9-27-2007

A Community Based Micro Hydro: A Promising Technology for Rural Development in Nepal

Bishwa Koirala

A Community Based Micro Hydro: A Promising Technology for Rural Development in Nepal

(The author would like to thank Prof. Alok Bohara for his continuous guidance and would like to thank Rural Energy Development Programme, UNDP for providing renewable energy survey data.)

Bishwa Koirala
Department of Economics,
The University of New Mexico
September 15, 2007

Abstract

The study finds that micro hydro (MH) has significant impact on reduction in fuel wood consumption. Communities are more inclined to harvest fuel wood from government forest. These led to the promotion of MH for forest conservation in rural Nepal. The study reveals that children have significantly less intensity to go for fuel wood collection. Their saved time can be used for study. The study shows a positive impact on time saving of rural women for fuel wood collection; however, a detail study is essential to conclude the finding. A policy measure for an increase installation of MH in rural areas of Nepal is ensued. The study comes to conclude that the MH has positive impact on income but further detail analysis would help to the find the critical point how much the electricity has to be available for a significant change.

Key words: micro hydro, fuel wood collection, fuel wood consumptions, children's time for fuel wood collection, government and community forests.

Introduction

Nepal with difficult terrain has endowed with some six thousand large and small streams. A wide topographical variation in a short span extending from north to south, Nepal has an immense potential of hydropower ranging from Pico to Mega Watt. Central Bureau of Statistics (2002) reports that country has the population of about 26 million of which about 86% live in rural areas in more than 4000 villages. This makes a system of electricity distribution technically more difficult and economically challenging. In result, only 40% of its populations have access to electricity and 33% of these are supplied through national grid and 7% from alternative energy (NEA, 2005). Per capita electricity consumption in Nepal ranks at the lowest among Asian countries and the biomass fuels largely dominate the energy needs of Nepal in general and specifically the rural part due to which there is a huge pressure on the forests creating a threat to environmental stability of the country (WECS, 2005).

Since the energy is an ingredient of the development process, low per capita energy consumption reflects the development situation of the rural Nepal. With the given economic situation of the country, government lacks hydropower generation to meet the existing demand. Further due to the high initial investment, the private sectors as well couldn't come for this business. In this situation, the renewable energy technologies (RETs) like solar, micro hydro, biogas and wind those need little initial investment seem to be more promising technologies to meet the energy demand of the rural Nepal. However, the RETs contributed only 0.26% in the year 2004/05 of the total consumption and it is projected to increase to 0.56 % by the year 2005/06 (AEPC/ESAP, 2005).

The energy consumption record shows that fuel wood contributed 89% of the total energy consumption and agriculture and cattle residues shared 4.3% and 6.5% respectively during FY 2004/05 and while in the FY 2005/06 it was expected that the consumption of fuel wood would remain at the same level while the agriculture and animal residues would be 4.34% and 6.7% respectively (AEPC/ESAP, 2005).

The prevailing pattern of energy use is unsustainable which has created adverse impacts on the fragile hill ecosystem and rural livelihoods. Which in result annual forest degradation in Nepal measures about 2.1 percent against the global average rate of .88 percent (MOPE, 2001). The depletion of the forest has negative impact on women and children's workload for collecting fuel wood.

Community level economic development is measured at micro level with indicators such as growing local economy, empowering local communities, improving health condition and education, creating entrepreneurship, changing physical and ecological environment, etc. An off-grid system with minimum expenses- the micro hydro plants owned and managed at the community level has become a gradual paving path of energy development to meet the energy needs in rural Nepal. Micro hydro (MH) involves moderate technology and has less initial cost that has been successfully accepted for energy supply in rural Nepal. Looking back to the history of MH, first MH was installed in 1960 but cost was the major factor for smooth growth. From 1995, due to the introduction of subsidy policy, its formal development started (REDP, 2000).

This paper highlights and analyses impacts of MH on fuel wood consumption and income of rural household and impact on time saving of both women and children for household energy. It further analyzes effects of MH on forest conservation in the middle mountain with an aim of giving an opportunity to recommend policy measure for income augmentation of rural poor and forest resources conservation. It uses data from two different period collected before and after the implementation of micro hydro projects.

The paper organizes introduction and literature review as the first section, theoretical and econometric models and the data as the second section, results and discussion as the fourth and the conclusion and recommendation as the fifth section.

