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APPRAISAL OF DOMESTIC BIOGAS PLANTS IN BANGLADESH

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Abstract

The main concern of paper is to appraise the cost and benefits of biogas plants in Bangladesh. Biogas activities in Bangladesh have been expanding to meet the needs of alternative energy sources and reduce of the country dependence on biomass energy. Biogas is viewed an innovative and most promising option toward a partial mitigation of the existing energy problems in Bangladesh. This study examined the cost-capacity relationships of biogas plant use while considering the financial and economic feasibility with several decision making tools. Data were collected from 150 small scale biogas plants from four districts of Bangladesh. Often three sizes of biogas plants- small (2.4 m^3), medium (3.2 m^3) and large (4.8 m^3) were found in the sample areas. Financial and economic analyses were done based on the decision making tools of Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PBP), and Net Benefit Increase (NBI). Four scenarios (with subsidy, without subsidy, health benefit, and income generate from time savings) and one scenario (carbon trading) were accounted under financial and economic evaluations, respectively and stated that biogas plants can be installed as profitable business in the potential areas of Bangladesh. The results highlighted that the investment cost would have a burden of biogas users while subsidy and credit were played a vital role to adopt the decision on biogas plant adoption. Considering five sensitive cases the investment cost also acutely inspired to implement the biogas project across the country. Finally, it may conclude that Bangladesh having a great potentiality to adopt more biogas plants, especially in the livestock prone areas for mitigating the existing environmental degradation, biomass difficulties and generating the income with good health.

I. INTRODUCTION

Bangladesh is a developing country facing important energy supply difficulties despite its inherit obtained green nature and plentiful renewable energy items. Inherited green resources nowadays have not been able to serve the drudgery in

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Bangladesh. As well, the shortage of green resources has led to economic, social, and environmental problems as economic success and quality of livelihoods of a country are, to some extent, determined by the per capita energy consumption.
Despite her huge population, Bangladesh is one of the less energy consuming countries with 257 KwH per capita (Bangladesh Economic Review, 2012). The supply of energy is enormously below the required demand level. The conventional fossil fuels are need to explore more due to its' depleting soon as well as urgent to explore alternative sources of energies which have a power to mitigate the existing crisis of energy while being convenient to environment. More than 70% of the total population inhabit in rural areas in Bangladesh while more than 90% rural people are dependent on biomass fuel. The regeneration limit of biomass fuels have been already beyond the population growth in Bangladesh (Goffar, 2006). Amide this situation, non sustainable use of fossil and biomass fuels have lead to increase awareness and widespread research into the accessibility of new renewable energy sources (Amigun, 2007) where domestic biogas could be an alternative source of traditional cooking system.

The biogas consists of Methane (CH4) by 60-70% and Carbon dioxide (CO2) by 30-40% with hydrozen sulphide and other trace gases (Singh and Sooch, 2004), which produced by anaerobic digestion of domestic and farm wastages like cowdung, poultry liter, are available in the livestock-prone areas of Bangladesh. Usually, cattle dung is predominantly used either directly by preparing dry cake for burning or by composting into the agricultural field. Both practices of cattle dung use are uneconomic and unhygienic. But the application of cow dung into an anaerobic digestion form provides a valuable gas as well as gives a good lesson to advocate for better livelihoods in the rural areas, like health benefit, income generation from surplus time, foreign currency earnings from carbon trading etc (Von EiJi, 2012; Walekhwa et al. 2009).

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 CO2 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 (Taleghani and Kia, 2005). 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(Singh et al. 1998).

In assessing the economic viability of biogas program, one should distinguish four major areas of applications: individual household units, plant areas, sufficient number of animals and biogas use. In each of these cases, the financial feasibility of the facility depends largely on whether the outputs in form of gas and slurry can substitute for costly fuels, fertilizer or feed that were previously purchased while, at the same time, abating pollution (Amigun et al. 2007).

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 (Bahauddin and Salahuddin, 2012).

So, "Green" energy is nowadays an issue of urgent and growing interest for sustainable energy and agricultural production as well as prompting good governance, power utility companies and private entrepreneurs to more attentively evaluate technology with indeed practical life (Rowlands et al. 2000).

