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Study on Potentiality of Biogas Plants and Their Role for the Conservation of Environment

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Abstract
This study presents the potentiality of biogas plants and their role for the conservation of environment. It is based on primary data collected from 84 household surveys, 6 key informant interviews and two focus group discussions. It was observed that more than 95% of the people residing in the VDCs were using firewood as a main source of energy. The total amount of firewood consumed was 510.570 ton/year which emits 775.052tCO_2e/year. Due to the presence of agriculture based livestock holding population, there is a great potential of biogas technology. The study showed that biogas technology could saved 34.40% of firewood which conserves 5.415 ha of forests area. There is a potentiality of 58 biogas plants of size 6 cu.m which will reduce 440.800 tCO_2e/year.

Key words: alternative energy, energy consumption, firewood, GHGs reduction

Introduction
Energy has been the basic need of humanity. Human life can hardly subsist without the use of energy. Every activity on earth depends on energy ranging from flora and fauna to environment, from agriculture to industry, transportation to communication. The global energy need is increasing rapidly with the expansion of population and industrialization but the conventional sources of energy are depleting at an alarming rate (Shrestha *et al*. 2004).

The biomass energy is supplied from three sources: agricultural crop, forest and livestock. A major share of biomass energy is supplied from the crop residue such as rice straw, husk and bran from rice plant, tails, roots and baggage of sugarcane, straw of wheat, jute stick. The trees, twigs and leaves from them are used as fuel. The dung produced from cattle is also used as important source of biomass fuel in Nepal (WECS 2010).

There are many technologies available today to deal with the problem of excessive use of biomass for household energy consumption in rural areas of developing countries like Nepal. These can include solar, wind, hydro power etc. Many of these technologies are well suited in specific areas based on the natural resources available there. However, a common problem for the majority of these technologies are that they are often associated with very high initial capital costs and a dependency on foreign financing and expertise. The appropriate solutions that have proven it to be very useful in most rural areas in developing countries is the use of biogas energy technology (Thapa 2012).

There is a need of research which determines the potentiality of biogas plant as an alternative and renewable source of energy in the hilly region of Nepal. So, the research is focused on determining the amount of energy consumed in terms of firewood among the biogas user and non user households. It will help to calculate the firewood consumption among biogas user and non user households and find out the potentiality of biogas in the study area.

Methodology

Study site

The study was carried out in Lamjung District of Bhalayakharka VDC which lies in the elevation of 300m to 1862 m from the sea level. The VDC is dominated by hot monsoon climate with average annual temperature above 23 degree Celsius. It is located between the latitude of $28^0$19' to $28^0$38' North and longitude of $84^0$11'23" to $84^0$11'10" East. The VDC is rich in biodiversity with different species of birds and animals. It is also rich in floral species like *Shorea robusta*, *Dalbergia sissoo*, *Schima wallichhi*, *Alnus nepalensis*, *Acacia catechu*, *Castanopsis indica*, etc. The map of the study area is shown below in figure 1.

