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Socio-environmental Benefits of Biogas Production in Rural Areas of Rangpur District, Bangladesh

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ABSTRACT

The study was conducted in Rangpur Sadar, Badarganj and Mithapukur Upazilas of Rangpur district, Bangladesh to assess the economic and environmental benefits of biogas production. 10 biogas plants owned households from these three Upazilas were selected purposively and a structured questionnaire survey was conducted for data generation. Biogas production was calculated using the ADB developed conversion table and CO_2 emission was calculated using the Climate Registry data sheet. Average biogas production rate found as 0.0251 m^3 per 1 Kg of cow dung. Average financial saving from biogas plant was US$ 1 per day/household and the monthly savings as 25 US$/month/household and 300 US$/year/household. Study revealed that the reduction of CO_2 emission due to biogas consumption is 9 m^3/household/year. The study indicated that biogas helps to improve socio-economic and environmental conditions of the rural area. It also suggested that biogas production should be linked to the national development initiative setting a biogas production target.

Keywords: Renewable energy, Biomass saving, Financial saving, CO_2 emission.

INTRODUCTION

Bangladesh is one of the environmentally threatened countries suffering from scarcity of fuels, especially biomass fuel which is the main source of energy for cooking (100% for the rural households, and 70% of urban households), and kerosene for lighting and the consumption pattern of biomass fuels depend on regional availability as well as household size, educational status, income, socio-economic categories and land ownership [1-3]. Actual biomass energy consumption in Bangladesh is still increasing like in other South Asian countries [4]. Biomass fuels comprise trees, tree residues and agricultural residues, animal excreta, kitchen by products etc. Total biomass consumed per year in the country is about 39 million tones of which about 50% come from agricultural residues and about 40% from fuel wood [5]. Of the total fuel wood supply more than 90% come from homestead forest and the rest from conventional forest and other areas. The country has rather small coverage of forest (about 15% of the total area of the country) and actual tree coverage may not however, be more than 7 to 8%. The forest coverage is said to be fragmented all over the country. In the current scenario, energy supply from forest is utterly inadequate for both forest sector and energy sector. Thus shifting from traditional energy to alternative energy consumption, like solar energy, biogas energy, wind energy etc. is getting priority nationwide.

Bangladesh is an agriculture based country which has huge potentials for utilizing biogas technologies. According to IFRD-there is potential of about four million biogas plants in the country [6]. It is notable that Bangladesh Government has planned to produce 5% of total power generation by 2015 and 10% by 2020 from renewable energy sources, like air, waste & solar energy [7]. Biogas technology utilizes energy sources in ways that do not deplete the earth's natural resources and are as environmentally benign as possible [8, 9]. And its use has been proven to contributing for reducing the emission of greenhouse gases [10]. Considering the issue, the study has been conducted in the countryside of Bangladesh with a view to investigate the biogas contribution in climate change mitigation and adaptation.

MATERIALS AND METHODS

Sampling

The present study was conducted in three Upazilas of Rangpur district namely Rangpur Sadar, Badarganj and Mithapukur situated in the northern part of Bangladesh and lies between 25º18´ and 25º57´ north latitudes and between 88º56´ and 89º32´ east longitudes (Fig. 1) [11]. For this study, 1 household from Sabyapushkarni Union and 2 households from Mominpur Union under Rangpur Sadar Upazila, 1 Gopalpur Union under Badarganj Upazila and 2 household from Mayenpur Union and 2 household from Khoragach Union under Mithapukur Upazila of Rangpur district were selected purposively and a structured questionnaire survey was conducted to investigate the socio-economic condition and energy consumption pattern.

The demographic status of the sampled households was 37 female and 39 male with average 7.6 persons per household.

Basis of estimation for biogas calculation

In order to estimate the biogas production, the conversion table from the interim report from the Asia Development Bank was used. It provides data about the generated amount of manure (kg/d/c), the chemical oxygen demand (COD) (kg/d/c) as well as its converting factor to biogas used in China [12]. The conversion is as follows: 1kg COD = 0.23 m^3 biogas. Data from the field survey was used for the calculation.

