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Evaluation of Economic Supply Price of Energy Sources in Selected Regions of Nepal: Its Relevance in Rural Energy Policy Formulations.

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BACKGROUND

In rural areas of Nepal the main forms of energy sources are fuelwood, agriculture residue, animal dung, solar, wind and water energy. Petroleum fuels and coal are imported primarily to meet the demand of transport and industrial sectors concentrated in urban areas.

Presently, the prices attached to different energy sources ("market price") are highly distorted causing wasteful usage pattern of energy. Thus the analysis carried out based on these premises are bound to be biased. It is thus imperative to evaluate the economic price of energy delivery using different sources to make meaningful comparison. Economic energy prices represent the real resource cost of supplying energy, or the opportunity cost of allocating the resource to energy as opposed to its next best alternative use. More specifically, it is the supply cost of supplying one unit of energy to the nation or society. It should be clearly understood that eventhough many traditional energy forms such as fuelwood, agriculture residue, and animal dung as well as alternate energy sources such as solar and wind do not have a financial or market price in developing countries they do have an economic value.

It is possible to determine the economic prices of supplying energy using different sources by making appropriate adjustment of market prices for some inputs and by evaluating the shadow prices or real resource costs for others. In case of capital expenditures and labour costs the financial prices must be adjusted to determine economic values. It requires three forms of adjustment: (i) Direct transfer payments represents the transfer of real resource costs from one individual in society to another. It does not represent real resource costs and should be removed when economic values are being determined. (ii) Price distortion in traded items can be either in exports or imports. There are two major steps in adjusting price distortions for traded items. Firstly, border price needs to be determined. For imports, the border price is the quality adjusted CIF price, and for exports, the border price is typically the quality adjusted FOB price. Secondly, allowance for transport and marketing costs between the point of import/export and the site. (iii) Price distortions in non-traded items can be adjusted by making certain adjustment to obtain a better estimate of opportunity cost and then multiplying it by the Standard Conversion Factor.

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METHODOLOGICAL GUIDELINES AND ASSUMPTIONS

Estimation of Economic Evaluation Parameters

In general, adjustments to economic values include consideration of three types of conversion factors. These are as follows:

Standard Conversion Factor (SCF)

On large capital intensive projects it is important to determine the conversion factor of each specific major input and/or output of trade associated with project. However, for the alternate energy evaluations it is possible to use a single conversion factor, known as the "Standard Conversion Factor" for all material goods. SCF is calculated on the basis of trade with foreign countries on a 10-year average basis (1975-85) and the resulting value is 0.90.

$$SCF = \left(\sum_t M_t + \sum_t X_t\right) \Big/ \left\{\left(\sum_t M_t + \sum_t TM_t\right) + \left(\sum_t X_t - \sum_t TX_t\right) + \sum_t SX_t\right\} \quad \ldots \quad (1)$$

Where, M = CIF value of imports;
X = FOB value of exports;
MT = Taxes on imports;
TX = Taxes on exports; and
SX = Subsidies on exports.

Suffix "t" is time variant for year.

Shadow Price of Labour (SPL)

The shadow price of labour is the cost of labour in Nepal adjusted for labour market discrepancies. The basic methodology for evaluating shadow price of labour is as follows:

(a) The prevailing market wage rate is estimated and taken as a peak season or scarcity wage rate.

(b) It is weighed by a percentage, judged to be the portion of the year during which peak wage rates apply, while during the remainder of the year a lower wage rate is assumed to exist.

(c) The sum of these weighed financial values is then translated into an economic value using SCF to arrive at the "Shadow Price of Labour."

The resulting shadow price is 0.9 for unskilled labour and 0.7 for skilled labour in Nepalese context.

Shadow Exchange Rate (SER)

The shadow exchange rate is equivalent to the official exchange rate divided by the SCF. The official exchange rate is assumed 27 Rs. per 1 US $.

Estimation of Economic Price of Energy Supply

Fuelwood

Economic prices of fuelwood are calculated on a site specific basis using the following two methods:

Method 1: This method assumes that fuelwood is the perfect substitute for dung when used for energy and the value of dung is based on avoided losses to paddy production using dung for fertilizer as opposed to fuel. The following assumptions are made to calculate the economic price of fuelwood:

(a) Nepal will continue to be an importer of foodgrains and that the loss in production from using dung as energy is offset by imports.

(b) The labour involved in collecting and preparing dung for use as a fuel is the same as that required to compost and spread an equal amount of dung on the field for crop fertilization.

(c) Farmers use an average of 8000 Kg of manure per hectare.

