Economics of Biogas Plant Uses and Its Impact on Rural Livelihood in a Selected Area of Bangladesh

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Abstract: ***Biogas is a reliable, easily available and economically feasible source of alternative and renewable energy which can be managed by locally available sources and simple technology in the rural villages of Bangladesh. The study was undertaken to assess the socio-economic characteristics of sample households, investigate the impact of biogas plant on livelihoods, and determine the NPV, BCR, IRR and NBI of biogas plant in Bangladesh. To achieve the objectives multi-stage cluster sampling technique was used to collect data from 50 respondents who were using biogas plant in Mymensingh district of Bangladesh. Survey method was followed to collect data from the respondents. To identify the socio-economic characteristics, simple statistical techniques were employed. To examine the impact of biogas plant on livelihoods, livelihood approach was used and financial analytical techniques were used to assess NPV, BCR, IRR and NBI. Socio-economic characteristics showed that 54% of the respondents were belonged to middle-aged group (30-50 years) and 24% respondents' occupation were business. About 36% of the respondents had the education up to higher secondary and an average family size of the respondents was 3.78. On an average about 8% of the respondents had middle income (Tk.100001-150000), about 92% had high (Tk.>150000) income level. Education, health, nutrition, capacity to work, skill and knowledge increased in 66%, 78%, 70%, 64%, 58% and network and connection, mutual support, common rules, women empowerment and leadership increased in 62%, 64%, 62%, 60%, 54%, respectively after using the biogas plant. The study represents NPV, BCR, IRR and NBI were TK.20247.64, 1.50, 19.26% and Tk. 2632.19, respectively. The results indicate that the future prospect of biogas plant is positive . Finally, it may be conclude that biogas plant has a great potentiality in Bangladesh context as there are a lot of waste materials and it will reduce the energy crisis of our country. It was very suitable for rural people and had positive impact on livelihoods.***

Keywords: Biogas plant, Impact, Rural livelihood, Financial viability, Bangladesh

1. Introduction

Bangladesh is deficient in of energy supply especially natural gas supply. Scientists around the world have already indicated that natural reserve of gas is decreasing day by day and the time is not too far when we will have not sufficient natural gas resource [1]. To solve this energy crisis we can use different form of renewable energy to generate power like biogas plant. Bangladesh is an agro-based country thus produces huge amount of waste materials. Converting these waste materials into energy through biogas plant is economically advantageous as well as helpful to solve the issue of power crisis. There is a bright future for biogas plant in the city corporation area, Metro areas, rural areas, where thousand ton of wastage is wasting everyday which is polluting our environment. If those wastage can utilize properly then we can get power as well as we can save our environment from pollution [2]. It is an environment friendly technology and many countries now-a-days are producing electricity from biogas. It will help the people of Bangladesh meet their demand of electricity. The government and the companies related to this technology can earn money which is also beneficial.

Waste is a resource by its nature of use, it may vary on the basis of location or on ownership's decision; so there is nothing waste if its transform into usable ones. The waste particularly produced in livestock farms may be converted into biogas as a source of environment friendly renewable energy. Access to energy is crucial for the development of any country [3].

Biogas is produced by methanogenic bacteria while acting upon the biodegradable materials in an anaerobic condition [4]. It is composed of 50 to 70% methane (CH_4), 30 to 40% carbon dioxide (CO_2), and some trace gasses like Hydrogen, Nitrogen, Hydrogen Sulphide [5]. As biogas has 70% methane, it could be used as a source of energy. Energy content of biogas can also be transformed into various other forms such as mechanical energy (for running machines) and heat energy (for cooking and lighting) through combustion. Furthermore, the slurry produced in the process of biogas production also used in agriculture as bio-fertilizer to increase crop production and to decrease fertilizer cost. Biogas can contribute to the reduction of greenhouse gas emissions by substituting fossil energy sources. As a result, production of biogas has got tremendous attention for mitigation harmful effects of carbon on environment. Despite its multiple benefits for the empowerment of rural households, there is dearth of studies which assess the plant owners' opinion about the impact of biogas on health and environment in Bangladesh. The main purpose of this study was to provide some empirical information about biogas plant owners' views on the effects of biogas plant on livelihood and its future prospect.