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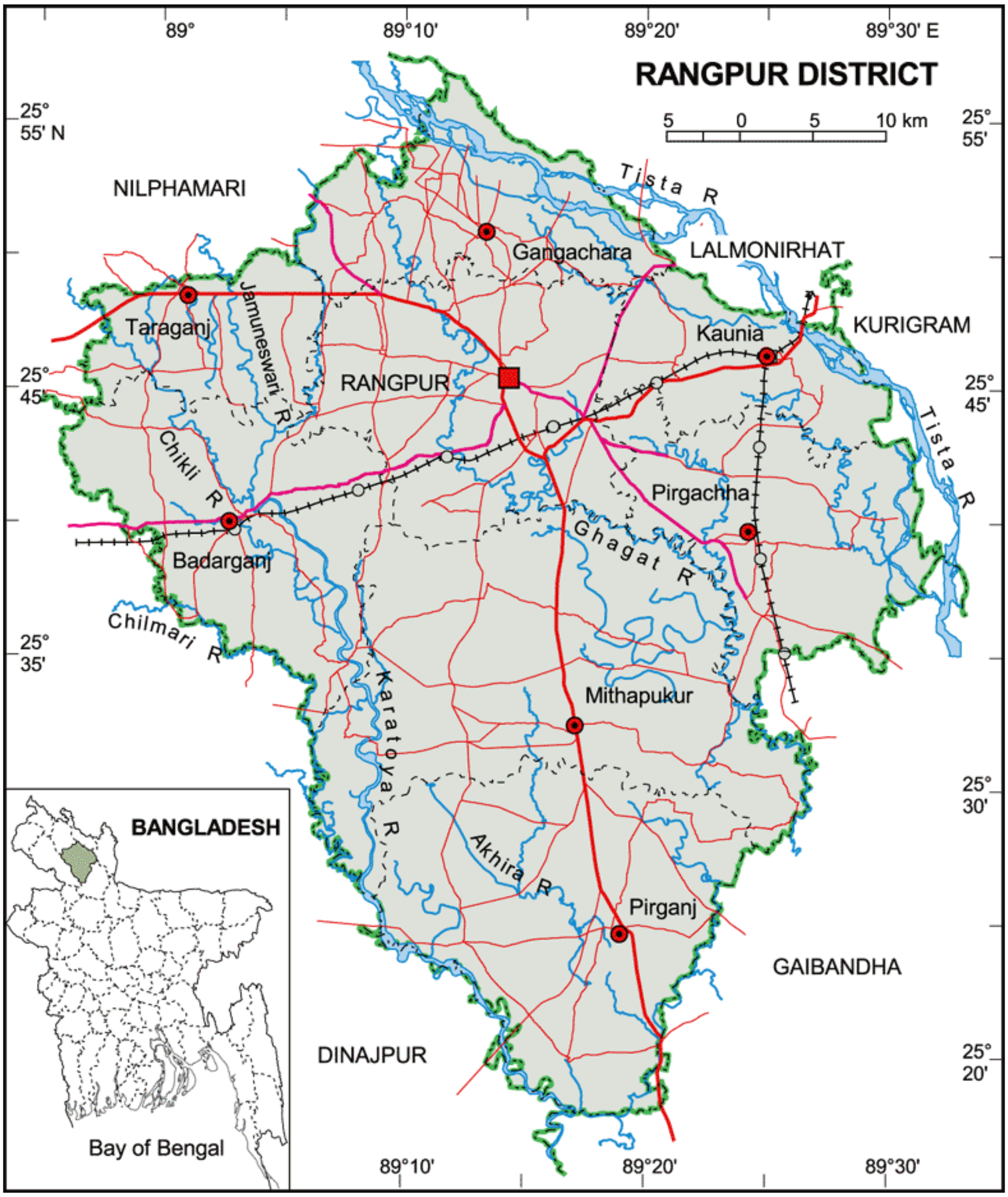

Fig. 1. Map of Rangpur district showing the study area.

