ANALYZING THE EFFECT OF CONSUMER SUSTAINABILITY KNOWLEDGE ON BIOGAS USING IN RURAL BANGLADESH

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Received: September 3, 2024 | Revised: September 21, 2024 | Accepted: September 30, 2024

DOI: 10.5281/zenodo.14211092

Abstract

Bangladesh is solely dependent on indigenous natural gas for power generation where it has been misusing for times due to bad monitoring and defective supply-chain system. In this research, the author tries to capture the positivity of biogas system that might be proved as alternative energy system. This research aims to measure the sustainable knowledge index that can affect consumer behavior for biogas production and use. The author takes 200 households data from Rural-Bangladesh who already use biogas in home and use this for generating electricity. In this research, following systematic sampling, the author develops sustainable knowledge index (SKI) with 16 independent variables to measure the impact of these variables on Biogas raw materials collection (BRC) considering as proxy variable for biogas production. The multiple regression shows that Household Income (HI), Household Head Education (HE), Biogas Reserve Area (BR), Cattle Numbers (CN), Domestic Birds (DB), Agricultural Residues (AR) and SKI has positive and significant impact on BRC. Moreover, the author finds that biogas plant area has been divided with 3 groups (small, medium and large) where, households earn profit of US$ 125.13 (13,765 BDT) for small, US$ 150.34 (16,538 BDT) for medium and US$ 144.88 (15,937 BDT) for large plants with annual basis. The government needs to focus some strategical policies to develop consumer mentality to use biogas with large scale.

Key words: Biogas, Sustainability, Natural Gas, Energy, Rural-Bangladesh.

Introduction

Biogas is achieving a worldwide importance and popularity, especially with the developing countries, because of its appropriateness in the context of technical, socio-economic and resource endowments of many countries. Some countries notably China and India have met with considerable success in extending the technology for the use of common people. Both urban and rural Bangladesh has favorable situation in the adoption of the technology. Necessary steps might open a new horizon of development for our country. Fuel demand is increasing with the increase of population. However, we do not have enough reserves of fuel for our future requirement. Experts apprehend that the stock of 10.7 trillion cubic meters of natural gas in our country will be exhausted by the year 2020. It is also not possible to expand the gas lines at the upazila level due to excessive cost associated with it (Hossain, 2003). Bangladesh and other developing countries are facing huge shortage of energy and power that caused slowing down the economic development as well as GDP growth. Although biogas program will not have a large impact on solving these problems, development of a large number of commercial biogas plants at rural and semi urban areas can reduce the government's pressure for further expansion of natural gas in country wide by gas distribution networks for households and small industries in rural and semi urban areas. In the rural areas, the environmental situation is getting worse. To solve the fuel crisis, biogas can play an important role. Biogas technology is a cheaper option. A total of 30,000 biogas plants have so far been installed in rural areas in the country as an alternative source of energy to reduce the use of firewood. People are using biogas for cooking, lighting and generation of electricity while residues

from the plants utilized as organic fertilizer for crop production (Rouf, 2002). Total fuel wood supply more than 90% comes from homestead forest and the rust from conventional forest and other areas (Islam and Rahman, 2006). The biogas being used has an impact on the national economy through fertilizer manufacture, electricity generation and direct energy use in some industries; it will not be economically feasible to supply the gas to the rural areas through pipelines in reverie Bangladesh (Mamun et al., 2009). An economic analysis of a biogas plant with a daily gas production of 100 cft was undertaken to assess the benefits to society of the use of biogas plants (Chowdhury et al., 2012). The possibilities of expanding the use of renewable energy to provide electricity and other energy services in Bangladesh are given greater relevance by the fact that less than 30% of all households are connected to grid electricity (Alam, et al., 2003). The Bio-gas plants are being used for cooking like natural gas, lighting rooms with mantel of hazak light, generating electricity for power appliances like light, fan, television and radio and it also can be converted into mechanical power for pumping irrigation water. The initiatives of construction of biogas plants was undertaken as an alternative to the energy produced from firewood, the cutting and burning of which is harmful for the environment.