(d) Use of manure as fertilizer increases the yield of a paddy crop by 15 percent.

(e) 4 Kg of manure equals 1 Kg of dried dung.

(f) All imports would enter Nepal through nearest custom check point from a site.

(g) Local paddy and maize is of lower quality compared to international standard, therefore, price of paddy is assumed to be 30 percent lower then that of international price and for maize it is 20 percent less.

(h) Financial cost of transportation is Rs. 850 per ton per 100 Kms.

(i) Cost of porter is Rs. 40 per day.

(j) Porter carries an average load of 30 Kg.

Economic price of fuelwood (EPFW) is calculated as follows:

$$EPFW_s = EFP_{s,c} * IY_{s,c} * ERMD \quad \ldots (3)$$

$$EFP = BP + TT + TP + PC + SL + BV + ML \quad \ldots (4)$$

$$IY = (AY * PIY)/AMU \quad \ldots (5)$$

$$BP = (FOBP + QAP + SHCIF + THNB) * SER \quad \ldots (6)$$

$$TT = FCTT * DT * SCF \quad \ldots (7)$$

$$TP = \{(CP * SPUL)/PL\} * SCF * PD \quad \ldots (8)$$

Where, EFP is per unit economic farm gate price;

IY is per unit incremental yield of crop;
ERMD is equivalence ratio of manure to dried dung;
BP is border price;
TT is economic cost per unit transported by truck;
TP is economic cost per unit transported by porter;
PC is processing cost for crop;
SL is per unit value of storage losses for crop;
BV is per unit by-product value of crop;
ML is per unit value of milling losses for crop;
AY is average yield per hectare of crop;
PIY is percentage increase in crop production by using manure as fertilizer;
AMU is average quantity of manure used per hectare;
FOBP is FOB price of traded crop;
QAP is quality adjusted price;
SHCIF is shipping and handling cost CIF Calcutta;
THNB is transport and handling cost upto Nepal border;
FCTT is financial cost per unit transported by truck;
DT is distance in kilometers from nearest custom check point to closest point from site with road access;
CP is cost of porter per day;
SPUL is shadow price of unskilled labour;
PL is porter load in Kg; and
PD is number of days porters required.

Suffix "s" stands for a particular area taken into consideration;
Suffix "c" stands for different crops such as paddy, maize, etc.

Method 2: Economic supply price of fuelwood (ESPF) is determined as the ratio of annualized economic cost of plantation/afforestation and annualized energy production from plantation/afforestation programme.

$$ESPF = \left[\sum_t TC_t/(1+i)^t\right] / \left[\sum_t FP_t/(1+i)^t\right] \quad \ldots (9)$$

Where, TC is annual total cost of plantation/afforestation;
FP is annual fuelwood production; and
i is economic discount rate (i.e., 10 percent);

Suffix "t" stands for year and varies from 0 to project period.

The following assumptions are made to calculate the economic supply price of fuelwood from plantation.

(a) Number of seedlings required is 2200 per hectare.

(b) 220 man-days are required initially for digging holes and planting seedlings.

(c) 1 man-day is required to look after 5 ha. of plantation area.

(d) Cost of labour is Rs. 40 per day.

(e) Cost of seedling is Rs. 50 per 100 saplings.

Agriculture Residue

Economic price of agriculture residue (EPAR) is calculated as follows based on replacement of agriculture residue being used as fodder with maize.

$$EPAR_s = EFP_{s,c} * TDNA * UFAR_s \quad \ldots (10)$$

Where, TDNA is average digestible nutrient content of agriculture residue per unit of maize (i.e., 0.20); and
UFAR is percentage of agriculture residue used as fodder (i.e., 60 percent).

Animal Dung

Economic price of animal dung (EPD) is calculated as follows based on the replacement of dung with imported chemical fertilizer.

$$EPD_s = [(EFP_{s,f} / PNC_f) * NC_f] / ERMD \quad \ldots (11)$$

Where, PNC is percent of nutrient content in chemical fertilizer;
NC is nutrient content of chemical fertilizer equivalent per unit of raw manure.

Suffix "f" stands for different chemical fertilizer such as Urea, Triple Super-Phosphate, etc.

The following assumptions are made to calculate the economic supply price of animal dung.

(a) The nutrient value by weight of imported Urea is 64 percent of Nitrogen.

(b) The nutrient content of Urea equivalent of 1 ton of raw manure is 5 Kg of Nitrogen.