Basis of estimation for CO_2 emission calculation

The main focus of the present study was on the CO_2 emission reduction due to consumption of biogas over traditional biomass energy. United States green house gas (hereafter GHG) emission data sheet developed by The Climate Registry 2013 was used to calculate the emission of CO_2 from different traditional biomass energy sources including biogas [13].

RESULT AND DISSCUSION

Gas production and use

Biogas production scenario in the study area was found that from 70 Kg raw materials composed of cow dung, organic household wastes and water used in the biogas Plant A, 1.70 m^3 of methane captured biogas was produced. So the production rate of biogas for Plant A is 0.0246 m^3 per 1 Kg raw materials (Table 1). In this way the highest production rate was identified in Plant F at a rate of 0.0261 m^3 per 1 Kg of raw materials whereas the lowest biogas production rate was found in Plant D at a rate of 0.0241 m^3 per 1 Kg raw materials. The overall production rates of the plants are 0.0251 m^3 of biogas per 1 Kg raw materials (Table 1). The functional rate of biogas production is higher than the functional plants in Pabna District [14].

Table 1. Biogas production rate in the study area.

Biogas plants*	Volume of Raw Materials (Kg)	Gas Production (m^3)	Gas Production rate (m^3/Kg)
A	70	1.70	0.0246
B	80	2.04	0.0255
C	85	2.18	0.0256
D	95	2.29	0.0241
E	100	2.49	0.0249
F	100	2.61	0.0261
G	110	2.77	0.0252
H	125	3.17	0.0253
I	140	3.54	0.0253
J	160	3.96	0.0247
Total	1065	26.79	0.0251

**Names of the biogas plants.*

However, the variation of biogas production was basically due to the variations in the composition of raw materials. If the major components of the raw materials are animal dung compared to other household wastes, the production of biogas will be more and vis-versa. From this study it was found that the production rate varies from 0.0241 to 0.0261 m^3 of biogas per 1 Kg of raw materials. Different studies conducted previously opined that the methane captured biogas production rate varies from 0.017 m^3 (or 0.6 SCF) to 0.0396 m^3 (or 1.4 SCF) of biogas from 1 Kg of raw materials [15].

Savings from biogas consumption

The study attempted to assess the quantity of conventional fuel used in the biogas households before and after the installation of biogas plant. The findings have been summarized in Table 2.

Table 2. Saving of conventional fuel after the installation of biogas plant.

Particulars	Quantity used before (Kg/day)	Quantity used after (Kg/day)	Savings (Kg/day)
			Fuelwood
Total quantity use	120	10	110
Per HH* use	12	1	11
			Dried dung cake
Total quantity use	30	0	30
Per HH* use	3	0	3
			Agricultural residues
Total quantity use	30	10	20
Per HH* use	3	1	2

			Kerosene
Total quantity use	3	0	3
Per HH* use	0.3	0	0.3

**HH means House Hold.*

Savings in the quantity of cooking and/or lighting fuel is directly an economic benefit of biogas plant to the concerned household. Theoretically, based on effective heat produced, a plant producing 2 m^3 of biogas each day can replace about 180-220 kilograms of fuelwood per month depending upon its quality [16]. The field finding revealed that 26.79 m^3 of biogas is produced by the plants under study per hh per day. This saves about 11 Kgs of fuelwood per hh per day. Thus the average savings of fuelwood would be therefore 4035 kg/year/hh which is higher than the studies average conducted by [15].

Table 3. Financial Gain from Saving of Conventional Fuel.