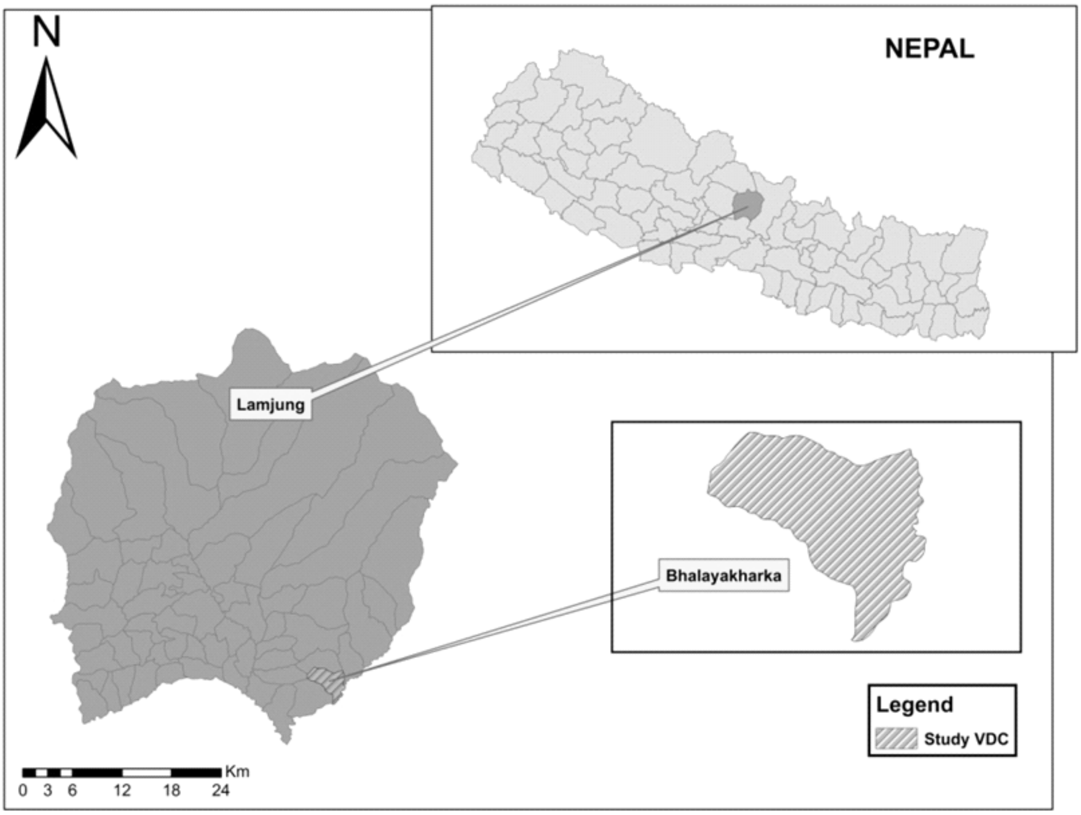

Fig.1. Map of the study area

Data collection

Data was collected from interviews among the 84 sampled households including marginalized and low income status people. Interview using structured questionnaire was administered to both the biogas user and non user households about their trends of firewood used in their daily activities.

The question on total number of people in the family, livestock holding and the amount of firewood used in *bhari* (head load of 35kg) was asked. The sampled households were asked about the number of cows and buffaloes owned to determine the daily dung production. The daily dung production/cattle/day equal to 10 kg/day was considered depending on criteria such as stall fed or grazed, adult and young cattle and partly stall fed or partly grazed.

The total amount of dung produced in the area and gas produced from the dung was calculated considering the gas produced per kg of dung (0.032 m^3) obtained as below (Werner, *et al.* 1989),

Gas produced per kg of dung = 0.230-0.040 m^3 (Average 0.032m^3)

Gas required for cooking per person = 0.200-0.300m^3/ (Average 0.250m^3/day)

Calculation of amount of dung required to generate 1m^3 of gas per day

1 kg of dung produces 0.032m^3

To produce 1m^3 of gas: 1/0.032 kg of dung is required =31.250 ~31 kg of dung

Calculation of amount of firewood saved

Amount of firewood saved was calculated based on the energy content on firewood as stated by Vaidya S., *et al*. (2011).

1 tonne of dry firewood contains 16.750 GJ of energy.

Calculation of number of trees saved and areas of forest protected

The equivalent forest area saved was estimated based on the study of Winrock and Eco Securities (2004) on impact of biogas on forest. The estimated number of trees saved through potential biogas plants was based on the estimation of an annual saving of 11.600 trees per biogas plant (Devkota 2007).

Estimation of GHGs emission reduction

One kg of firewood generates 1.518 kg equivalent of carbon emission (Smith *et al*.1999) GHGs emission reduction in terms of carbon dioxide was obtained as follows:

GHGs emission reduction (gm) = amount of firewood saved *GHGs emission per kg of firewood

Procedure applied in calculation of firewood, gas produced and forest area saved

- Average weight of one kg of firewood was determined by weighing randomly six *bhari* of firewood from the sampled households and found as 35 kg in a *bhari* of firewood.
- Annual income saving from reduction in firewood was calculated at the local rate of NRs. 80 per *bhari* (35kg).
- The estimated number of trees saved through potential biogas plants was based on the estimation of an annual saving of 11.600 trees from one 6 cu.m biogas plant (Devkota 2007).
- The equivalent forest area saved was estimated based on the study of Winrock and Eco Securities *et al*. (2004) on Impact of Biogas on Forest.
- The estimated number of technically potential biogas plant was based on the daily dung available from cattle as 10 kg/ animal (BSP 2009).
- The emission factor of GHG for firewood developed by 1996 IPCC and Smith *et al.* 1999 guidelines were used for the estimation of GHGs, i.e. 1.518 kg equivalent of carbon emission.
- Total GHGs emission (kg) = Amount of firewood burned (kg) x GHGs emission per kg of firewood.

Results and Discussion

Distribution of domestic animals/livestock holding status

All the households in the community generally had livestock in their houses including cows, buffaloes and ox. Few people rely on domestic animals for their income generation. There were 120 cow/ox and 121 buffaloes.