The economy of biogas plant is characterized by notable investment cost, couple of operation and maintenance costs mostly practice free raw materials (animal dung, poultry litter, aquatic weeds, industrial wastage, terrestrial plants, sewage sludge, etc.) and finally income generate from the forming of the gas. Other external values would be added: produce bio-fertilizer, reduce CO_2 emission, diminish health cost, and decrease time for cooking and collecting the biogas fuel. The installation cost of a typical biogas plant is site specific (it depends on the topography of the area, labor cost at the site location, community participation, learning curve, and use of the biogas product). As well, the economic performance of a biogas system is likely to be site specific since it depends on the current market price of inputs and output, the natural agriculture practices and the system of organization adopted by the community involved [6]. The future cost of biogas energy will not only depend on factors such as the extend of technological advances in the biogas energy conversion and feedstock productivity but also on the good understanding of the relation between capital costs and plant size [7].

Biogas energy production and use has been illustrated to have the potential to reduce wood fuel consumption, militate against climate change and reduce indoor air pollution [8]. The biomass cow dung has often been applied as raw material into biogas digesters to produce the biogas, which results in not only gas and bio-fertilizer production but also provides other social, economic and environmental benefits including improvement in health of women and children, soil fertility, reduced CO_2 emission, income generation, reduced deforestation, better sanitation, reduced water and air pollution and reduction of imported fuels [9,10].

Earlier renewable energy (green energy) treated as technological infeasible or even economically not viable. Nevertheless, investment cost of renewable energies such as biogas plant is generally higher compared to fossil fuels, but viewed over time, the use of renewable energy becomes economically viable when all externalities (environmental cost, health hazards, employment generation, etc.) and lower operating cost are taken into account [11].

Economic growth and development are necessary to reduce poverty and human deprivation in the developing countries. Renewable energy sources are playing a very important role in the developed as well as the developing countries. Such renewable energies offer developing countries the prospect of increasing their energy supplies in a self-reliant way at national and local levels along with the attended economic, social, and security benefits. Long term sustainable development in all countries, and particularly developing world, requires a gradual shift towards renewable sources of energy that are more equitably distributed and less environmentally destructive than fossil fuel sources [12].

In Bangladesh energy problems are more acute in the rural area and there are also many waste materials. So if we utilize these waste materials in biogas plant and produce energy, then energy problems of Bangladesh will be reduced in future. Through the production of energy the livelihoods of the rural people in Bangladesh will be improved and it will remove the energy problems of Bangladesh and our country will be developed very smoothly.

Biogas energy production and use could have sound benefits to both public health and climate change mitigation through cleaner combustion, and reduced consumption of biomass and wood. Restraining methane emissions from cattle dung represents a valuable starting point for mitigating agricultural contributions to global climate change [13].

Therefore, researcher focused on financial viability and impact of biogas plant of the users to see whether the project could have positive impact on the respondents particularly in reducing poverty. This research was mainly aimed to assess the socio-economic characteristics of households which have biogas plant, investigate the impact of biogas plant on livelihoods with financial analysis for the sustainability of the project.

2. Materials and Methods

Haluaghat upazila under Mymensingh district in Bangladesh was selected purposively because of availability of biogas plants and familiarity of the area. A total 50 biogas plant users were selected through multi-stage cluster sampling technique and data were collected through survey method using semi-structure survey schedule. Repeated visits were made for collecting primary data. To assess the socio-economic characteristics of biogas plant users, various determinants such as age, education, occupation, family size, annual incomes, land holding status, annual expenditures etc. were analyzed using descriptive statistics. To examine the impact of solar panel on livelihood of the households, DFID (2000) Sustainable Livelihoods Guidance Sheets framework was used for the analysis of households throughout several features using the household approach of identifying household assets within the vast social and economic transforming processes of community institutions and obligations, lawful framework and market structures [14] . To determine the NPV, BCR, IRR and NBI, financial techniques were applied.