Given the high investment cost, incentives and loans are available to support the households' commitment in biogas plants use in Bangladesh. Incentives or loan do not guarantee the economic viability of biogas activities and it sustainability as there is no study with the focus on the economic evaluation of domestic biogas plants in Bangladesh. There is no prognosis regarding how well biogas activities would be profitable under future conditions such as changes in the credit interest rates or incentives. A good understanding of the economic viability of biogas activities and its sensitivity to possible future changes could be very useful and informative for energy policy in Bangladesh. In this backdrop, the major objective of this study is to appraise the cost and benefits of domestic biogas plants in Bangladesh.

II. METHODOLOGY

The study was conducted by a survey method on respondents from June to September 2011 in six sub-districts (Mymensingh sadar, Fulpur, Chatmohor, Atghoria, Thakurgaon sadar, and Bochaganj) covering four selected districts (Mymensingh, Pabna, Thakurgaon and Dinajpur) in Bangladesh. Primary data were collected from 150 respondent households. Stratified random sampling technique was use to select the respondents since the number of biogas users in comparison to the total number of households was pretty smaller in the study zone. From the sample of households data related to direct cost and revenue, indirect benefits were collected. The data collection was carried out through semi-structured one-to-one interview based on a pre-tested questionnaire. In addition to the primary data collection, secondary data were collected from several journals, books, NGOs and Government offices in Bangladesh.

Financial and economic appraisal of different domestic biogas plants based on decision making tools including NPV, IRR, PBP and NBI, and sensitivity analyses also were conducted with considering few sensitive items.

Cost estimation of domestic biogas plant

The land occupied by the biogas plant was not accounted in the investment cost because the small pieces of land usually allocated to biogas plant installation are normally found unused for economic activities. Previous studies on economic evaluation of biogas systems in developing countries (Yiridoe et al. 2009; Adeoti et al. 2000; Sinha and Kandpal 1990; Biswas and Lucas 1996; Caputo et al. 2005) have also excluded the cost of land in their capital cost analysis because the plants are often sited on the households' land.

The tasks of collection, stirring and feeding the substrates into the biogas digester were largely performed by household's members to whom the biogas technology belonged. Family size biogas plant is sited within the homestead that is usually near to the cattle shed. Thus, the cost of family labor for this purpose was omitted in the present analysis because of least amount of labor is required for biogas energy production.

The cost of fresh dung input for the family-sized biogas plants, especially where cow dung is bought, was considered to be the main operational cost. Since the dung was assumed to be readily available to the households in the study areas, an average price derived from the survey results as maximum price the household was willing to pay for the cow dung was used to estimate the cost of fresh dung.

Annual operation and maintenance (O&M) costs of biogas plants were related to repairing, maintenance and replacement (Kandpa et al. 1991). It was not found any life cycle completed biogas plant in the study areas. Thus, depreciation cost was assumed by 4% of the total capital cost of the plant which is similar assumption of Singh and Sooch (2004).

Benefit estimation of domestic biogas plants

Quantification of the benefits of a biogas system is a crucial step in the economic viability evaluation of biogas activities. The benefits accruing from establishing and running a biogas digester fall into two basic categories: monetary and environmental. The monetary benefits are the saved costs on fuel substituted by biogas and on fertilizer costs substituted by digester slurry (Purohit and Kandpal, 2007; Biswas and Lucas, 1996).
It is essential to find an indirect method to evaluate the benefits, and the most logical method is to place market values in term of alternative fuels for a given end use (Singh and Sooch, 2004; Kandpal et al, 1991; Rubab and Kandpal, 1995). Thus, there is no universal method of evaluation of benefits from biogas uses (Islam and Islam, 2005) In this study, the total benefits from slurry used accounted by money saved per year by reduce application of biomass practices and chemical fertilizer were used for calculation.

Economic viability of biogas energy production from domestic biogas plants

After quantification and valuation of the costs and benefits of the biogas technology, four economic decision criteria have used in the analysis of the economic viability including NPV, IRR, PBP and NBI (Torries, 1998; Brigham and Ehrhardt, 2001; Groppelli and Nikbakht, 2006, Richard et al. 2006).

$$NPV=\sum_{t=1}^{T}\frac{TAB_b - AOT_c}{(1+i)^t} - C \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(1)$$

Where, the annual benefits, TAB_b, and annual operating costs, AOT_c, are uniform over lifetime, t, of the biogas plant, the expression for TAB_b and

$AOT_{c,}$ C is investment cost, t is the expected life time of the digester, i is the discount rate

$$IRR = \sum_{t=0}^{n} (TAB_b - C)(1+i)^{-t} = 0 \quad \text{...(2)}$$

$$PBP=TI/NR \quad \text{..(3)}$$

Where, TI= Amount of total investment, NR= Annual net revenue (profit) which is annual gross income less annual operational cost.