Table 1. Livestock in sampled HH

Animals	No. of population
Cow/Ox	120
Buffalo	121

Potentiality of biogas plants

From the study, it was found that there was a potential of 78 biogas plants among the sampled household of 84 of which 20 of them have already constructed. So, 58 more plants can be constructed.

Table 2. Total potential of biogas plants in the study area

Livestock	No. of livestock	Total no of livestock	Dung/animal/ day	Total dung/day	Kg of dung required to run one 6 cu.m. plant	Potential of plants of 6 cu.m.
Cow Buffalo	120 121	241	10	2410	31	77.74
Potential plant = 78, Available plant = 20, More feasible plant = (78-20) = 58						

Amount of GHGs reduction from biogas plant

Altogether 153.12 ton of CO_2e/year of GHG was reduced from the available biogas plant in the VDC.

Table 3. Amount of GHGs reduction from the available plant

Size of biogas plant	Hill (tCO_2e/year/plant)	No of plant	Total reduction tCO_2e/year
$4m^3$	5.430	2	10.860
$6m^3$	7.600	15	114
$8m^3$	9.420	3	28.260
Total		20	153.120

Potential of GHGs reduction

If the potential biogas plant of size 6 cu.m will be constructed from the dung produced annually then the reduction of GHGs will be,

= 7.60*58 (no. of potential biogas plant from study)

= 440.800 tCO_2e/year

The total amount of GHGs reduction will be (153.120+440.800) =593.920tCO_2e/year.

Firewood consumption among biogas user, non-biogas user household and amount of firewood saved

The comparison between biogas user and non user households shows that biogas user households use 11.900 kg of firewood per day. Non-biogas user households use 18.140 kg of firewood per day. It shows the expenditure of NRs. 9946.620/year in the case of biogas user households and NRs. 15162.320/year in non-biogas user households.Therefore, there is a saving of NRs.5215.700 with the saving of 2277.600 kg and 34.40% of firewood per year per household as shown in table below.

Table 4. Firewood consumption among biogas user and non-biogas user households

Particulars	Biogas user households	Non-Biogas user households
Average firewood consumption in kg/HH/day	11.900	18.140
Average firewood consumption in kg/HH/year	4343.500	6621.100
Expenditure in firewood per year/HH in NRs.	9946.620	15162.320
Firewood saved per year/HH in kg	2277.600	-
Expenses saved per year/HH in NRs.	5215.700	-
% of firewood saved	34.40 %	-

1 Bhari = 35 kg

Cost for 35 kg firewood = NRs. 80

Potential firewood saved

If the potential plant is constructed from the dung produced annually, the amount of firewood saved will be 177.650 tonnes/ year (2.278 * 78 potential biogas plants).

Estimation of number of trees saved and areas of forest protected

The number of potential biogas plant was found to be 78 in number. Therefore, total number of trees saved from the estimated biogas plant of size 6 cu.m will be 904.800 annually. Hence, the forest area protected will be 5.4145 ha/year which is shown in table 5 below (1ha=32.810million tonnes of firewood).

Table 5. Estimation of equivalent area of forest area protected

Particulars	Comparing biogas and non-biogas holding HH
Annual firewood saving (tones/HH/year)	2.278
Equivalent forest area protected (ha)	5.415

Estimation of GHGs emission from current firewood consumption practices

From the study, it was found that with the consumption of 510574.170 kg of firewood there was total annual GHG emission of 775051.590 kg in terms of CO_2e.

Total annual firewood consumption	GHGs	CO_2e	Total annual CO_2e emission in kg
510574.170 kg	CO_2	1.406 kg/kg	775051.590
	CH_4	0.084 kg/kg	
	N_2O	0.028 kg/kg	

Impact of biogas on environment and health

One of the principal causes of pollution in the households is attributed to firewood burning. Apart from this, contamination of faecal waste produces obnoxious smell that is detrimental to human health and environment. Therefore, construction of biogas plant with the connected toilets helps in the better management of animal dung and human waste with better environment.

Biogas is an alternative form of energy due to easy availability of raw materials and of its efficient technology. Therefore, the indoor air pollution can be reduced through biogas stove and consequently reduce the respiratory diseases and eye related problems to those working in the kitchen. On the other hand, there will be conservation of forest resources, wildlife habitat and natural balanced ecosystem.

Besides this, biogas is a clean form of energy, where Nepal is gaining huge amount of revenue from CDM project.

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