Research Objectives

a. To determine the consumer sustainability knowledge on biogas using in Rural-Bangladesh.

b. To analyze the annual profit using biogas in Rural-Bangladesh.

Research Questions

a) How does consumer sustainability knowledge affect biogas using in Rural-Bangladesh?

b) How does cost-benefit ratio effect on consumer behavior for using biogas in house?

Material and methods

Literature review. Energy is considered as one of the basic elements that are essential for the progress of human civilization and all development activities. Generally, energy sources are broadly classified into two categories, conventional and fossil fuel and renewable energy. It is recognized that the conventional sources of energy such as oil, coal and natural gas would be available to mankind only for a limited time. The proven gas reserves may support electricity generation, fertilizer production, industrial, domestic, commercial, transportation (CNG operated vehicles) and other needs for about 50 years or more (Rouf and Islam, 2002).

Renewable energy refers to the energy extracted from sources that are partly or wholly regenerated in the course of annual or solar cycle. Renewable energy sources have been established as a clean, sustainable and environment friendly. They do not get depleted like the conventional sources of energy and do not contribute to greenhouse gases and acid rains. Many renewable energy technologies are already in use and more are being developed. Solar, wind, mini/micro hydro, tidal and wave power, biomass and biogas have been successfully exploited and used in different parts of the globe with great advantages (Hasan and Khan, 1997). Bangladesh is one of the environmentally threatened countries suffering from scarcity of fuels, especially biomass fuels. Biomass fuels comprise trees, tree residues and agricultural residues, animal excreta, kitchen by products etc. 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 7-8% of the total fuel wood supply more than 90% come from homestead forest and the rust from conventional forest and other areas. Total biomass consumed per year in the country is about 39 million tons of which about 50% come from agricultural residues (Atikullah and Eusuf, 2005).

Renewable energy is almost unlimited source of energy if one considers the energy is necessary for mankind, compared with the huge amount of energy we receive from the sun. Gradually renewable energy and its different energy conversion technologies become economically viable, capable of competing with fossil-fueled technologies in the energy market (Eusuf, 1993).

Although investment costs of renewable energy are generally higher compared to fossil fuel alternatives, this option becomes economically viable when all externalities such as environmental cost, health hazards etc. and lower operating cost are taken into consideration (Biswas et al., 2011). The first biogas plant was introduced by a professor of Bangladesh Agricultural University (BAU) Dr. M. A. Karim in 1972 in the University campus. (Wim et al., 2005). Prakash C. G. (2005) study explained that the interest in biogas technology in Bangladesh is growing due to the increasing awareness of the importance of the renewable energy sources and their potential role in decentralized energy generation in rural areas. The rate of growth of biogas technology is expected to accelerate in future and realization of the importance of biogas in enhancing rural livelihoods. Biogas plants have not only the advantage of improved efficiency and multidimensional use, the GHG (Green House Gases) emissions will also be reduced and organic fertilizers will be available as a by-product. Energy is considered as one of the basic elements that are essential for the progress of human civilization and all development activities (Hossain, 2003). Generally, energy sources are broadly classified into two categories, conventional and fossil fuel and renewable energy. It is recognized that the conventional sources of energy such as oil, coal and natural gas would be available to mankind only for a limited time. As a country of large population and for the convenient environment Biogas might be the potential source of energy. Recently government has initiated some pilot project with the help of some foreign NGOs, but the utilization of the full potential is yet to reach (Uddin and Majumder, 2011). In recent years, the importance of biogas energy has raised manifold and has become universal. This is due to the realization that biogas capture and utilization has great potential in controlling global warming (Abbasi et al., 2011). Biomass is the most significant energy source in Bangladesh which accounts for 70% of the total final energy consumption (Biswas et al., 2011). This technology can be disseminated on a larger scale for electricity generation. The main sources of biomass fuels are: Trees (wood fuels, twigs, leaves, plant residues), Agricultural Residues (paddy husk, bran, jute stick etc.), and Livestock. There are three million potential households with adequate cattle or poultry. In Bangladesh biogas is being used mainly for cooking purpose. From 1971 to October 2009 about 41000 biogas plants has been constructed by different NGOs, under national domestic biogas and manure program of IDCOL, sustainable energy for development (SED) program of German technical cooperation (GTZ), and other government organizations (Bahauddin and Salahuddin, 2012). During the last 50 to 60 years this technology has not realized its full potential due to a number of factors. Agricultural residues, animal dung, leaves and twigs, and trees, etc. are the main sources of biomass fuels. There are indications that consumption of biomass energy already exceeded the regenerative limit and there prevails energy crisis in rural areas in Bangladesh (Islam and Rahman, 2006). The gas being used has an impact on the national economy through fertilizer manufacture, electricity generation and direct energy use in some industries; it will not be economically feasible to supply the gas to the rural areas through pipelines in reverie Bangladesh (Mamun et al., 2009).