2.1 Analytical Tools

The following models were used for the study.

Net Present Value (NPV):
NPV is the difference between the present value of cash inflow and present value of cash outflow. NPV study is sensitive to future cash inflow that an investment will yield [15].

$$\text{NPV}\ (r, \text{N}) = \sum_{t=0}^{N} \frac{R_t}{(1+r)^t} \qquad (1)$$

Where
t = the time of the cash flow
r = the (the that could be earned on an investment in the financial markets with similar risk); the opportunity cost of capital.
$\mathbf{R_t}$ = the net cash flow i.e. cash inflow – cash outflow, at time *t*. For educational purposes,
R_o is commonly placed to the left of the sum to emphasize its role as (minus) the investment.
N = The total number of periods

If NPV>0, that means positive, the project supposed to be accepted. However, if NPV<0 that is negative, the project should be rejected as cash flow will also be negative.

Benefit Cost Ratio (BCR):
The BCR is a relative measure, which is used to compare benefit per unit of cost. The BCR was estimated as a ratio of total cash inflow and total cash outflow [16]. The formula of Calculating BCR (undiscounted) is:

$$BCR = \frac{\sum_{t=1}^{r} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{r} \frac{C_t}{(1+r)^t}} \quad (2)$$

Where, B_t is the benefit in time t and
C_t is the cost in time t.
If BCR>1, the project is accepted and beneficial.
If BCR=1, we interpret it as indifferent
If BCR<1, the project is rejected.

Internal Rate of Return (IRR):
Internal Rate of Return is a discount rate that makes the NPV of all cash flows from a particular project equal to zero. The IRR is the annual percentage rate of return that an investment real returns over the whole life of the investment. It is expressed in percentage (%) terms [17].

$$IRR = r_a + \frac{NPV_a (r_b - r_a)}{(NPV_a - NPV_b)} \quad (3)$$

r_a = lower discount rate
r_a = higher discount rate
NPV_a = NPV using the lower discount rate
NPV_b = NPV using the higher discount rate

If IRR is greater than cost of capital, then the project is accepted, Other than rejected.

Net Benefit Increase (NBI)
Net Benefit Increase is an estimation of how much return (total revenue-total cost) comes back to investors year by year [18].

$$NBI = NPV * CRF_{t.i}$$

$$CRF_{t.i} = \frac{(1+i)^t . i}{(1+i)^t - 1} \quad (4)$$

Where,
CRF means capital returns factor
t = Expected lifetime of the biogas plant
i = Discount rate

3. Results and Discussion

3.1 Socio-economic characteristics of sample households

In this section socioeconomic characteristics of sample household were discussed. Behaviors of an individual were largely determined by his/her characteristics. Actually, biogas plant users socio-economic characteristics were influenced by their various characteristics.

3.1.1 Age

In this study, a family was considered as a group of individuals living together, taking meals together and living under one household. It included husband, wife, son, father, mother, brother, sister etc. The respondents were classified into three categories (1) below 30 years, (2) age between 30-50 years and (3) above 51 years [19]. Table 1 reveals that about 22% of the respondents were between 30-50 years in Tikuria and it was 18 % in village of Rustompur and Maijpara it was 14%, which implies that active persons were more among the surveyed family. About 8%, 6%, 6% respondents were between below to 30 years in Tikuria, Rustompur and Maijpara respectively. The percentage of respondents who were above 51 years old is 6%, 10%, 10%, in Tikuria, Rustompur and Maijpara, respectively.