This NBI can be estimated as:

$$NBI = NPV * CRF_{t,i} \quad \text{...(4)}$$

$$CRF_{t,i} = \frac{(1+i)^t . i}{(1+i)^t - 1} \quad \text{...(5)}$$

Where CRF means capital returns factor, t is the expected life time of the digester and i is the discount rate and NPV presents net present value. The expected value of NBI is positive means the project is preferable for continuing the business for the future.

Summarize all assumptions of cost and benefit of a biogas plant

The following assumptions are often adopted from previous empirical studies (Singh et al, 1998; Purohit and Kandpal, 2007; Walekhwa et al. 2009; Yiridoe et al. 2009; Von EiJi, 2012). Yet, above implicit explanation was summarized:

- In General:

  a) Three sizes of biogas plant have been observed: 2.4 cubic meter, 3.2 cubic meters and 4.8 cubic meters.

  b) The price of land occupied by biogas plant was not account to the cost items.

  c) Households have accessed to credit and subsidy facilities.

  d) NGos are strict to repayment of 25% of total investment as down payment and remain money paid by 24 monthly installments with 8% flat rate interest.

e) Four decision making tools included NPV, IRR, PBP and NBI have been applied for examine the future nature of biogas technology in Bangladesh.

f) Four scenarios under financial evaluation and one scenario under economic evaluation, in total five scenarios of cost-benefit of biogas plant have been observed through decision making tools.

- **Annual O&M costs of biogas plant**

a) Labor cost is not considered for estimation of total cost of biogas plant.

b) Cowdung cost is assumed by 0.18 BDT per kilogram followed by Singh and Sooch (2004).

c) Depreciation cost is assumed by 4% of the total investment cost followed by Singh and Sooch (2004).

- **Annual benefits of biogas**

a) The monetary benefit of gas is estimated by the difference of previous and existing cost of biomass items due to unavailability of measurable indicator.

b) The monetary benefit of slurry is calculated by difference of previous and existing cost of chemical fertilizers plus cost of slurry.

- **Decision making tools**

a) Four decision making tools: NPR, IRR, PBP and NBI are assumed for apprise for long term business of biogas technology in Bangladesh.

b) Discount factor, interest rate, duration of a plant are assumed 12%, 8% for two years and 15 years, respectively.

Scenario analysis

Financial and economic analyses were undertaken to estimate the different scenarios of domestic biogas activities in Bangladesh under certain future changing conditions. Financial analysis explains the costs and benefits for biogas plants for individual perspective while economic analysis accounts for costs and benefits for society, nations' as well as global interest. Financial analysis considers only the direct many cost items like investment costs, monitoring costs, and depreciation costs and direct benefits from biogas plants. Besides, economic analysis considers external costs and benefits receiving for adopting the biogas plants.

Financial estimation of biogas plant covers four scenarios including with subsidy, without subsidy, health facility issue, and income generating issue from surplus time. Economic analysis considered only carbon trading issue for economical estimation.

Many uncertainties and assumptions were activated into cost-benefit analysis of new technology. Sensitivity analysis explores the net effect of the net present cost of the systematic changes in individual parameters (Wilson, 1979) and it was performed by varying the discount rate, capital cost, operating and maintenance costs to determine the economic stability of family-size biogas energy production (Walekhwa et al. 2009).

III. RESULTS AND DISCUSSION

Analysis of investment cost of small scale biogas plant

Investment cost is covered the major part of the total cost of a biogas plant. Fig. 1 shows the average investment cost of plants was BDT[3] 33692. It is also estimated that the average investment cost of biogas plant in Bangladesh was about USD 400 while for Pakistan, Nepal, Vietnam, China, Rwanda, Tanzania, and Kenya were estimated to be 426, 547,480, 293, 1306, 780 and 787 USD, respectively (Von Eije, 2012).

State owned renewable energy regulatory organization, Infrastruce Development Company Limited (IDCOL) has endorsed to grant a subsidy by BDT 9000 per plant since 2005-2006 (Haque, 2008), but finally this study found that household received on an average BDT 8,830 as subsidy. In addition to this subsidy, NGO's offered soft loan to biogas users with only 8% simple interest rate.