Petroleum Fuels and Coal

Economic price of petroleum fuels and coal, all of which is imported, is calculated as follows:

$$EPPF_{s,p} = BP_p + TT_p + TP_p + TEMP_p + OTC_p \quad \ldots (12)$$

$$EPC_{s,v} = BP_v + TT_v + TP_v + OTC_v \quad \ldots \quad (13)$$

Where, TEMP is unit cost assigned for product losses due to temperature difference.

OTC is other costs assigned by Nepal Oil Corporation in case of petroleum fuels and Nepal Coal Limited in case of coal which mainly includes administrative cost, depreciation, interest, exchange rate losses and dealer's commission incurred by Nepal Oil Corporation or Nepal Coal Limited.

Suffix "p" stands for different types of petroleum fuels such as motor spirit, high speed diesel oil, kerosene, etc.

Suffix "v" stands for different grade of coal such as steam coal, slack coal, soft coal, hard coal, etc.

Solar Energy

Economic supply price of solar energy (ESPS) is calculated as follows based on the best alternative use of land for crop production and resulting annual benefits if it has not been occupied by solar collectors.

$$ESPS = [EFP_{s,c} * YIL_{s,c}]/SEA_s \quad \ldots \quad (14)$$

Where, SEA is solar energy available for extraction on a hectare of land.

Wind Energy

Economic supply price of wind energy (ESWE) is calculated as follows based on the best alternative use of land for crop production and resulting annual benefits if it has not been occupied by wind mill or generators.

$$ESWE = [EFP_{s,c} * YIL_{s,c}] / [EOP/SOW] \quad \ldots \quad (15)$$

Where, EOP is unit capacity of wind generator or mill; and
SOW is space occupied by wind generator or mill which is assumed as three times the rotor diameter in hectares.

Water Energy

Economic supply price of water energy (ESPW) is calculated as follows based on the best alternative use of land for crop production and resulting annual benefits if it has not been occupied by Hydro power plant and canals.

$$ESPW = [EFP_{s,c} * YIL_{s,c}] / [EOP/SOH] \quad \ldots \quad (16)$$

Where, EOP is unit capacity of wind generator or mill; and
SOH is space occupied by hydro power plant and canals in hectares.

RESULTS AND DISCUSSIONS

The methodology described in our text is applied to determine the economic supply prices of different energy forms for three villages each from different physiographic zones of Nepal. The detail energy use survey was carried out in these villages and energy demand pattern as well as resource availability was estimated. The topographical features and other relevant variables for this analysis is reported in Table 1. The estimated border price of paddy, maize and urea is enumerated in Table 2.

Table 3 details the various cost components as well as estimated economic supply prices of traditional energy forms. It is interesting to note that fuelwood supply price is lower in the Hill compared to Terai and Mountain villages. The price seems to be correlated with the present deforestation rate and forest regenerative capability in different physiographic zones of Nepal. The economic supply price of agriculture residue and animal dung increases substantially in the Hill and Mountain compared to Terai village mainly due to transportation bottleneck and low agriculture productivity.

The resulting economic supply price of fuelwood from plantation and associated annualized cost components and fuelwood production is detailed in Table 4. The main factor which affects the economic price of fuelwood is productivity of fuelwood plantation and the associated fuelwood transportation cost as indicated by the higher prices in Mountain and Terai villages compared to the Hill. There is extra transportation cost associated with the delivery of fuelwood in the Terai village due to clearing of forest land for agricultural activities though fuelwood plantation productivity is higher. The economic supply price of fuelwood plantation is low in Mountain village due to low fuelwood plantation productivity. It can be concluded that Terai should get high priority for fuelwood plantation, and the Mountains for natural forest enrichment and protection activities.

The economic supply price of petroleum fuels and coal is reported in Table 5. The economic price of high speed diesel oil in Hills and Mountains is 1.9 and 2.5 times that of Terai villages. This is mainly contributed due to substantial increase in transportation cost. Similar trend is visible for other petroleum fuels and coal as well. This clearly indicates the increasing relevance of indigenous energy sources in rural parts of Hills and Mountains. Though the market price is slightly higher than the economic price of petroleum fuels and coal in Terai, it is reverse in case of Hills and Mountains and is heavily subsidized by the Government. As long as these discrepancies persist there is little hope for alternate energy sources to find place in market economic without concerted policy implementations.