Table 1: Distribution of respondents according to their age

Categories according to age	Tikuria		Rustompur		Maijpara	
	Number	Percentage	Number	Percentage	Number	Percentage
Below 30 years	4	8	3	6	3	6
30-50 years	11	22	9	18	7	14
Above 51 years	3	6	5	10	5	10
Total	18	36	17	34	15	30

Source: Field Survey, 2018

3.1.2 Educational Level of the Respondents

Educational level is crucial important because it plays a vital role for taking decision. The respondents were classified into following four categories

Table 2: Definition of education level

Category	Years of schooling
Illiterate	No schooling
Primary education	1-5 years schooling
Secondary education	6-10 years schooling
Above secondary education	Above 10 years schooling

Source: Field Survey, 2018

Table 3 reflects that there were few illiterate members among the three villages. Only 14% respondents are illiterate among three villages. The number of respondents having primary education was also higher (about 40%) in Maijpara. The table also reveals that higher number of respondents was in Tikuria having secondary level of education (about 38.89%) and higher number of respondents (23.53%) in Rustompur who had above secondary education. It can be concluded that the educational level among the biogas plant user respondents was satisfactory in these villages.

Table 3: Educational level of the respondents

Village	Illiterate		Primary education		Secondary education		Above Secondary education		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Tikuria	2	11.11	5	27.78	7	38.89	4	22.22	18	100
Rustompur	2	11.76	5	29.41	6	35.29	4	23.53	17	100
Maijpara	3	20	6	40	5	33.33	1	6.67	15	100
Total	7	14	16	32	18	36	9	18	50	100

Source: Field Survey, 2018

3.1.3 Occupational Status of Earning Members

The occupation from where family income had been come during the study period. Only family head and primary occupation is considered. It was found that the earning members of respondent's family were engaged in different types of occupation. In the study occupation was classified as Agriculture, services, shopkeepers, business, etc. In this study, occupational status of earning members was observed which are presented in Table 4.

Table 4 reveals that most of the respondents are businessmen (24%) as their occupation in three the villages. A significant number of respondents were involved in agriculture (20%) as their occupation. Both Poultry farming and livestock husbandry involved was 18%. In average 4% respondent are involved in grocery shop and 16% were involve in other work. The respondents were tried to change their dependency in agriculture and they are involve in others occupation.

Table 4: Occupational status of the earning members of the respondent's family

Village	Categories according to occupation						All
	Agriculture (No and %)	Business (No and %)	Poultry farming (No. and %)	Livestock (No and %)	Shopkeeper (No and %)	Others (No and %)	(No and %)
Tikuria	5 (27.78%)	2 (11.11%)	5 (27.78%)	4 (22.22%)	0 (0%)	2 (11.11%)	18 (100%)
Rustompur	3 (17.65%)	5 (29.41%)	2 (11.76%)	3 (17.65%)	1 (5.88%)	3 (17.65%)	17 (100%)
Maijpara	2 (13.33%)	5 (33.33%)	2 (13.33%)	2 (13.33%)	1 (6.67%)	3 (20%)	15 (100%)
Total	10 (20%)	12 (24%)	9 (18%)	9 (18%)	2 (4%)	8 (16%)	50 (100%)

Source: Field Survey, 2018

3.1.4 Family Size

Family size of the respondents ranged from 2 to 9 members. Distribution of households according to their family size is shown in Table 5. Family sizes of the respondents were classified into three categories. These are
1) Small (up to 3 members),
2) Medium (4-6 members) and
3) Large (7 and above)

It is evident from the Table 5, that the average family size in Tikuria, Rustompur and Maijpara village were about 5.30, 4.90 and 3.78, respectively. The table also reveals that most of the respondents were within medium family size in three villages and the percentages are 4.92%, 4.71%, 4.57%, in Tikuria, Rustompur and Maijpara village, respectively.

Table 5: Distribution of respondents according to their family size

Categories according to family size	Tikuria			Rustompur			Maijpara		
	No.	Total members	Average	No.	Total members	Average	No.	Total members	Average
Small family (up to 3)	2	6	3	1	3	3	1	3	3
Medium family (4-6)	13	64	4.92	14	66	4.71	14	64	4.57
Large family (7 and above)	3	24	8	2	14	7	0	0	0
Total/Average	18	94	5.30	17	83	4.90	15	67	3.78

Source: Field Survey, 2017

3.1.5 Average Annual Income of the Respondent

The Table 6 represents that there are no respondents in lower income category it reveals that after installation of biogas plant they all are being economically efficient. The average income of the respondents is 0% has low income, about 7.89 % have medium income and 92.11% have high income.