The villagers used crop field as the major source of fuel and biomass. The sources of biomass in the study areas come from different field crop residues, which are cereals such as *Aus, Aman, Boro* of wheat, pulses, jute, oil seeds and from different vegetable crops. Most of the villagers meet up their biomass fuel from the crop residues like as straw, husk, etc. followed by dry cow dung, leaves and twigs, kitchen by product, etc. As there is no facility of gas, most of the farmers depend on natural sources of biomass. For lack of community forests the farmers collect fuel wood from the homestead forestry. The other sources of biogas production materials are animal excreta, human wastes, kitchen by product etc. An economic analysis of a biogas plant with a daily gas production of 100 cft was undertaken to assess the benefits to society of the use of biogas plants (Chowdhury et al., 2012). The climate of Bangladesh is favorable for biogas production. More over raw material for biogas digester is available and it is cheap in Bangladesh. Cow dung and poultry liter are the

common raw material for biogas digester in Bangladesh. Poultry sector alone can generate about 490-GWH electricity per year, which is nearly 2% of total electricity generation of the country in 2008-2009 fiscal years. Up to 2009 total installed biogas plants are 34,484. The possibilities of expanding the use of renewable energy to provide electricity and other energy services in Bangladesh are given greater relevance by the fact that less than 30% of all households are connected to grid electricity (Alam and Eusuf, 2003). The usage pattern of cattle dung in the country shows: fuel 34%, manure 46%, building materials 5%, and waste 15%. The portions used as fuel and fertilizer (in total 80%) may be made available for biogas production (Eusuf, 1993).

Research methods

1. Research Methodology

Data are collected by HHs level survey at Satkhira district, Bangladesh. The author selects four villages named: Parulia, Tala, Modonpur, Jamira villages to conduct the study. The author selects 50 households from every village to obtain 200 households for this research work. The author uses systematic sampling procedure to conduct this study. The author considers dependent variables as biogas using per day (In Liter) based on set of dependent variables. To ensure this research objective, the author build a sustainable Knowledge Index (SKI) following scoring Index with a set of independent variables. This index counts from 1 to 5 with qualitative method based on primary data and FGD. The author used systematic sampling method to collect this household database. Moreover, the four teams collect data independently in four villages using questionnaire method and observation method. The research team collect data from door to door survey. We have selected small-scale biogas plants in the study area for our study purpose. There are three types of small-size biogas plants that are operated in Bangladesh that are 2.4 m^3, 3.2 m^3, and 4.8 m^3 capacity plants.

1.1 Cost Benefit Ratio of Biogas Using

According to the Rana et al. (2021), the author focuses cost-benefit ratio to measure actual profit of using biogas in household perspective.

$$BCR = \frac{\sum_{t=1}^{t=T} \frac{(Benefit)t}{(1+r)t}}{\sum_{t=1}^{t=T} \frac{(Cost)t}{(1+r)t}}$$

The author uses cost-benefit ratio to measure the actual profit level for household level. The author collects data based on household survey setting specific indicators for the biogas using level.