Table 1
Characteristics of Typical Villages of Nepal

		Unit	Baijnathpur (Terai)	Lekhgaun (Hill)	Marpha (Mountain
1.	Location				
	- Latitude	Degree M	26.48-26.53	28.60-28.70	28.72-28.8
	- Longitude	Degree E	87.28-87.32	81.52-81.62	83.63-83.7
	- Altitude (M.S.L.)	Meters	72	1176	2660
2.	Total Area	Sq. Km.	7.2	30.9	43.2
	- Forest Cover	% of Area	0.4	52	34
	- Agriculture Land	% of Area	87	24	4
3.	Distance From Nearest Border Entry Point				
	- Motorable	Kms.	8	553	368
	- Trail	Hrs.	0.5	3.5	42
4.	Demographic Composition				
	- Population	Nos.	3434	3855	1212
	- No. of Households	Nos.	664	548	253
5.	Occupational Profile				
	- Agriculture Farming	% of hh	18	88	84
	- Landless	% of hh	74	4	4
6.	Livestock Holding	LSU/hh	2.2	5.4	7.7
7.	Agriculture Production	Ton/hh	1.9	1.6	2.4
8.	Household Expenditures	Rs/hh/yr	4125	2250	6925

Table 2
Border Price of Selected Crops and Fertilizers

Economic Prices (1990 Constant)	Unit	Paddy	Maize	Urea
FOB Price	US$/Ton	311.8	133.8	243.6
Quality Adjusted Price	US$/Ton	218.3	107.1	-
Shipping & Handling	US$/Ton	57.1	105.3	84.2
Transport & Handling to Nepal Border	US$/Ton	73.7	73.7	73.7
Border Price	US$/Ton	349.1	286.1	401.5
	Rs/Ton	10474.3	8583.4	12044.0

Source: WECS (6).

Table 3
Cost Components for Determining Economic Energy Price of Traditional Energies

Cost Components	Unit	Baijnathpur (Terai)			Lekhgaun (Hill)			Marpha (Mountain)		
		Paddy	Maize	Urea	Paddy	Maize	Urea	Paddy	Maize	Urea
Border Price	Rs/Kg	10.47	8.58	12.04	10.47	8.58	12.04	10.47	8.58	12.04
Transportation										
- Truck	Rs/Kg	0.06	0.06	0.06	4.23	4.23	4.23	2.82	2.82	2.82
- Porter	Rs/Kg	0.06	0.06	0.06	0.42	0.42	0.42	5.04	5.04	5.04
Processing Cost	Rs/Kg	0.21	0.00	-	0.21	0.00	-	0.21	0.00	-
Storage Losses	Rs/Kg	-0.31	-0.80	-	-0.31	-0.80	-	-0.31	-0.80	-
By Product Value	Rs/Kg	0.09	0.05	-	0.09	0.05	-	0.09	0.05	-
Milling Losses	Rs/Kg	3.08	0.00	-	3.08	0.00	-	3.08	0.00	-
Administrative Cost	Rs/Kg	-	-	1.51	-	-	1.51	-	-	1.51
Economic Farmgate Price	Rs/Kg	7.51	7.96	13.67	12.03	12.5	18.20	15.2	15.7	21.40
Avg. Yield	Kg/Ha	1812	-	-	1006	-	-	1289	-	-
Incremental Yield		0.0340	-	-	0.0189	-	-	0.0242	-	-
Price Per Kg of Nutrient	Rs/Kg	-	-	29.7	-	-	39.6	-	-	46.5
Economic Supply Price										
- Dung	Rs/Ton	-	-	594	-	-	791	-	-	931
- Ag. Residue	Rs/Ton	-	955	-	-	1498	-	-	1883	-
-Fuelwood (Method 1)	Rs/Ton	2336	-	-	1391	-	-	2257	-	-

Table 4
Economic Supply Price of Fuelwood From Plantation in Typical Villages of Nepal

Descriptions	Unit	Baijnathpur (Terai)	Lekhgaun (Hill)	Marpha (Mountain)
Annualized Costs	Rs.	14682	16844	8859
- Investment	Rs.	1985	2623	2623
- Seedlings	Rs.	231	231	231
- Labour	Rs.	1436	1436	1436
- Transport	Rs.	319	957	957
- Recurring	Rs.	12697	14221	6236
- Maintenance	Rs.	2044	2044	2044
- Harvest	Rs.	10653	12177	4192
Annualized Fuelwood (Production (1)	Tons	15	12	3
Economic Supply Price	Rs/Ton	1750	1400	2608

Note: (1) - Referred From WECs (14); MFSP (15).