Literature review

Energy has direct correlation with income. It can affect both at macro and micro level. Analysis on relation between energy use and GDP growth showed in cross-country study showed a positive correlation between energy consumption and economic prosperity[1]. The relations between GDP per capita and an energy consumption shift showed that a rising GDP per capita is accompanied by a shift away from biomass and towards fossil fuels and to the use of electric power (Victor and Elias, 2005). Data on effects at micro level are difficult to get and change in rural households levels are generally overshadowed by the large-scale industrial data set. Hence exact recording are difficult to get. Further, the income in developing countries earned by the rural poor communities is mostly non-monetary and hard to quantify, which in result found unrecorded. Victor and

[1] IEA Key Energy Statistics 2004

Elias (2005) opine that change in expenditure could be used as a proxy for income. However, Leiwen and O'Neill (2003) found the correlation between income and expenditure less than one (just 0.516). But fuel wood is the least preferred energy so as income changes (increases) people prefer to shift to the more modern energy resources. In general, fuel choices at household levels are conceptualized with "energy ladder" but households may not follow the energy ladder if supplies of modern fuels lack and income are not sufficient to switch over (Baland et al, 2002 & Heltberg, 2003). Here the micro (MH) hydro is highly preferred and accepted energy technology and all households have switched to this technology replacing kerosene completely. It has further induced to substitute fuel wood in some places where the power supply is sufficient. Impact of MH on income has positive effects.

Renewable energy resources are environmentally friendly and are highly accredited by the society. Micro hydro is a pollution free technology. Application of MH will emit zero level of pollution and female and children mainly can get benefit of it. Due to high demand for renewable energy, its costs are relatively high in comparison but in the context of Nepal MH has lower KWh^2 cost in comparison to grid system (REDP, 2002). With less cost involvement and less technical management skills, the demand for MH has increased in the rural areas of Nepal.

Impact of MH on time budget has positive effects. Bhatt and Sachan (2004) opine that the toll that traditional energy use takes on time budgets can be substantial; particularly for women and the modern energy technologies reduce this toll. Women and children have to

[2] Kilo Watt Hour

spend a considerable segment of productive time of each day to gather biomass fuels in absence of modern energy technologies. Study reports have revealed that in some part of India, a time range between 2 and 7 hours each day has to spend to collecte fuels for cooking (IEA, 2002). However, this figure is quite high, in Nepal the median weekly time allotment is 7.5 hours in Nepal and in rural South Africa, the median time devoted to collecting wood fuel is approximately 6 hours per week (ESMAP, 2003). Kumar and Hotchkiss (1988) writes that rural women in Nepal devotes significantly higher time to collect fuel wood which results in reducing time for agriculture and children rearing. A study of households on the Indian island of Sagar Dweep found that the use of electric power (provided by a local photovoltaic, PV, plant) saved women an average of 1.5hr in cooking time per day and this saved time has been used for economically potential activities for income generation (Chakrabarti and Chakrabarti, 2002).

Application of modern energy technology opens opportunity for the promotion of cottage industries like agro-processors, bakery, in scent stick making, Thanka Painting[3], etc. It further provides illumination that extends the workday, again augmenting the ability to increase output (WEC/FAO, 1999; Bastakoti, 2003). In Nepalese context, women's involvement in agricultural sector of total household income contributes 54 percent (Acharya and Bennet, 1981). So, the saving women's time would help increase household level income in Nepal. Besides the income generation activities, rural women use the saved time for their education. Saghir (2004) explains that electricity frees time from labor-intensive tasks that they can allocate to literacy. The good thing of electricity

[3] A painted or embroidered Buddhist banner, which is hung in a monastery or a family altar and carried by lamas in ceremonial processions.

is that it provides illumination into the night, extending the hours available for educational activities. A study carried out in Sagar Dweep found that electric lighting increased the average nightly study time of students by 2.25 hours (Chakrabarti and Chakrabarti 2002).

Forests are the main source for fuel wood collection in rural Nepal. Fuel wood consumption pattern in rural household reveals that the households may seek fuel substitution. Micro hydro can be a substitute to the fuel wood. There is a temptation of collection of fuel wood from government forest than community-managed forest (Adhikari, 1996).