1.2. Multiple Regression Model

The author uses multiple regression model based on some independent variables and one dependent variable. The author considers one dependent variable and 16 independent variables to measure the actual impact on model.

$$BP = \beta 0 + \beta 1\, HI + \beta 2\, HE + \beta 3\, HA + \beta 4\, FM + \beta 5\, HG + \beta 6\, HH + \beta 7\, BR + \beta 8\, CN + \beta 9\, SE + \beta 10\, DB + \beta 11\, TF + \beta 12\, MC + \beta 13\, AR + \beta 14\, HE + \beta 15\, NP + \beta 16\, SKI + u$$

Table 1. Estimation of Sustainability Knowledge Index (SKI)

Indicators	Scoring Index	Required Score
Knowledge about Greenhouse Effect	1 to 5	Very Low=1, Low=2, Moderate = 3, Good=4, Very Good=5
Knowledge about Environmental Pollution	1 to 5	
Awareness about Public Health	1 to 5	

Indicators	Scoring Index	Required Score
Responsible Knowledge of Production and Consumption	1 to 5	(Minimum Score=6 and Maximum Score =30)
Knowledge about Environmental-friendly Biogas Plant	1 to 5	
Knowledge about Wastage Management	1 to 5	

Source: Authors Own compilation (2024)

Table 2. Estimation of Variables with Expected Sign for Biogas Using

S.N	Variables Name	Variable Sign	Measurement Scale	Expected Sign	Literature References
1.	Household Income	*HI*	In BDT (Monthly)	+	Torries (1998)
2.	Household Head Education	*HE*	Years of Schooling	+	Tigner (2006)
3.	Household Head Age	*HA*	In Numbers	+ or -	Barnes and Toman (2006)
4.	Family Members	*FM*	In Numbers	+	Singh and Sooch (2004)
5.	Household Head Gender	*HG*	Male =1, Female = 0	+ or -	Mohammed et al. (2017)
6.	Household Head Occupation	*HH*	If Farmer=1, Others =0	+ or -	Acharya et al. (2005)
7.	Biogas Reserved Area	*BR*	Cubic Meter	+	(Gofran, 2012
8.	Cattle Numbers	*CN*	In Numbers	+	(Amjid et al., 2011)
9.	Solar Energy Availability	*SE*	If Yes=1, Others=0	-	Belli et al. (2001)
10.	Domestic Birds Numbers	*DB*	In Numbers	+	Mohammed et al. (2017)
11.	Training Facility on Biogas Using	*TF*	If Yes=1, Others=0	+	(Drury, 2008)
12.	Media Connectivity	*MC*	If Yes=1, Others=0	+	(Drury, 2008)
13.	Agricultural Residues	*AR*	In Kilograms (KG)	+	(Tigner, 2006)
14.	Home Electric Equipment's	*HE*	In Numbers	+ or -	Kanagawa and Nakata (2007)
15.	NGOs Participation	*NP*	If Yes=1, Others=0	+	Mohammed et al. (2017)
16.	Sustainability Knowledge Index	*SKI*	Index Score	+	Author Own Compilation
Dependent Variable: Biogas Raw-materials Collection (BRM) (In KG)					

Source: Author Own Compilation based on Field Survey (2024)

Result

The author considers two parts to measure the influencing factors to produce biogas in daily basis, moreover, the author analyzed cost-benefit ratio to measure the actual scenario of biogas using and its effect of consumer behavior.

1. Multiple Regression Result Analysis

The author applies multiple regression model, where the biogas production capacity depends on the biogas raw-materials collection in daily basis.