Table 5
Economic Supply Price of Petroleum Fuels and Coal

Village Site/ Cost Components	Petroleum Fuels				Coal			
	Motor Spirit (Rs/KI)	High Speed Diesel (Rs/KI)	Kerosene (Rs/KI)	LPG (Rs/Ton)	Steam (Rs/Ton)	Slack (Rs/Ton)	Hard (Rs/Ton)	Soft (Rs/Ton)
Baijnathpur (Terai)								
Border Price (1)								
Transportation	4132	3872	4100	8980	946	946	1063	265
- Truck	43	51	48	61	61	61	61	61
- Porter	43	50	47	60	60	60	60	60
Temp. Adjustment (2)	0	0	0	0	-	-	-	-
Other Costs (3)	418	288	222	288	156	156	175	44
Economic Supply Price	4636	4260	4416	9389	1223	1223	1360	429
Lekhgaun (Hill)								
Border Price	4132	3872	4100	8980	946	946	1063	265
Transportation								
- Truck	2998	3496	3292	4230	4230	4230	4230	4230
- Porter	298	347	327	420	420	420	420	420
Temp. Adjustment (2)	15	6	9	15	-	-	-	-
Other Costs (3)	418	288	222	288	156	156	175	44
Economic Supply Price	7861	8010	7950	13933	5753	5753	5889	4959
Marpha (Mountain)								
Border Price	4132	3872	4100	8980	946	946	1063	265
Transportation								
- Truck	1995	2327	2191	2815	2815	2815	2815	2815
- Porter	3572	4165	3922	5040	5040	5040	5040	5040
Temp. Adjustment (2)	29	13	19	30	-	-	-	-
Other Costs (3)	418	288	222	288	156	156	175	44
Economic Supply Price	10147	10665	10454	17153	8957	8957	9094	8163

Note: (1) Referred From WECS.
(2) Referred From WECS.
(3) Per. Comm.

Table 6 compares the economic supply price of various energy forms that would be available in rural areas of Nepal. The economic supply price of fuelwood estimated by Method 1 reflects the short-run resource cost whereas Method 2 reflects the long-run resource cost. It is observed that the short-run resource cost is higher than long-run resource cost in Terai, while it is reverse in Mountain indicating the higher benefits of fuelwood plantation in Terai and forest enrichment activities in Mountain corroborating the findings already discussed. This study clearly indicates that animal dung is a "better" economic option compared to other traditional fuels in the rurals of Nepal. It also indicates that solar and water energy are the cheapest forms of energy available which is abundantly available, whereas wind energy viability depends on the availability of good wind and is too site specific.

Table 6
Economic Supply Price os Primary Energy Sources in Three Villages of Nepal

Unit: Rs/GJ

Primary Energy Sources	Baijnathpur (Terai)	Lekhgaun (Hill)	Marpha (Mountain)
Fuelwood			
- Method 1 (Dung Replace)	140	83	135
- Method 2 (Plantation)	105	84	156
Agriculture Residue	76	119	149
Animal Dung	55	73	85
Petroleum Fuels			
- Motor Spirit	139	235	304
- High Speed Diesel	114	214	284
- Kerosene	120	215	283
- Liquidfied Petro. Gas	191	283	349
Coal			
- Steam	49	228	355
- Slack	49	228	355
- Hard	54	234	361
- Soft	17	197	324
Solar Energy	2	2	3
Wind Energy	-	-	87
Water Energy	57	40	39

CONCLUSION

Determination of economic supply prices of various energy sources helps to understand the existing distortion in supply prices (i.e., market prices). There is huge distortion between market price and economic price of energy forms in rural areas of Nepal. For example, economic supply price of traditional energies is 50 to 156 Rs/GJ, whereas market price of these fuels is almost zero. Thus when comparison is made traditional energies are bound to show "better" financial attractiveness than water, solar and wind energies. Rural energy policy should be devised in such a manner that the existing distortion in economic and market price as well as long-run and short-run price of energy delivery is minimized to perpetuate a healthy competition based on economic merits rather than hidden subsidies. As long as distortion in energy prices exists, there is little scope for indigenous alternate energies that are economically cost effective to find its place in rural areas whereby they could contribute substantially in National energy scene.

Economic supply price of different energy forms also indicates the desired minimum level of relative efficiency and cost of end-use device for exploiting various energy forms to meet the useful energy requirements.

More emphasis needs to be attached towards disseminating and developing alternate energy technologies which utilize animal dung, hydro energy, solar and wind energy with ingenuity in the rural area of Nepal so as to fulfill their energy needs freeing them from long wanderings in search of fuels. Thus saving precious time which could be put to better use for increasing the productivity of agriculture and cottage industries. Further, fuelwood plantation should receive high priority in the Terai and forest enrichment activities in Mountains, with a combination of both in the Hills of Nepal.

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