Table 6: Distribution of sample households on the basis annual average income

Village	Categories according to income (Tk.)							
	Low income (up to Tk. 100,000)		Medium income Tk.(100,001-150000)		High Income Tk. (>150,000)		Total	
	No.	%	No.	%	No.	%	No.	%
Tikuria	0	0	2	11.11	16	88.89	18	100
Rustompur	0	0	1	5.88	16	94.12	17	100
Maijpara	0	0	1	6.67	14	93.33	15	100
Total/Average	0	0	4	7.89	46	92.11	50	100

Source: Field Survey, 2018

3.2 Impact of Biogas Plant on Livelihoods

We analyzed the impact of biogas plants on rural livelihoods on the basis of assets pentagon like human, social, natural, physical and financial assets. To think of human capital as a store of capability, which can contribute to yield a flow of services. Being able to work with contemporary equipment is individual productive capabilities. But these capabilities not only depend on knowledge but also comprise useful behavioral way of life as well as level of liveliness and physical and mental health. Social capital means the stock of belief, common thoughtful, common ethics, and communally held information that facilitates the social harmonization of economic activity [20]. Natural resources including their. Physical capital has two dimension one is natural another one is produced. Produced capital is that kind of physical assets that are generated by applying human fruitful activities to natural capital, and that are used to make available of goods or services. Financial capital is what allows all these useful activities to get going, in a financial system, in progress of the returns that will stream from them.

Above all five kinds of assets were given in the Table 7. The table shows that most of the assets were positively changed after using biogas.

Table 7: Change of different type of assets

Assets	*Items*	*Degree of change*		
		Increased	Unchanged	Decreased
Human assets	Education	33 (66%)	13 (26%)	4 (8%)
	Health	39 (78%)	5 (10%)	6 (12%)
	Nutrition	35 (70%)	11 (22%)	4 (8%)
	Capacity to work	32 (64%)	14 (28%)	4 (8%)
	Skill and knowledge	29 (58%)	13 (26%)	8 (16%)
Social assets	Network and connection	31(62%)	12(24%)	7(14%)
	Mutual support	32(64%)	12(24%)	6(12%)
	Common rules	31(62%)	11(22%)	8(16%)
	Women empowerment	30(60%)	16(32%)	4(8%)
	Leadership	27(54%)	16(32%)	7(14%)
Natural assets	Land	27(54%)	23(46%)	0(0)
Physical assets	Bed	27(54%)	19(38%)	4(8%)
	Chair	39(78%)	11(22%)	0(0%)
	Table	33(66%)	15(30%)	2(4%)
	Cupboard	42(84%)	8(16%)	0(0%)
	Showcase	32(64%)	12(24%)	6(12%)
	Weeder	32(64%)	13(26%)	5(10%)
	Harvester	38(76%)	10(20%)	2(45)
Financial assets	Cash in hand	45(90%)	5(10%)	0(0%)
	Deposit in the bank	34(68%)	10(20%)	6(12%)
	Savings	29(58%)	17(34%)	4(8%)
	Poultry birds	33(66%)	14(28%)	3(6%)
	Cow	40(80%)	9(18%)	1(2%)
	Goat	25(50%)	21(42%)	4(8%)

(Figures in parentheses indicate percentages)
Source: Field Survey, 2018

3.3 Determination of the NPV, BCR ,IRR and NBI of the Biogas Plant

After quantification and valuation of the costs and benefits of the biogas plant, four economic decision criteria had used in the analysis of the economic viability including NPV, BCR, IRR and NBI [21,22,23,24]. The monetary benefit of biogas was estimated by the yearly existing cost of fuel used in the house considering inflation rate.