Model for impact analysis of Micro Hydro

The Micro Hydro (MH) has multifaceted impacts on the community. The impact ranges from welfare change of community to the forest conservation. The paper tries to analyze the impacts at the household level on income, as a part of welfare change, on fuel wood consumption, and on fuel wood collection pressure to children and women which seems to be more demanding for policy measures for the promotion of MH. To capture impacts of micro hydro, analysis of a single model is not enough because the single model may not lead to any conversing conclusion as well as it is not feasible to measure all kinds of impact. The paper uses five different models to capture the impacts of MH on the rural community.

The paper uses two-period panel data of the same households from the same community before and after the installation of MH.

Change in fuel wood consumption

One of the main interests of the paper is to estimate the impact on fuel wood consumption due to MH. To capture this important variable, it is considered that the change in fuel wood consumption is the function of change in income, electricity cost, MH, change in family members and forest resources. An econometric model used to analyze the effect on the change in fuel wood consumption is linear log-log model. The log-log model is chosen based on its minimum deviation property. The following econometric model (1) is applied to estimate the fuel wood consumption.

1.

Change in income

The model assumes that the change in income is a function of electricity consumption, cottage industry; MH installed capacity, time saving resulting from switching to electricity from kerosene and change in total family member. The differences are taken by subtracting data of independent variables from 2005 to 1996. To estimate income change, a simultaneous equation model has been applied to avoid a possible joint dependency, or endogeneity problem, because the change in income and expenditure on

energy (electricity cost) are mutually dependent variables. The OLS does not give efficient as well as consistent results in such a joint problem. So, the Two Stage Least Square (2SLS) model has been applied. A 2SLS econometric model to estimate the changes in income are given as

2.1

2.2

Choice of forest resources

The purpose of capturing the choice of forest resources for extraction is to analyze the types of forest resources- either community or government forest that the communities are tempted to exploit for fuel wood collection. This analysis would help to come up a policy recommendation whether to continue with government management or hand over the management ownership to the community. For this, it has been considered that the extracting forest resource for fuel wood is the function of change in fuel wood, change in income, change in travel time for kerosene. Here paper considers the change in travel time by taking the difference between kerosene buying time and zero time for electricity, change in family members, and MH. The econometric model used for analysis is given as

3.

Here the dependent variable has binary output, a *logit* model has been used to capture the probability of collecting fuel wood from community forest taking the government forest as the base.

Pressure to children to collect fuel wood

To capture the impact on children's time involvement for fuel wood collection or measure drudgery, a model with children fuel wood collection as the dependent variable has been considered is a function of change in fuel wood, change in income, change in family member, change in energy obtaining time and MH. The econometric model used for this analysis is given as

4.

Here the dependent variable has binary output; a *logit* model has been used to capture the probability of children's involvement in fuel wood collection. A dummy variable representing man for fuel wood collection has been created. It has been assumed for analysis that children's involvement in fuel wood collection would have effects on their education and will have drudgery effect.

Pressure to women to collect fuel wood

A similar kind of impact as analysis as on children' s time, here it has been tried to capture the impact on women's time and drudgery. For this, wood collection by women

has been considered as the dependent variable and is a function of change in fuel wood, change in income, change in family member, change in energy obtaining time and MH. The econometric model used for estimation is given as

5.

To capture the probability of women's involvement in fuel wood collection *logit* has been applied as the output is binary.

Definition of Variables:

dlfwc :difference of log of daily household fuel wood in kg

dlincome :difference log of total annual income of household in Rs[4].

dletime :difference of log of time from electricity to kerosene collection time

dltf :difference of log of total family member in household

lmh :log of micro hydro power in Watt

dcotind :difference in increase in cottage industries, binary variable

fc05 :female in fuel wood collection in 2005

childc05 :children's in fuel wood collection in 2005

cf :community forest

elec05 :expenditure on electricity in 2005 in Rs.

lelec05 :log of electricity expenditure per month in RS.

lelectw :log of electricity used at household level in Watt

[4] Nepali currency

Data mining and sources

The data used in the study is obtained from household survey carried out by Rural Energy Development Programme, UNDP in Nepal in two different dates. First in 1996 before the implementation of Micro Hydro (MH) schemes and the second in 2005 after the implementation of MH schemes. The surveyed data are from the same household and the same VDC[5] carried out in two different dates. Surveyed data in two different dates give an opportunity for an impact analysis of MH schemes in those rural households. The survey carried out in 1996 was for the purpose of development of renewable energy and survey carried out in 2005 was to analyze the changes that REDP program has brought in the communities. The 2005 survey covers the MH scheme communities. The total MH schemes covered during the survey are 20 from different VDCs. Total households covered by are 1503.