Conventional Fuel	Consumption (Kg/hh/day)		Quantity savings (Kg/hh/day)	Average Cost (BDT/Kg)	Total Saving (BDT/HH/ day)
	Before	**After**			
Fuelwood	12	1	11	2.75	30
Dried Dung	3	0	3	2.60	8
Agril. Residue	3	1	2	1.2	2
Kerosene	0.3	0	0.3	70	21
				Total	61

Financial savings that derived from the savings of conventional fuels due to the use of biogas per day has been given in the table 3 which shows that the average financial savings from each biogas plant was calculated at a rate of BDT 61 or about US$ 1 per day/household. In this way the monthly savings would be BDT 1830 or about US$ 25 per month/household and BDT 22265 or about US$ 300 per household per year. Considering the average income of BDT 115800 or US$ 1550 per household per year in rural household of Bangladesh, the saving of US$ 300 would contribute 20% to their income [17]. This indicates that if the biogas energy technology can be facilitated nationwide, the economic condition of the rural society will be upgraded significantly.

Energy consumption scenario

Figure 2 denotes that before the installation of biogas plant, various types of fuels were used and the average rate of consumption is 12 kg/hh/day for fuelwood, 3kg/hh/day for dung cake, 3kg/hh/day for agricultural residues, and 0.3 kg/hh/day for kerosene but after the installation of biogas plant the consumption of traditional fuels has been substantially reduced and the rate is 2.68 m^3/hh/day for biogas, 1kg/hh/day for fuelwood, 0 kg/hh/day for dung cake, 1kg/day for agricultural residues, and 0.3kg/hh/day for kerosene.

CO_2 emission reduction

According to United States GHG emission data sheet, the CO_2 emission rate is 1.54 Kg of CO_2 per m^3 biogas, 1.62 Kg of CO_2 per Kg of fuelwood, 2.725 Kg of CO_2 per Kg of dung cake, 0.975 Kg of CO_2 per Kg of agricultural residues and 2.99 Kg CO_2 per Kg of kerosene [13]. The study estimated that before biogas plant installation, the CO_2 emission from fuel wood, dung cake, agricultural residues and kerosene was respectively 19.44 Kg, 8.175 Kg, 2.925 Kg and 0.897 Kg and after the biogas plant installation, the emission was 4.143 Kg from biogas, 1.62 Kg from fuel wood and

0.975 Kg from Kerosene consumption. In culmination, before the installation of biogas plant, on an average the total emission of CO_2 from a single studied household was 31.44 Kg and the later scenario is only 6.74 Kg. So the reduction of CO_2 emission due to biogas consumption from a single household is 24.7 Kg per day and 26 m^3 per year. It indicates that the amount of CO_2 emitted by a family before biogas consumption in a single month would be emitted by the same family in about five month if the source of energy is biogas.

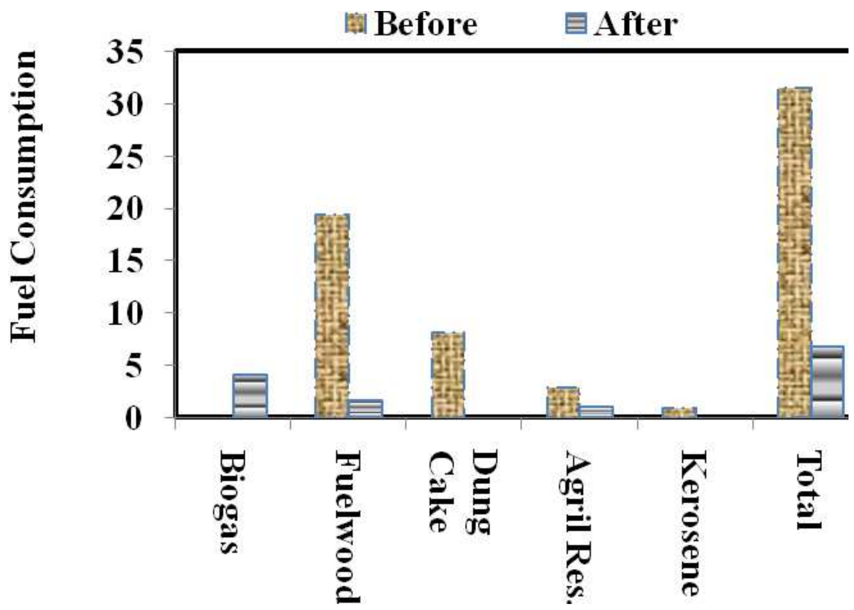

Fig. 2. Energy consumption scenarios of sample household.