On average, each household received loan about BDT 25,129 per biogas plant.Nevertheless, it was upto households decision to ignore the loan if they would not like to take the loan, but the study revealed that households

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[3] 1 USD = 75 BDT

were often interested in taking the necessary loan for installing up the biogas plant.

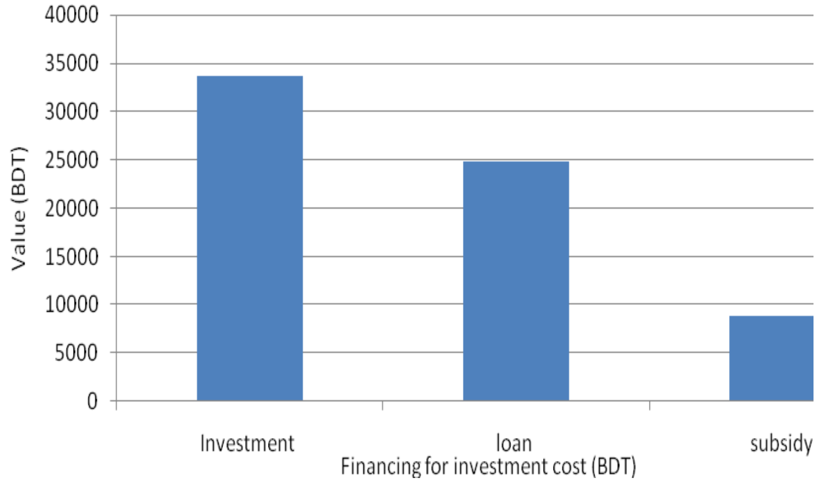

Fig 1. Investment cost and financing of biogas plant

Annual variable costs of small scale biogas plants

Besides the installation cost, the total cost of the small scale biogas plants was computed as total capital costs, including the total operational and maintenance costs as shown as Fig 2, The bulk of the capital cost comprises of construction costs and capital cost.

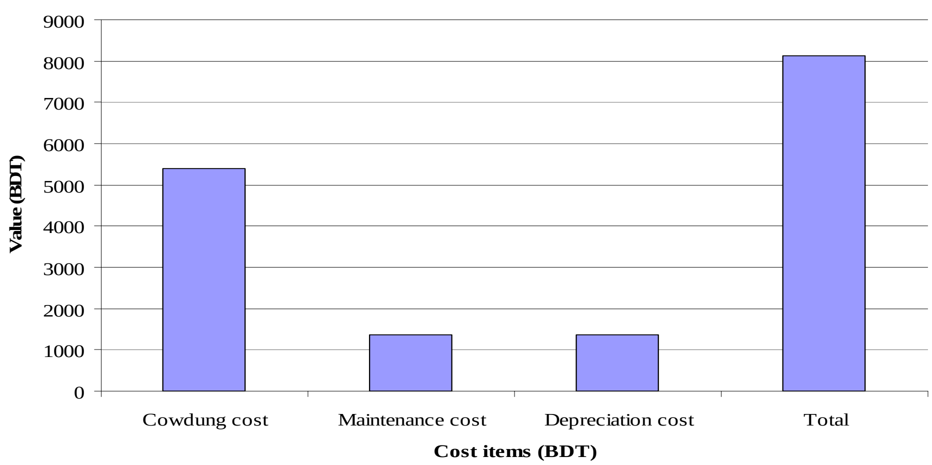

Fig 2. Estimation of annual variable costs for small scale biogas plants

It was assumed that the cost of cowdung was about BDT 0.18. It should be advised that a household rears cattle to ensure a steady supply of feed stock. The highest cost of cattle can be inhabitant factor for biogas production and use if the household is to purchase the dung. About BDT 8,000 was expended for running a biogas plant while, cowdung is the major sharer of the variable cost. Biogas users were expended about 4% of total capital cost for operation and maintenance purpose. While, depreciation cost assumed by 4% of the total investment cost.