The data provides socio-economic characteristics of individual household that includes total family members, agricultural and total income; use of electricity, fuel wood consumption, types of forest for fuel wood collection, status of cottage industries, involvement of children and female in fuel wood collection, etc. The descriptive statistics of households is given in Annex 1.

Empirical results and analysis

Change in fuel wood consumption model was run with OLS estimator to find the change before and after the micro hydro. Heteroscedasticity was tested and found not significant.

[5] Village development committee

The results of the model are presented in Table 1. The results came up with the expectation. More importantly, it is found that the introduction of MH reduces the fuel wood consumption significantly. The result is significant at 1 % level. Which is more positive for policy recommendation for implementation of MH in rural areas of Nepal where the fuel wood consumption is dominant energy source. Another worth noting result of the model shows that community people are more interested to harvest fuel wood from government forest rather than from community forest. Which is another implication for policy recommendation to switch the management ownership from government to community forest.

Table 1. Difference of log of total monthly fuel wood consumption in Kg

Explanatory variable	estimates
diff. of log of total income	-.05878 *
	(.0312569)
log of electricity consumption	-.148586***
	(.0396946)
log micro hydro	-.1182458***
	(.0319259)
diff. log of total family member	.1352856*
	(.0796182)
community forest	-.0999314***
	(.0382487)
Intercept	1.788964***
	(.324006)

Number of observations = 1466
R-squared = 0.0281
***, ** and * indicate significance at 1%, 5% and 10% levels respectively.
Figure in the parenthesis are robust standard errors.

In income model, Hausman test on difference in log of total annual income of household in Rs. total land, total family member and household male heading has been carried out for endogeneity test and found that the model has endogeneity problem. To overcome the endogeinity problem, Two Stage Least Square (2SLS) model has been considered for estimation. Results are presented in the Table 2. and are found as expected.

Table 2.Difference in log of total income per month in Rs.

Explanatory variable	estimates
diff. electricity time	-.03937373**
	(.0179495)
electricity consumption cost	-.0044378***
	(.0004405)
log micro hydro	.0123792
	(.0272759)
square of elec. consumption	.0000264***
	(.0000058)
intercept	.6504928**
	(.2585047)

Number of observations = 1390
R-squared = 0.0727
***, ** and * indicate significance at 1%, 5% and 10% levels respectively.
Figure in the parenthesis are robust standard errors.

The MH has positive impact on income but not significant. An interesting result between change in income and use of electricity is found negatively significant which is just opposite to the expectation. But when looked at the relationship between those two variables in scatter plot, it showed that after certain point the income is rising with the electricity. The scatter plot has been attached in the Annex for reference. Looking at this

plot then running another model only with change in log of income with the square of the electricity cost it is found a significantly positive, which is presented in the Table 2. From these two models it can be inferred that MH can play significant role in income of rural community as well as in conserving the fragile mountain ecosystem by reducing fuel wood consumption.

The result of model #3 is presented in Table 3. The results of model 3 show that if fuel wood consumption is increased, the tendency to collect from community forest decreases. This value is significant at 5 % level. In the same line, the application of MH has increased the tendency of fuel wood collection from government forest rather than the community forest. This value is also significant at 5% level. It gives a message to the policy makers that government forests are no more sustainable as the community people tend to consume more fuel wood if government manages forest sources.

One interesting result of this model is if family members are increased there is a negatively significant result on fuel wood collection tendency from community forest. This leads to infer that the community forest group may have some limited extraction of fuel wood per month. And as there is an increase in family member there is an increase in fuel wood demand[6] so they may have to go for government forest by the limit of the harvest amount. This analysis supports for community management for forest (it has to be analyzed in detail latter on).

[6] a study carried out in spring 2005 for 509 paper showed the result is significant.

Table 3.fuel wood collection form community forest (logit model)

Explanatory variable	estimates
diff. fuel wood consumption	-.0662617**
	(.0913606)
diff. income	.0231392
	(.0004405)
log micro hydro	-.7313792***
	(.1029745)
diff. total family member	-.7480597**
	(.3138095)
Intercept	6.383326***
	(.2585047)

Number of observations = 1466
Pseudo R-squared = 0.0439
***, ** and * indicate significance at 1%, 5% and 10% levels respectively.
Figure in the parenthesis are robust standard errors.