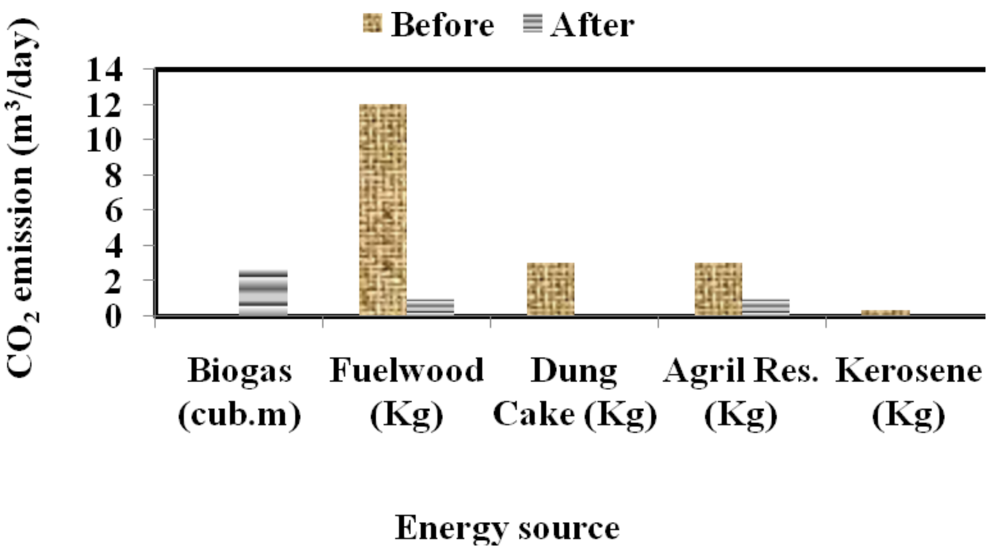

Fig. 3. CO_2 emission scenario of biogas and other energy sources

Chand et al. (2012) showed that the amount of GHGs emission reduction due to biogas consumption was calculated and found to be 8.02 tones per plant per the CO_2 equivalent and total of 641.66 tones/year of CO_2 equivalent in Baitada Community Forest User Group (BCFUG) for the emission factor 1.518 kg CO_2 equivalent/kg of the fuel wood [18]. The number of trees saved per plants per year is found in this study to be 10.15 trees that help to mitigate the climate change through carbon sequestration and increase adaptive capacity of the user.

This study estimated that for a single household with an average family size of 7.6 persons (As found in the present studied household including the servants and maid servants), the CO_2 emission is cut down by about 26 m^3 per year. Moreover the fuel wood saving is on an average 11 Kg per day or 4015 Kg per household per year. Forest conservation means number of tree saved from the reduction of the fuel wood consumption. A study conducted by Chand et al. (2012) mentioned that the average volume of fuel wood per tree was estimated to be 520.55 kg [18]. Using this estimation, it can be calculated that the tree saving per biogas plant per year is 7.72 or almost 8 trees. This huge volume of plants can contribute CO_2 removal from atmosphere through carbon sequestration mechanism.

According to Global Climate Risk Index 2013 Bangladesh is the 4th most vulnerable country in terms of climate change impacts throughout the world [19]. Every year, the country is facing various types of extreme climatic events with more intensity for example cyclone, tornado, floods, drought etc. In the northern Bangladesh, the drought scenario is more prevailing climate induce hazard and the situation is becoming more devastating in time consideration. Deforestation is acting as a triggering factor for the drought formation which is the major source of rural energy supply in Bangladesh in the northern region [20]. This study indicates that every year, biogas consumption in a household with an average family size of 7.6 can save about 4035 Kg plants. This means the biogas consumption has a significant contribution to the climate change adaptation in the rural Bangladesh. Moreover the biogas can ensure the energy sustainability as the country is facing severe energy crisis [21-23]. In the rural Bangladesh, in every household there are a number of livestock which dung can be potential source of biogas energy and can play a vital role in solving the crisis in a sustainable manner.