For determining the NPV, BCR , IRR and NBI of the biogas plant, cost of biogas plants, benefits of biogas plants and then economic viability of biogas production from biogas plant was estimated. By analyzing the data we found that an average initial investment or cash outflow for the use of biogas plant was Tk. 36900. Annual operation and maintenance (O&M) costs of solar panels were related to repairing and maintenance [25]. We also found that an average operation and maintenance cost were Tk.106.33 and it was increased on the basis of 8% inflation rate for the biogas plant life time which was an average 20 years. Quantification of the benefits of a biogas plant is a decisive step in the economic feasibility assessment of biogas plant activities. The benefits accruing from establishing and operating a biogas plant fall into two essential categories: financial and environmental. The financial benefits are the saved costs on energy substituted by biogas produced. It is vital to find an indirect technique to appraise the benefits, and the most realistic method is to place market values in term of substitute electricity for a given final use [26]. It was estimated for the data that an average cash inflow was Tk. 6031. The NPV, BCR,IRR and NBI was calculated on discount rate 12% and 20%. We used the discount rates 12% and 20% because of getting positive NPV and negative NPV value. At discount rate 12%, NPV was Tk. 20247.64 and BCR was 1.50 and at discount rate 20%, NPV was Tk. -2058.1. Using the both discounting rates (Lower discounting rate 12% and upper discounting rate 20%) we found the IRR 19.26% which was greater than opportunity cost of capital (15%, lending rate of interest) the project was economically viable. NBI was positive (NBI>0) and the value was Tk. 2632.19. So, the project was economically viable and acceptable (see appendix-1 and appendix-2).

4. Conclusion

Bangladesh is an overpopulated country where most of people are deprived of energy resources. Because of energy shortage being cramped our economic development and most of people can't receive advantages of energy. Very few people are enjoyed supply of natural gas. Biogas has become very popular supplement of natural gas due to increasing awareness. Biogas is an eco-friendly technology. Cattle dung, wastages and poultry litter pollute environment which are used in the production of biogas as raw materials. Besides the biogas household get bio slurry which are used their agricultural field and it reduces the use of chemical fertilizer and reduce the cost of chemical fertilizer. Extra bio slurry also sells to another farmer. Biogas plant set up is very easy and investment is not so large. Biogas technology might be a very good technology to reducing the energy crisis. Eventually said that biogas technology improved livelihood standard of respondent. It improved the socioeconomic status of the respondents. Biogas technology plays positive impact on livelihoods on biogas users almost. The findings of the present study indicate that if the biogas technology can be spread to the people, it must be financially viable and help to develop living standards of the people. On the basis the study some recommendation can be drawn up like; government should provide training the household member of biogas users and reduce interest rate.

5. Conflict of interest

The author declare no conflicts of interest in this paper.

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Appendix-1

Calculation of NPV at discount rate 12%

Year	Cash Outflow (Investment) Tk.	Cash Outflow (O&M) Tk.	Discount At 12%	Cash outflow (investment)	Discounted Outflow (O&M) Tk.	Total Present Outflow Tk.	Total Cash Inflow Tk.	Discounted Inflow Tk.
0	36900	0	1	36900	0		0	0
1		106.33	.892		94.85		6031	5379.65
2		110.58	.797		88.13		6272.24	4998.97
3		115.00	.711		81.77		6523.13	4637.94
4		119.60	.635		75.95		6784.06	4307.87
5		124.38	.567		70.52		7055.42	4000.42
6		129.36	.506		65.46	37925.57	7337.63	3712.84
7		134.53	.452		60.80		7631.14	3449.28
8		139.91	.403		56.38		7936.39	3198.36
9		145.51	.360		52.38		8253.85	2971.38
10		151.33	.321		48.58		8584.00	2755.46
11		157.38	.287		45.17		8927.36	2562.15
12		163.68	.256		41.90		9284.45	2376.82

13		170.23	.229		38.98		9655.83	2211.18
14		177.04	.204		36.12		10042.06	2048.58
15		184.12	.182		33.51		10443.74	1900.76
16		191.48	.163		31.21		10861.48	1770.42
17		199.14	.145		28.88		11295.94	1637.91
18		207.11	.130		26.92		11747.78	1527.21
19		215.39	.116		24.99		12217.69	1417.25
20		224.00	.103		23.07		12706.39	1308.76
			Total	36900	1025.57			58173.21

Source: Field Survey, 2018

NPV=Discounted cash inflow-Total cash outflow
=58173.21-37925.57
=20247.64

Since, NPV was positive (NPV>0) and the value was Tk. 20247.64, the project was economically viable.