Result on children's involvement in fuel wood collection shows that if the difference of time for energy (difference of time of electricity to kerosene, which is taken negative of kerosene buying time for analysis) increases the children are likely to go to fuel wood collection. But the time for electricity is zero. Which infers that the children are less likely to go for fuel wood collection after the introduction of micro hydro.

Another promising result has been obtained from the same model that children have negative relation for fuel wood collection with the presence of MH and the value is significant at 1% level. This result helps come across that the MH will help to reduce children drudgery and save fuel wood collection time if MH is installed. Their saving in time will provide them to invest this time for study. The result is presented in Table 4.

Table 4. Children's involvement in fuel wood collection (logit model)

Explanatory variable	estimates
diff. in fuel wood consumption	-.0421228
	(.0869419)
diff. electricity time	.0456888
	(.0687377)
diff. income	.1009596
	(.0960173)
log micro hydro	-.3613689***
	(.0984217)
diff. total family member	-.1928137
Intercept	2.937717**
	(.949796)
	(.2642394)

Number of observations = 1381
Pseudo R-squared = 0.0092
***, ** and * indicate significance at 1%, 5% and 10% levels respectively.
Figure in the parenthesis are robust standard errors.

The result in women's tendency to collect fuel wood shows that there is a negative tendency to go for fuel wood collection if the difference in fuel wood increases. The result is presented in Table 5.

Another result shows that women are less likely to go for fuel wood collection if MH has been installed. But the result is not significant. One of the results we already found above from the model #1 shows that the MH reduces the fuel wood consumption. From that, it can be inferred that there is no significant change in women's time for fuel wood collection. But one of the possibilities might be, as children will reduces their time for fuel wood collection, in result women have to go. We already found that application of

MH has reduced in change in fuel wood consumption. Hence, it can be inferred that MH creates positive impact on reducing women's time for fuel wood collection.

Table 5. Women's involvement in fuel wood collection (logit model)

Explanatory variable	estimates
diff. in fuel wood consumption	-.3608796
	(.1497411)
diff. electricity time	.4941888
	(.1083426)
diff. income	.1239628
	(.1546172)
log micro hydro	-.0860447
	(.1639626)
diff. total family member	.7188595
	(.4626087)
Intercept	3.285586**
	(1.589945)

Number of observations = 1381
Pseudo R-squared = 0.0314
***, ** and * indicate significance at 1%, 5% and 10% levels respectively.
Figure in the parenthesis are robust standard errors.

Conclusion and policy recommendation

The study finds that micro hydro has contributed significantly in reducing the fuel wood consumption. A policy recommendation for the promotion of micro hydro in the rural areas of Nepal is ensued. Study shows that communities are more inclined to harvest fuel wood from government forest, which is another crucial finding for policy recommendations. A policy to hand over government forest to the community for management followed by an intensive program for implementation is strongly

recommended. The study finds an important outcome that is after the installations of MH children have significantly less intensity to go for fuel wood collection. This leads to a point that with MH, children can save their time. The saved time can be sued for study. Further, MH provides light at night for study, so that children can spend their nighttime on study. A policy recommendation for children's education, promotion of MH in rural areas is highly recommended.

Still there can be seen that there is no significant change brought by MH in women's time and drudgery but the tendency of women not going to collect fuel wood is seen. As Nepal is dominated by patriarchal cultural, men want more household work done by female. It can be recommended that gender base energy policy would help reduce female's workload in rural Nepal.

Important finding of the study on income side is the MH has positive impact on income but further detail analysis would help to the find the critical point how much the electricity has to be available for a significant change. A further study on fuel substitution and an income change with the installation of micro hydro is recommended for future study.

The study discovers that the micro hydro has multidimensional positive impacts on socio-economic development. With the given socio-economic conditions, topographical variations and available technical feasibility, the study finds that the micro hydro is a promising technology for rural development in Nepal.

Bibliography

Adhikari, B.,1996, *Common Property Resource Management by User Groups: An Experience from Middle Hill of Nepal*. In Proceedings of International Symposium on Geology and Environment, 31 January-2 February 1996, Chinag Mai University, Chiang Mai 50200, Thailand.

AEPC/ESAP. *Micro-hydro Year Book of Nepal 2001*, Kathmandu: Alternative Energy Promotion Centre/Energy Sector Assistance Programme, 2005.