CONCLUSION

The present state of methane captured biogas production using cattle manure and vegetable wastes from household sources was discussed in this paper. The methane gas is widely used to substitute the traditional forms of energy sources such as cattle dung cakes, fuel wood, agriculture residues, etc. This has greatly helped the people in many ways such as income generation, litter management, life style improvement and cost saving. Biogas technology is considered as the one of the best energy sources that provide energy in one hand and reduce the emission of the GHGs on the other hand. It is the effective and appropriate mitigation effort in the Bangladesh. Though biogas technology has already created a ground at the rural communities in the country, this has happened with isolated efforts in an uncoordinated manner by some sector institutions especially BCSIR. To effectively harness the high potential of 950,000 domestic biogas plants across the country a base has been created and there is need of coordinated approach and collaborative efforts of the sector institutions.

REFERENCES

[1]. M Asaduzzaman; DF Barnes; SR Khandker; Restoring Balance: Bangladesh's Rural Energy Realities. World Bank Working Paper No. 181. Washington, D.C.: The World Bank, **2010**.
[2]. MN Rao; BS Reddy; Variations in Energy use by Indian Households: An analysis of micro level data. Energy. **2007**; 32 (2): 143-153.
[3]. MAR Sarker; SMN Islam; Rural energy and its utilization in Bangladesh. Energy. **1998**; 23 (9): 785-789.
[4]. Z Haq; M Iqbal; MA Jabbar; Renewable Energy Status and Potentials in Costal areas of Bangladesh, Dhaka, **2003**.
[5]. M Eusuf; Dissemination of Biogas Technology in Bangladesh. Proceedings of the National Seminar on Renewable Energy for Poverty Alleviation (NSREPA-97). **2008**; 20-27.
[6]. M Islam; Renewable Energy Prospects & Trends in Bangladesh. Dhaka: Bangladesh Power Development Board. Ministry of Power Energy and Mineral Resource. Government of the People's Republic of Bangladesh, **2008**.
[7]. MoPEMR. Renewable Energy Policy of Bangladesh. Power Division. Dhaka: Bangladesh Power Development Board. Ministry of Power Energy and Mineral Resource. Government of the People's Republic of Bangladesh, **2008**.
[8]. UN. Renewable Energy Technologies for Rural Development. A Paper Presented in the United Nations Conference on Trade and Development. New York: United Nations, **2010**.
[9]. H Katuwal; AL Bohara; Biogas: A Promising Renewable Technology and its Impact on Rural Household in Nepal. Renewable and Sustainable Energy Reviews. **2009**; 13(9): 2668–2674.
[10]. MoE. Status of Climate Change in Nepal. Government of Nepal, Ministry of Environment, Singha Durbar, Kathmandu, Nepal, **2011**.
[11]. BBS. Community Report. Rangpur Zila. Population and Housing Census 2011. Bangladesh Bureau of Statistics. Statistics and Informatics Division. Ministry of Planning. Government of the People's Republic of Bangladesh, **2012**.
[12]. ADB Asian Development Bank. PRC: Preparing the Integrated Renewable Biomass Energy Development Project – Final Report, Project Number: 40682. Beijing: ADB, **2009**.
[13]. Climate Registry. U.S. Default Factors for Calculating CO_2 Emissions from Fossil Fuel and Biomass Combustion. Climate Registry Default Emission Factors. 41, **2013**.
[14]. M Ali; The Use and Status of Biogas Plants of Pabna District in Bangladesh. Ms. thesis. University of Flensburg; **2005**.
[15]. PC Ghimire; Final report on technical study of biogas plants installed in Bangladesh. National Program on Domestic Biogas in Bangladesh, a Partnership Program of Netherlands Development Organisation (SNV) and Infrastructure Development Company Ltd (IDCOL), **2013**.