Annual benefit of domestic biogas plant

Singh and Sooch (2004) examined the benefits of biogas according to direct gas production considering its capacity. But in Bangladesh, it is not realistic to use this direct measurement approach. Indeed, it is difficult to assess the exact biogas production since the measurable indicators are not installed along the biogas plant. Thus, the opportunity cost of biogas plant was used as a proxy to estimate the benefits of gas production. The cost of biomass including firewood, agricultural by-products, jute sticks, dry dung cake etc., have been remarkably reduced due to the biogas production. Later on, the reduced cost of fertilisers due to the use of slurry is an additional benefit of biogas production. Hence, the reduced costs of biomass products and chemical fertilizers account for the benefits of biogas production. Fig. 3 shows the annual payment for biomass is being reduced for biogas plant installation. Reduced cost of chemical fertilizers has estimated by using the cropping intensity in Bangladesh which was about 191.00%. It means about two crops are cultivated across the country (BBS, 2011). Thus, the chemical fertilizers reduction due to slurry uses have been considered for two seasons per year for estimation of benefits of a biogas plant. Ultimately, total reduction of biomass and chemical fertilizers costs are adding up to biogas users benefit due to biogas use.

The annual benefit from reduced biomass practices was BDT 19,093 and the household can save on average BDT 10,391 per year from a biogas plant. Bio-slurry used as substitute of chemical fertilizer which reduced cost on an average BDT 1129 per year. Case of Pakistan, slurry can reduce chemical fertilizer use to an amount of PKR 600 monthly (Amjid et al. 2011). Profit is estimated by total benefit (comprises of cost of firewood, dry dung, agricultural wastage, reduce cost of the chemical fertilizers and slurry) minus total variable cost (comprises of cowdung cost, maintenance and depreciation cost).

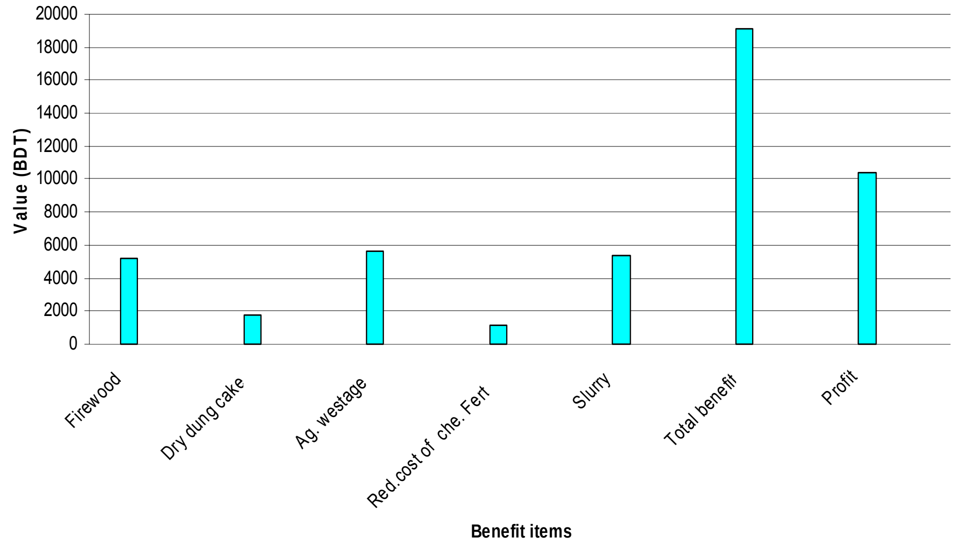

Fig 3. Estimation of annual benefits of biogas plant (BDT)

Financial evaluation scenarios

The financial estimation considered only the direct costs and benefits of a biogas plant for the interest of individual, excluding all other external matters. With subsidy considered as the first scenario for appraising the cost and benefit of a biogas plant by applying different decision-making instrument and also considered other scenarios: without subsidy, health benefits, surplus time utilize for productive purpose under financial evaluation.

Figure 4 shows the decision-making activities of biogas users under the scenarios with and without subsidy. Results revealed that a notable difference of NPV between biogas plants with subsidy and without subsidy estimated about BDT 43,854 and BDT 31,750, respectively. The two values of IRR under conditions with and without subsidy were 39% and 25%, respectively, emphasizing the advantages of the biogas activities for all categories of biogas users. Von Eije (2012) also estimated NPV, IRR, and PBP per biogas plant in Bangladesh at 687 USD, 45%, and less than three years, respectively. Regarding to their category, the biogas users were returned the total cost within less than three years time period.

Health benefits from biogas use are very common scenario of plant-adopted areas in Bangladesh. Health benefits include reduced smoke exposure and particle concentration indoors, resulting the reduced acute respiratory infection and eye ailments, as well as lower infant mortality rates (Acharya et al. 2005; Kanagawa and Nakata, 2007). The use of modern fuel like biogas can have a mechanism of alleviation such health hazardousness problems (World Bank, 2002).