Amacher, G., W. Hyde and B. Joshee, 1993, *Joint Production and Consumption in Traditional Households: Fuel Wood and Crop Residues in Two Districts in Nepal*. Journal of Development Studies, Vol. 30 (1) pp: 206-225.

Amacher, G., W. Hyde and K. Kanel, 1999, *Nepali Fuel Wood Production and Consumption: Regional and Household Distinctions, Substitution and Successful Intervention*. Journal of Development Studies, Vol. 35 (4) pp: 138-63.

Bardhan, P., Baland, J. M., Das, S., Mookherjee, D.and Sarkar, R., 2001, *Household Firewood Collection in Rural Nepal: The Role of Poverty, Collective Action and Modernization*

Bardhan, P., Baland, J. M., Das, S., Mookherjee, D.and Sarkar, R., 2002, *The environmental impact of poverty: evidence from firewood collection in rural Nepal*.

Bjracharya, D.,1979, *Firewood Consumption in the Nepali Hills: A Comparison of the Annual Recall and the Weekly Recorded Data*. University of Sussex, Brighton, UK.
Elias, Rebecca J. & Victor, David G. (2005), Energy Transitions in Developing Countries: a Review of Concepts and Literature, working paper #40

Barnes, Douglas F. and Jonathan Halpern. "The role of energy subsidies," in ESMAP, *Energy Services for the World's Poor*. Washington, DC: The World Bank. 2000.

Bastakoti, Badri Prasad. "Rural electrification and efforts to create enterprises for the effective use of power." *Applied Energy*. Vol. 26. 2003. 145-155.

Bhatt, B.P. and M.S. Sachan. "Firewood consumption pattern of different tribal communities in Northeast India." *Energy Policy*. Vol. 32. 2004. 1-6.

Chakrabarti, Snigdha and Subhendu Chakrabarti. "Rural electrification program with solar energy in remote region—a case study in an island." *Energy Policy*. Vol. 30. 2002. 33-42.

CBS. Statistical Pocket Book Nepal. Kathmandu: Central Bureau of Statistics, 2002.

Energy Research and Development Group, TU,1979, *Nepal, the Energy Sector:Energy Research and Development*, Tribhuvan University.

Flora, J., N., and Jill,.L.,F., 2003, *Natural resource collection work and children's schooling in Malawi*, A conference paper in 25th International Conference of Agricultural Economics, Aug 16-22, 03, Durban South Africa

Heltberg, R., T. Arndt, N. Sekhar, 2000, *Fulewood Consumption and Forest Degradation: A Household Model for Domestic Energy Substitution in Rural India*. Land Economics, Vol. 76 (2) pp: 213-232.

Hardie, I., W. and Hassan, A., A., 1986, *An Econometric Analysis of residential Demand for Fuel wood in the United States, 1980-1981*, Forest Science Vol 32, No 4, pp1001-1015

Kelkar, G., and Nathan, D., , *Gender relations and The energy Transition in Rural Asia*, CRGGE and ENERGIA, DFID, UK.

Koirala, B. S., 2001, *Biomass energy uses: an experience and application of alternative energy technologies in Nepal*. A conference paper in 9th Biomass Energy Conference in Orlando, Floriad

Kumar. S.K., and Hotchkiss, D., 1988, Consequences of deforestation for women's time allocation, agricultural production and nutrition in hill areas of Nepal, International food policy research institute report 69, Washington DC.

Israel, D., 2004, *Household Fuel use in Rural Bolivia (draft)*, Indiana State University
Mekonnen, A., 1999, *Rural Household Biomass Fuel Production and Consumption in Ethiopia: A case Study*, Journal of Forest Economics 5:1

MOPE, 2001, Nepal's State of the Environment (Agriculture and Forests), Ministry of Population and Environment/ ESS, Kathmandu.

NEA. Nepal Electricity Authority: A Year in Review. Kathmandu: Nepal Electricity Authority, 2005.

NPC, 2004, Nepal Living Standard Survey- 2003/04: Statistical Report Vol II, CBS, NPN/HMG, Nepal

Sharma, M. and Bhattacharya, S.C., 1997, *A study of biomass as a source of energy: Nepal,* Energy for Sustainable Development Volume III No. 5 Energy Program, Asian Institute of Technology, P.O. Box 4, Klong Luang, Pathumthani - 12120, Thailand January 1997

Saghir, Jamal. *Energy and Poverty*. Paper Prepared for the International Energy Forum. Washington, DC: The World Bank. 2004.

