,354,293	654
VII	154,466	482,712	274	306,334	10,966,006	479
VIII	101,335	325,371	105	237,811	10,217,735	381
IX	59,445	191,803	111	176,581	12,991,086	467
X	103,460	364,144	146	215,996	14,638,374	427
XI	171,062	473,533	277	239,670	13,279,364	448
XII	66,616	202,037	101	143,761	13,498,633	391

When severe multicollinearity is suspected, it was considered useful to produce at least one set of estimates in addition to the OLS estimates. Thus, this study also did Ridge regression, which was ran through an “R program”.

The derived “best” OLS regression models for urban area and rural area underwent multiple regression diagnostics for assumptions of linearity, normality, constant variance and independence. Hypotheses testing and substitution of data followed after the models met all of these assumptions.

Using the “best” regression models (one for each urban area and rural area), the 1995 HCNF was re-estimated. A one-sample t test was employed to compare the result of this study with that of ENRAP IV. Specifically, the author tested the hypothesis that the 1989 HCNF is greater than the result of ENRAP IV equal to 4,418,961 tons.

## VII. Results, Analysis And Interpretation Of Data

The “all possible regressions procedure” resulted to the following “best”

OLS regression models for the 1989 HCNF:

Urban (P2)	$\hat{Y} = 0.187 \times P2$
Rural (P1)	$\hat{Y} = 3.403 \times P1$
Rural (P1, L1)	$\hat{Y} = 2.315 \times P1 + 0.033 \times L1$
Rural (P1, A)	$\hat{Y} = 1.998 \times P1 + 939.294 \times A$

All of these equations underwent and passed the multiple regression diagnostics for assumptions of collinearity, linearity, normality, constant variance and independence.

The Ridge regression was also employed because the independent variables were highly correlated with one another, and the results were as follows:

Urban (P2, L1, A)	$\hat{Y} = 12,660.870 + 0.400 \times P2 + (0.005) \times L1 + (35.453) A$
Rural (P1, L1, A)	$\hat{Y} = (112,319.100) + 3.096 \times P1 + 0.076 \times L1 + (1,469.014) A$

To estimate the 1995 HCNF, both OLS regression models and Ridge regression models were considered. Substitution of data to these models resulted to a number of estimates, which are presented in Table 5. Given the 1995 HECS result on the total quantity of self-collected/ gathered fuelwood or simply supply of HCNF equal to 13,012,436 tons, the “best” estimate of the 1995 HCNF is the one which is less than or equal to this total, and parsimonious.

**Table 5. Estimated 1995 HCNF by Model**

Model	Estimated 1995 HCNF (In Tons)
<b>OLS:</b>	
Urban (P2) and Rural (P1)	11,658,042
Urban (P2) and Rural (P1, L1)	19,693,029
Urban (P2) and Rural (P1, A)	12,802,760
<b>Ridge regression:</b>	
Urban (P2, L1, A) and Rural (P1, L1, A)	26,776,402

The simple OLS linear regression models, Urban (P2) and Rural (P1) had generated the “best” estimate of HCNF in 1995, (Table 5). It yielded a total quantity equal to 11,658,042 tons or 89.59 % of the total supply of HCNF in 1995. The bulk of this quantity equal to 10,240,604 tons or 87.84 % was attributed to rural area.

The “best” OLS regression model for the 1989 HCNF in urban area ( $\hat{Y} = 0.187 \times P2$ ) had an  $R^2$  of 62%. This implies that 62% of the variation in the 1989 HCNF can be explained by the regression on magnitude of poor population (P2). The regression coefficient of P2 says that there is a minimal 0.187 ton increase in HCNF for every increase in magnitude of poor population (P2).

For the “best” OLS regression model for the 1989 HCNF in rural area ( $\hat{Y} = 3.403 \times P1$ ), the  $100\%R^2$  equals to 69%. This means that 69% of the variation in the 1989 HCNF can be explained by the regression on magnitude of poor

families (P1). The regression coefficient of P1 indicates that the HCNF increases by 3.403 tons for every increase in magnitude of poor families (P1).

Table 6 presents the comparative estimates of HCNF by survey/ study undertaken: 1989 HECS, ENRAP IV and this study.