Table 3. Multiple Regression Model to measure the impact of Independent variables on BRC

Variables Name	Variable Sign	Coefficient Value	t Value
Household Income	HI	0.0054***	5.78
Household Head Education	HE	3.439**	2.08
Household Head Age	HA	0.7523	0.782
Family Members	FM	7.0245	1.452
Household Head Gender	HG	-12.753	-0.25
Household Head Occupation	HH	2.45	1.23
Biogas Reserved Area	BR	10.453**	2.20
Cattle Numbers	CN	9.7534*	1.79
Solar Energy Availability	SE	-0.7536	-0.89
Domestic Birds Numbers	DB	0.04536*	1.74
sTraining Facility on Biogas Using	TF	0.4537	0.45
Media Connectivity	MC	-2.456	-0.89
Agricultural Residues	AR	56.987*	1.87
Home Electric Equipment's	HE	-12.457	-0.56
NGOs Participation	NP	-9.453	-0.00
Sustainability Knowledge Index	SKI	12.789***	3.56
Constant	-14.45	-9.45	-1.05
Observations			182
R^2			0.584
Adjusted R^2			0.562
*Significance Level: *p<0.1; **p<0.05; ***p<0.01*			
Dependent Variable: Biogas Raw-materials Collection (BRC) (In KG)			

Source: Author Own Compilation based on Field Survey (2024)

1.2 Cost-benefit of Biogas Plant

The author considers cost-benefit ratio of biogas plant setup for household level. This research has been conducted on 200 households, where actual profit ration can be calculated from basic costing and profit measurement.

Table 4. Estimation of Yearly Costs for Small Scale Biogas Plants

Name of the mechanisms	Biogas Plant Capacity Level			
	Small (2.4 m^3)	Medium (3.2 m^3)	Large (4.8 m^3)	Average
Cow dung Collection (kg/day)	59	85	115	86.33
Cow dung cost (USD/year)	32.45	52.55	72.08	52.36
Labor cost (USD/year)	75.45	82.42	152.5	103.45
Preservation cost excluding labor cost (USD/year)	11.62	15.10	17.05	14.59
Various cost excluding labor cost (USD/year)	14.50	12.50	20.00	15.66
Total cost (USD/year)	134.02	162.57	261.63	186.07

Source: Field Survey, (2024) (According to May, 2024: 1 US$= 110 BDT)

Table 5. Estimation of Yearly Benefits for Small Scale Biogas Plants

Name of the mechanisms (US$ / Yearly)	Biogas Plant Capacity Level			
	Small (2.4 m^3)	Medium (3.2 m^3)	Large (4.8 m^3)	Average
Firewood	127.52	135.57	220.57	161.22
Agricultural Residues	35.35	7.75	3.55	15.55
Dry Manure Cake	10.14	8.56	5.45	8.05
Reduced cost of chemical fertilizer	25.69	20.54	55.49	33.90
Slurry	60.45	140.49	121.45	107.46
Total benefit (USD/year)	259.15	312.91	406.51	326.19
Profit	125.13	150.34	144.88	140.11

Source: Field Survey (2024 (According to May, 2024: 1 US$= 110 BDT))

From the section, the author tries to find out the socio-economic characteristics of household on biogas raw materials collection, which is acting as proxy variable for biogas production, and use in this research in (Figure 1).

Figure. Biogas Use for Cooking

Discussion

1. Multiple Regression Result

From the Table 3, the author considers 16 independent variables to measure the impact of these on dependent variable (BRC), considering as proxy variable of biogas production. Household income has positive connection with BRC, If the household monthly income increases by 1000 BDT, biogas raw materials will be collected 5.4 Kg more, it is statistically significant at 1 percent level. Household education qualification has positive connection with BRC, because if the household is more educated, he or she will be more serious to collect more biogas materials to save energy cost. If the household head gets 1 year of more education, BRC will be increased 3.4 kg more. It is statistically 5 percent level of significance. Biogas reserved area has positive and significant connection with BRC, because raw materials collection and storage are highly dependent on total reserved area of plant. If the plant size been increased by 1 cubic meter, biogas materials will be collected 10.45 kg more. It is 5 percent level of significance. Domestic bird has positive connection with BRC, if the domestic birds increased by 100, it will lead to collect biogas by 4.5 kg. Agricultural residue has positive and significant connection with BRC, when the household head and his family members collect more agricultural residue, it will help to increase biogas production with significant relationship. Moreover, SKI has positive and significant relationship with BRC, when the sustainability knowledge index has been increased, it will lead BRC by 12.78 kg, it is statistically significant at 1 percent level. The value R^2 is 0.582 that means independent variables has explained dependent variable (BRC) as 58 percent in this regression model.