The study examined that the average annual savings from medication due to the use of biogas plant was BDT 902 per plant. Still considering the savings from medication shows the NPV, IRR, PBP, and NBI were found to be BDT 37,880, 27%, 3.64 years, and BDT 5,561, respectively (Fig. 4).

Alternatively, collection of fuel wood takes a big working time share in rural area and keep people (especially school going children and women) away from other productive pursuits (Saghir, 2004; Barnes and Toman, 2006). This way to reduce traditional biomass energy consumption can lead to saving time and offering better opportunities. The person could distribute their saving time and utilize these couple of time for other productive purposes, including handy craft activities, agricultural activities, small business, livestock rearing, home gardening, better care to child education, recreation, etc.

By using biogas plant, households could save on average 2.49 hours per day, implying income gain by BDT 16001 per year. NPV, IRR, PBP and NBI of income generation from surplus time were by BDT 138,792, 64%, 1.65 years, and BDT 20,378, respectively. It is found that biogas energy production is economically feasible for small size dairy farms when the non market co-benefits were included (Yiridoe, 2009). Likewise, the present results reveal that biogas activities in Bangladesh are economically viable under income generation from time savings condition.

Fig 4 shows that four categories of scenarios in financial appraisal are to have positive NPV, more than 12% IRR rate and always PBP are notably less than duration of biogas plant and NBI also found positive. Thus one can easily say as biogas plant is a profitable business. Considering the financial scenarios, biogas users can be continued their business as profitable enterprise.

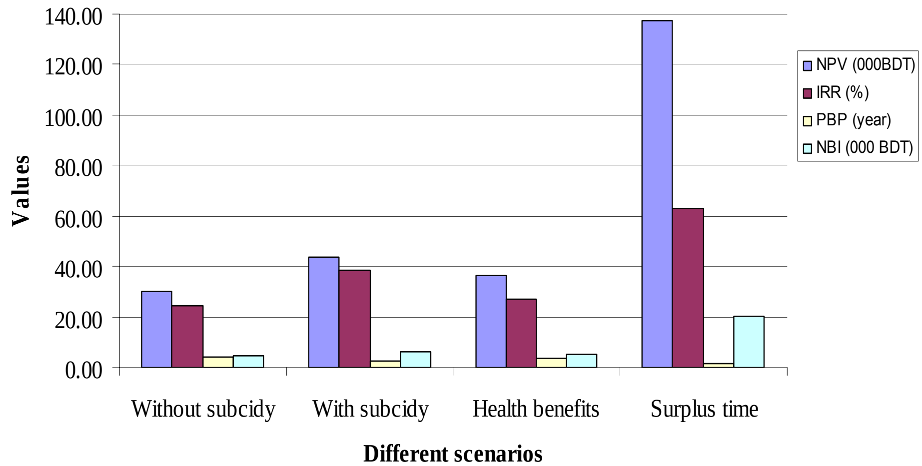

Fig 4. Financial appraisal estimation of biogas plant

These results compare to other developing countries like Ethiopia where cost benefit analysis of biogas plant yields positive net present value for households collecting their own energy sources and results highly dependent on slurry are being effectively used as a source of fertilizer (Gwavuya et al. 2012).

Economical estimation scenarios

Financial and economic analyses also differ in their treatment of external effects (benefits and costs), such as favorable effects on health, climate change etc. The economic estimation is accounted in the greater interest of the society. Carbon trading is one of the most external effect which could have come from biogas uses, country can be benefited from these business by monetary as well as environmental aspects.

The Clean Development Mechanism (CDM) is one of the “flexible mechanisms” under the Kyoto Protocol. It provides for industrialized countries to invest in CO2emission-reducing projects in developing countries and to use (part of) the resulting “certified emission reductions” toward their own compliance with the emission limitation target set forth by the Kyoto protocol (Schlamadinger and Jürgens, 2012).