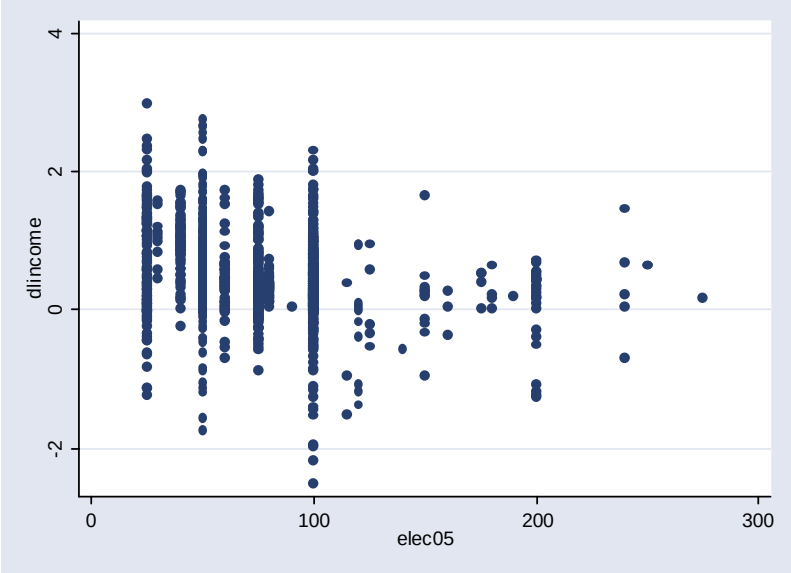
Shrestha, G., Shrestha, S. R. and Shrestha, G., R., 2004, *Household Energy for Rural Women in Nepal: Reality and Potential*, WREC VIII, Elsevier Ltd.

WECS. *Energy Synopsis Report*. GON. Ministry of Water resources. Kathmandu: Water and Energy Commission Secretariat, 2005.

The World Bank, 2003, *Household fuel and energy use in developing countries- A multi country study*, Draft for discussion May 14, 2003 Rasmus Heltberg Oil and Gas Policy Division The World Bank

Annex 1

Variable	Obs	Mean	Std. Dev.	Min	Max
fid	1480	1691.657	1202.521	1	19990
income05	1480	73960.42	64431.57	3217	811368
incomecause	1480	2.847297	5.542234	0	97
district	1480	43.80608	19.96683	22	74
projname	1480	10.9777	5.729552	1	20
mhkw	1480	18.51419	8.261599	5	35
region	1480	3.247973	1.221288	2	5
ethnicity	1480	2.903378	1.251688	1	6
caste	1480	4.791892	4.130716	1	50
tfm96	1480	6.668919	3.214842	1	32
tfm5	1480	6.641892	2.931976	1	44
income96	1480	49465.1	38126.11	1350	282445
cindistry05	1480	1.487838	2.186346	0	10
fwb05mth	1480	8.093243	3.054069	0	27
fw05kgpm	1480	404.6622	152.7035	0	1350
cc05	1480	1.64527	.7422199	1	22
fcc05	1480	1.091892	.359835	0	9
mcc05	1480	1.131757	.4022481	0	9
gforest	1480	1.252703	.4805122	0	9
cforest	1480	1.691892	.5011837	1	9
kerouse05	1480	0	0	0	0
kp05	1480	25.20338	1.616301	23	28
kerouse96	1479	3.027045	4.696681	0	99
kerocost96	1480	90.05878	85.92503	0	999
elecost05	1480	62.70676	26.19688	25	150
engcost05	1480	63.4027	31.49863	25	700
fwbharimth96	1472	9.702446	6.727364	1	80
fw96kgpm	1480	482.5	337.3391	0	4000
forest96	1480	1.55	.4976619	1	2
fc1996	1480	1.456081	.4982357	1	2
fcoll96	1479	1.772143	.6951467	1	3
kerotime96	1474	2.141248	2.098367	0	12
millexpes96	1480	70.95743	70.65856	2	990
millexpen05	1478	87.73884	73.18509	0	600
fdishr	1480	2.573784	2.12149	.4	12
changecott0	1480	1.544595	.4981757	1	2
changecott	1480	1.499324	.5001685	1	2


dlincome
4
2
0
-2
0
100
200
300
elec05