**Table 6. Estimated HCNF by Survey/ Study, 1989 and 1995**

AREA	1989 (1989 HECS)	1995	
		ENRAP IV	THIS STUDY
Philippines	14,316,390 (100.00%)	4,418,961 (100.00%)	11,658,042 (100.00%)
Urban	1,528,740 (10.68%)	1,581,117 (35.78%)	1,417,438 (12.16%)
Rural	12,787,650 (89.32%)	2,837,844 (64.22%)	10,240,604 (87.84%)

The estimate of this study was greater than ENRAP IV's estimate by 7,239,081 tons or 163.82 %. Using one-sample t test, the alternative hypothesis that the true quantity of HCNF in 1995 is greater than ENRAP IV's result of 4,418,961 tons was accepted at 5 % level of significance. The 95% confidence interval ranges from 9,609,936 tons to 13,706,140 tons.

Compared to the 1989 HECS result on HCNF equal to 14,316,390 tons, the estimate of this study was 18.57 % lower. This is consistent with the findings of the 1995 HECS that the "total consumption of fuelwood had plummeted by 20.5 % from 1989 to 1995." Meanwhile, although rural area still accounted for the bulk of the estimated 1995 HCNF at 87.84 %, the percentage consumption of the rural area decreased by 19.92 % during the period in review. This is also consistent with the 1995 HECS findings that "rural consumption of fuelwood declined by 29.1 %."

With reference to the 1995 HECS figure on supply of non-marketed fuelwood equal to 13,012,436 tons, the estimate of this study implied that 89.59 % of the supply of the non-marketed fuelwood in 1995 was consumed, while the remaining 10.41% was sold.

Meanwhile, on the assumption that all things remained equal from 1995 to 2000, the same set of simple OLS linear regression models were used to estimate the 2000 HCNF. This resulted to 11,999,213 tons: 1,051,891 tons (8.77%) – urban area, and 10,947,322 tons (91.23%) rural area. From an estimated value of 11,658,042 tons in 1995, HCNF grew to its 2000 estimate at an average rate of 0.58 percent annually.

## **VIII. Conclusions**

Based on the results of this study, the level of household consumption of

non-marketed fuelwood is indeed very site-specific. Its factors were seen to differ from urban area to rural area. The magnitude of poor population (P2) was the “best” predictor variable for urban area, while the magnitude of poor families (P1) was the “best” predictor variable for rural area. This might have been brought about by the difference in mindset of individuals dwelling in each of the area. While value for kinship still prevails in rural area, individualism is gaining ground in urban area.

Between OLS and Ridge regression methods of estimation, OLS yielded the “best” linear regression models for this study. Both models for the 1989 HCNF in urban area and rural area were simple OLS linear regression models of indicators of population size: P2 for urban area and P1 for rural area. This implies adequacy of the population size as the lone factor of the 1989 HCNF.

The  $R^2$  values of the models for the 1989 HCNF in urban area (62%) and in rural area (69%) suggested further investigation. Other factors of HCNF, such as fuel accessibility, could have contributed more if suitable and sufficient data indicators were available. The data indicator of fuel accessibility in this case lacked an important component – the child field labor.

This study had shown that the 1995 HCNF was underestimated by ENRAP IV by about 163.82 %, and that its true value was approximately equal to 11,658,042 tons, with 95% confidence interval ranging from 9,609,936 tons to 13,706,140 tons. Using the data of ENRAP IV on the real (1994=100) price per ton of the non-marketed fuelwood – Php 891 for urban and Php 484 for rural – the computed value of subsistence production of non-marketed fuelwood in 1995, which was not accounted for in the national accounts amounted to Php 6,219 million.

## **IX. Recommendations**

Although the author believes that the result of this study had provided an economical yet statistically sound means of estimating HCNF in 1995 and 2000, the inclusion of the HCNF in the future conduct of the Household Energy Consumption Survey (HECS) is still highly recommended. In so doing, a more accurate and precise update of HCNF will be available not only for immediate use and/ or reference, but also for verification and/ or improvement of the results of this study.

The author suggests the inclusion of the following data items to whichever censuses and/ or surveys of the Philippine Statistical System these could be appropriately covered: 1) child field labor, 2) types of wood energy devices used by households, and other data items that may indicate physical access to source of fuelwood. Moreover, the author encourages similar or further studies using new statistical methods, such as the Small-Area Estimation (SAE).

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