Bhattacharya et al. (2002) found that emission factor for CO, CO_2, CH_4, total Non-methane organic compounds (TNMOC) and NOx of the traditional and improved biogas stoves in Asian developing countries, and concluded that as the efficiency of the cook stoves increases, the emission factors in *gram* per useful biomass energy used for all pollutants declines. In context of Bangladesh, *Grameen Shakti (GS)* already submitted the required documents for registration to United Nations Framework on Climate Change (UNFCC) on carbon trading across the developed world (Hackett, 2012). After getting the registration, it would sell the carbon and earning foreign currencies distribute to major portion to the incumbents of biogas users. It was assumed in this study that biogas farm could have reduced 3.80 ton of CO_2 and earned BDT 3540 per year. In Nepal, Biogas Sector Partnership (BSP) estimated also a net reduction of 4.7 tons/year of CO_2 equivalent per plant, or 660,000 tons/year for all the plants installed to date (UNCTAD, 2010). Thus, biogas users are doing twofold beneficiary activities concerning an issue that they will have earned foreign currency as well as preparing the sustainable environment atmosphere over world. The NPV, IRR, PBP, and NBI of biogas plant with carbon trading were BDT 53,658, 34%, 2.95 years and BDT 7,878, respectively (Fig. 5).

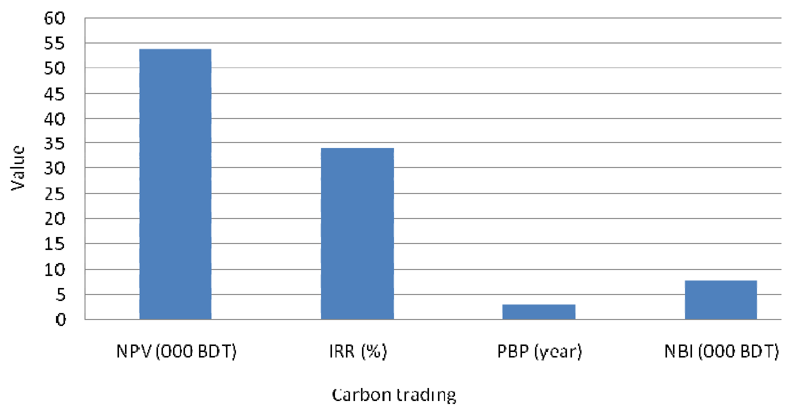

Fig 5. Economic appraisals of biogas plants

Considering the five scenario analyses, with subsidy, without subsidy, health benefits, surplus time utilization and carbon trading are appraised based on the NPV, IRR, NBI and PBP, biogas plant can be installed in the potential areas of Bangladesh, especially for households with sufficient number of cattle or poultry birds. Surplus time utilization scenario has appraised the most appreciable value of decision making tools compare to other four scenarios. This finding is more or less seems to have similar as mentioned earlier as biogas use has internal and external, social and economical, direct or indirect advantages for society. The mean values of the decision-making tools including NPV, IRR, PBP and NBI were all very convenient for suggesting the potential biogas users to install at least one small scale biogas plant in the surrounding of their home. Among other benefits, household members, especially women can get more time to using for economic activities and assist to total income of the family. Thus, income generation from surplus time appraised the highest NPV, IRR and NBI with the lowest PBP compared to the remain sceanrios components.

Sensitivity Analysis

To take into account the future economic viability of biogas activities, five valid sensitivity cases were considered. These cases are: 1) reduced span of biogas plant life from 15 to 10 years, 2) increased interest on investment cost from 8% to 16%, imposed 15% investment cost, 12% to 20% discount rate with 16% interest rate, and 4) increased of investment cost from up to 50%.