From the Table 4 and 5, it is analyzed that, the actual yearly profit of is differed for plant size. In small plant, the yearly profit is 125.13 US$ (About 13,765 BDT) for small, yearly profit is 150.34 US$ (About 16,538 BDT) for medium, and yearly profit is 144.88 US$ (About 15,937 BDT) for large. On an average, they commonly save US$140.11 (About 15, 412 BDT) annually. The biogas using is not growing at maximum level due to dissatisfaction of bad smell and other factors. However, this can be traced as sustainable energy in future.

2. SWOT Analysis of Biogas *Uses*

The strengths of biogas are manifold. Biogas by itself can positively affect the economy of rural areas. The strengths of biogas uses are given below:

2.1 Strength of Biogas Uses

a. Biogas change is carried out in a machine called the polythene biogas digester. Cow dung slurry is put into the machine. The product is organic fertilizer of high quality. The fertilizer obtained is rich in Nitrogen. It has been analyzed, that, fertilizer made by the polythene biogas digester contains Nitrogen content 3 times more than the product made by conventional processes. It is completely natural.

b. Smaller biogas production units can support lighting and cooking requirements. Biogas is fully capable of replacing other rural energy sources like wood, hard coal, kerosene, plant residues, and propane.

c. From field survey, it is seen that women engaged in day-to-day household work. Installing a biogas plant is considered as a helping hand. It relieves her of the tiring and tedious job of collecting firewood. Since, biogas burns cleanly, the rural homes are free from smoke. Cooking is also easier with a gas stove and takes less time.

d. Biogas plants lower the incidence of respiratory diseases. Diseases like asthma, lung problems, and eye infections have considerably decreased in the same area when compared to the pre-biogas plant times.

2.2 Weakness of Biogas Uses

a. Sometimes biogas plant's construction system is very poor in quality. Because the

ignorance of respondents and proper authority.

b. It is a common problem of every user that in cooking time gas supply is suddenly closed.

c. Biogas is not well renowned still now. So that the local offices, which are related to biogas, many of, times workers are not active. For that reason, users have encountered technical problems for a long time.

d. In some cases it is seen that users have no access to get maintenance services for their own ignorance that is occurred by social restrictions.

Conclusions

Biogas has great economic impact and the biogas plants set up feasible in this selected area. It is seen that main component of biogas that is cow dung and poultry waste is available in this region. Moreover, livestock is available in the most of families. The income of the respondent of the surveyed area is good enough to set up a biogas plant and biogas is considered as a cost saving way for cooking purpose. Although it is easy to get equipment for biogas production, there are few local NGOs which are working for setting biogas plants in this region. So biogas can be a good alternative of traditional fuel. To set up a biogas plant it is needed to search for household support. Most of the households in the surveyed area have positive perception about biogas. After the analysis it can be concluded that biogas technology is spreading in the surveyed area day by day for its advantages. By using biogas people are benefited economically, socially and environmentally. It generates employment and self-employment for trained local people in providing post-plant implementation services to owners. Biogas digested manure saves money for the farmer otherwise spent for the purchase of costly inorganic fertilizers. Author tries to find out the economic impact of biogas use in the study area only. Environmental issue is greatly involved in biogas. This matter is skipped from this study for some limitations. It can be a great option for further research.

Acknowledgment

I would like to thank all honorable reviewers who help to improve the quality of this paper. Especially, I would like to thank my dear friend **Tanbir Hossain,** Senior Lecturer, Head, Department of Economics, North Western University, Bangladesh and **Shakil Ahmed**, Assistant Professor, Department of Development Studies, North Western University, Bangladesh to act as my paper-reviewers. I also give cordial thanks to **Sazia Ahmed**, Assistant Professor, Economics Discipline, Khulna University (Ph.D. Student, University of Waikato, New Zealand) who helped me a lot to conduct this research.

Use of AI tools declaration

The author declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflicts of interest

The author declares no conflicts of interest.

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