Here present cash inflow is greater than present cash outflow for this NPV is positive that is why biogas plant is economically viable for user. It has low maintenance cost high feedback.

BCR=Discounted cash inflow/Total cash outflow
=58173.21/37925.57
=1.5
Here BCR is greater than 1 for the cause of greater cash inflow that is why biogas plant is economically beneficial.

CRF= $(1+i)^{\wedge t}$ x $i/(1+i)^{\wedge t}-1$
= $(1+.12)^{\wedge 20}$ x $.12/(1+.12)^{\wedge 20}-1$
=1.16/8.65
=0.13
NBI=NPV X CRF
=20247.64 X .13
=2632.19

Since, NBI was positive (NBI>0) and the value was Tk. 2632.19, it can be understand that biogas is economically viable.

Appendix-2

Calculation of NPV at discount rate 20%

Year	Cash Outflow (Investment) Tk.	Cash Outflow (O&M) Tk.	Discount At 12%	Cash outflow (investment)	Discounted Outflow (O&M) Tk.	Total Present Outflow Tk.	Total Cash Inflow Tk.	Discounted Inflow Tk.
0	36900	0	1	36900	0		0	0
1		106.33	.833		88.57		6031	5023.82
2		110.58	.694		76.74		6272.24	4352.93
3		115.00	.578		66.47		6523.13	3770.36
4		119.60	.482		57.65		6784.06	3269.91
5		124.38	.401		49.88		7055.42	2829.22
6		129.36	.334		43.21		7337.63	2450.76
7		134.53	.279		37.53		7631.14	2129.08
8		139.91	.232		32.46		7936.39	1841.24
9		145.51	.193		28.08	37525.23	8253.85	1592.99
10		151.33	.161		24.36		8584.00	1382.02
11		157.38	.134		21.09		8927.36	1196.26
12		163.68	.112		18.33		9284.45	1039.85
13		170.23	.093		15.83		9655.83	897.99
14		177.04	.077		13.63		10042.06	773.24
15		184.12	.065		11.97		10443.74	678.84
16		191.48	.054		10.34		10861.48	586.52
17		199.14	.045		8.96		11295.94	508.32
18		207.11	.037		7.66		11747.78	434.67
19		215.39	.031		6.68		12217.69	378.75
20		224.00	.026		5.82		12706.39	330.36
					625.23			35467.13

Source: Field Survey, 2018

NPV=Discounted inflow-Total present outflow

=35467.13-37525.23
= -2058.1 Tk.
Since, NPV was negative (NPV<0) and the value was Tk. -2058.1, biogas installation was economically not viable.

BCR=Discounted cash inflow/Total cash outflow
=35467.13/37525.23
=0.94
Since the BCR is lower than 1, the project was economically not viable.

IRR=LDR+ (NPV at lower discount rate/difference between two discount) x (HDR-LDR)
=12+ (20247.64/22305.74)x8
=19.26
Since the IRR for twelve years at 20% discount rate was 19.26 % which was greater than interest rate on lending which was 12%, it can be shown that biogas plant installation is economically viable and acceptable.

CRF = $(1+i)^{\wedge 20}$ xi/$(1+i)^{\wedge t}$-1
= $(1+.2)^{\wedge 20}$ x .2/$(1+.2)^{\wedge 20}$ -1
=7.66/37.34
=0.205

NBI= NPV X CRF
= (-2058.1) X0 .205
= -421.91
Since, NBI was negative (NBI<0) and the value was Tk. -421.91, biogas installation was not economically viable.