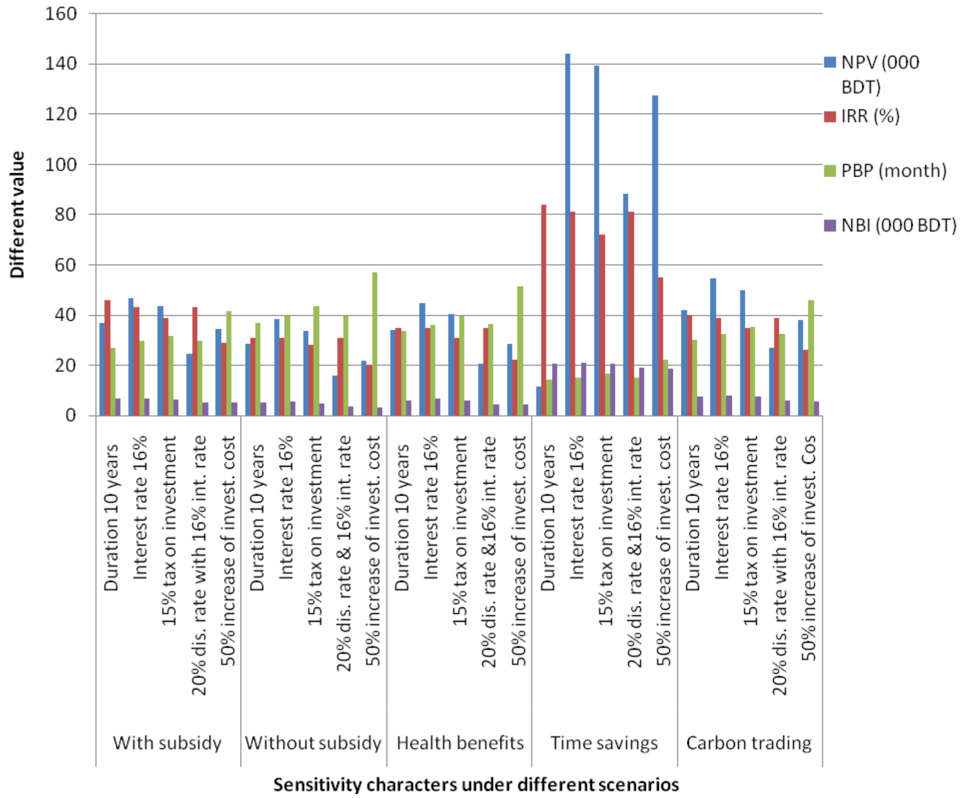

Fig 6. Sensitive analysis under different scenarios of biogas plant in Bangladesh

As earlier section appraised the income generation from the surplus time activities estimated highest levels of NPV, IRR, and NBI, and lowest level of PBP. Considering the above sensitive issues, this income generation from time saving character also shows often similarly level of NPV, IRR, PBP and NBI compare to other four characters (Fig 6). On the other hand, without subsidy issue performed less considering these sensitive characters where less amount of NPV, IRR and NBI beside the highest size of PBP comparing other four scenarios. But all the values of decision characters of without subsidy are more than convenient to insist the biogas plant owner to adopt a biogas plant in a home.

Above discussion naturally is being encouraged to the potential biogas users to adopt a biogas plant within a house, however there have a few constraints that also found in this study like mason people are not frequently available, interest rate on credit still high, subsidy distribution is need to more transparent, awareness on slurry management for crop production etc. However, with these few constraints, Bangladesh is going up to adopt more and more biogas plants across the country.

IV. CONCLUSION AND POLICY IMPLICATIONS

The main purpose of this study is to appraise on cost and benefit of biogas plants use in Bangladesh.

Financial and economic estimation on the basis of four decision making tools (NPV, IRR, PBP and NBI) were considered for appraising on profitability of biogas plant in Bangladesh. Five scenarios including with subsidy, without subsidy, health benefits, surplus time utilization for income generation and carbon trading are taken to estimate the financial and economic analysis. Under financial estimation, surplus time utilization for income generation has served very impressive result based on four decision making tools comparison to other scenarios. Carbon trading scenario under economic appraisal also revealed a good result of decision making tools. The small scale biogas plant is a profitable enterprise under circumstances of five scenarios. In addition to five sensitive characters also estimated that biogas technology in Bangladesh can be extended to potential areas and explore the potential farmers. Potential users are often motivated by taking those two items- subsidy and credit. Mostly three size of biogas plants (2.4 m^3, 3.2 m^3 and 4.8 m^3) were often found in the study areas. Investment cost is the lion share of total cost. Subsidy also played a substantial role to adopt a biogas plant because about 30% of total investment cost is supplied from subsidy besides NGOs are also ready to disburse the necessary credit to potential farmers for install a plant. Biogas extension in rural area of Bangladesh could have contributed not only to improve the health condition of habitants but also to mitigate the environmental degradation with positive impacts on socio-economic situation of both local and global arena. Subsidy and easy access to loan facility also assist the rural potential people to get the decision on biogas technology. The present study has few limitations like, this study didn't consider the statistical estimation on biogas plants, the impact of bio-slurry on agricultural productivity, the adoption level of biogas plant around the potentials areas, institutional activities in the renewable energy sector, etc. Above discussion leads to conclude that Government should develop the institutional activities and NGOs would also have taken further initiatives by which potential biogas users will be motivated to invest for a biogas plant and then, that rural household would have a greater chance to serve the nation as well as global society on less CO2 emission, increase the soil fertility, increase the income generation and improve mother-child health.

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