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**DIFFUSION OF BIOGAS TECHNOLOGY:
A COMMUNITY BASED APPROACH**

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Abstract: The scarcity of energy in rural Bangladesh is already acute and bears little sign of improvement. Energy from commercial sources accounts for only 8.6% of all energy used in the domestic sector and again which is not uniformly distributed. Only a small number of villages have access to electricity. Complete rural electrification will entail high transmission and distribution costs. Biomass is used recklessly. Irrational and unplanned exploitation of biomass resources is resulting in environmental degradation. Biogas technology can be a partial but significant solution to these and many other problems of energy. It is a simple technology generally referred to as 'intermediate', which has every prospect to have an extensive use in Bangladesh. But adoption of biogas technology does not end with the construction of a plant, rather it requires proper planning with respect to creation of social and economic acceptability apart from technology diffusion. At present the Government of Bangladesh is encouraging only the 'single-owner' plants, where only a segment of population (specifically the rich who have 5-6 cows) have the access to derive its benefit. But it would be comparatively economic to construct larger plants for community use as well as to bring a large group of population under its' benefit. But adoption of community approach, by its' very nature and because of the intended use, will require such activities as mobilisation of community supported by, awareness building, supervised credit, training of users regarding operation and maintenance etc. Before undertaking such activities, decisions regarding technical details, institution-building etc. should be arrived at the national level. Thus since biogas technology is a 'new arrival' to the traditional way of living, some planned activities will have to be taken initially. Mass adoption of the new technology will not only be a significant step forward to meet the challenge of acute energy crisis but will also be an affective measure to environmental protection.

Key words: Biogas; Diffusion; Energy

Introduction

Due to lack of alternative energy at affordable cost, most of the rural people of Bangladesh have to rely on biomass as their major source of fuel energy. According to the estimation of Bangladesh Energy Commission (1994), more than 39 million tons of the traditional fuel (equivalent to ten million metric tons of oil), such as, agricultural residue, tree twigs, jute stick, leaves and cow dung are used as fuel in Bangladesh each year. Agricultural residue and animal dung comprised 84.68% of the total fuel used in 1995-96 (BBS, 1998). Wood accounted for 16.2% and commercial energy sources

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contributed 26.9% (BBS, 1991) of the household fuel demand, as revealed by 1991 Population Census. But reckless and unplanned use of biomass is gradually leading to its consumption beyond regenerative limits with serious environmental consequences. The current situation in the energy sector leads the policy makers to think about the alternative sources of energy, which will be renewable in nature and can be adopted throughout the country. This paper examines the feasibility of introducing community biogas plant to resolve fuel crisis in rural Bangladesh.

Fuel Problem in Rural Areas

Energy from commercial source accounts for only 8.6% of all energy used in the domestic sector. Again the energy sources are not uniformly distributed. About 23,000 villages (35% of the total) have access to electricity (Biswas, 1995). According to Biswas, complete rural electrification entails high transmission and distribution costs (\$U.S. 25,000 per mile; \$U.S.1= Tk.54). Moreover, the energy sector of Bangladesh is not in a sound condition at present. The present demand of electricity in the country is estimated nearly about 2900 megawatts (MW), while the production is estimated to be between 2500 to 2700 MW (PDB March, 2000). There is no accurate data regarding gas reserve in the country. One estimate shows it has a deposit of 21.35 trillion cubic feet (TCF), of which 12.416 TCF is recoverable. The domestic share of natural gas is negligible and the supply is limited only to the major urban areas. In 1993, the consumption of natural gas was 0.21 TCF in which the domestic share was only 2.2% (GOB, 1996). Besides, the delivery of commercial fuel such as petroleum, LPG and coal to remote rural areas is difficult and not cost effective.

For generations, rural households are used to traditional fuels like, straw, leave, dung-cake, jute-stick as their primary source of fuel due to their easy availability and affordable cost. Rural women and children spend much of their daytime in collection of fuel materials, which could otherwise be spent in different productive activities. Bangladesh, as a tropical country, possesses seasonal variations. During rainy season the supply of biomass materials becomes nearly nil. So, almost 5 to 6 months the rural people are plunged into a serious scarcity of fuel materials. Bangladesh Bureau of Statistic estimated that 18.3% domestic fuel originated from firewood, twigs and wastes in 1996-97. It indicates that a large number of trees are being cut to meet the fuel requirement. And the tendency of cutting trees is increasing alarmingly day by day with the increase in population, which threatens depletion of biomass resources in rural areas. Continuous use of leaves, twigs, agricultural and animal residues as fuel is not only a reason for natural resources depletion but is also a cause of deprivation of the soil of valuable nutrients that result in soil erosion, especially in the coastal areas (Biswas, 1995).

Need for Alternative Source of Energy

Once there were ample trees in the homesteads and the village as well. Gradually, as population increased, demand for fuel grew and vegetation started to disappear. Afforestation failed to keep pace with the rate of depletion and the result was environmental degradation. In the face of shrinking vegetation and livestock against increasing population, it is unlikely that trees or animals will continue to be sustainable sources of fuel for rural community in the coming days. It is also unlikely that natural gas would reach vast and remote rural households due to highly uneconomic cost of transportation. This situation calls for search of alternative sources of energy to meet the growing energy demand of future generations. The 18th century discovery of biogas as a cooking fuel seems to be an effective answer to the likely energy crisis of the developing countries in the next century. The 1991 government task force on energy emphasized on energy audit and suggested the integration of biogas as an energy source within the overall development policy of Bangladesh. Though the use of biogas is limited in Bangladesh, it is believed to have a wide prospect here.

Biogas Movement Around the World

After a comprehensive research, Volta first innovated biogas technology in 1776. Biogas, produced from degradable waste was discovered as methane by Henry in 1803. Payoff (1875) and Geon (1883) clearly described the existence and use of biogas. Ancient Chinese experimented with burning the gas given off by vegetable and manure, which was left to rot in a closed vessel. More recently, Volta, Beachans and Pasteur worked with biogas producing organisms. At the turn of the 20th century, communities in England and India disposed off wastes in closed container and collected the resulting gas for cooking and lighting. Germany, the United States, Australia, Algeria, France and other nations constructed such methane digesters to supplement dwindling energy supply during the two world wars.

China showed an excellent performance in diffusion of biogas technology. The history of biogas exploration and utilization in China spans over a period of nearly eighty years. Until late 80s in Chinese rural areas more than 5 million small biogas digesters were constructed, where over 20 million people could use biogas as fuel (Yangfu, 1989). Great achievements were also made in the comprehensive utilization of biogas and its' by-product manure. The popularization of biogas has produced beneficial effects on the exploration of energy and fertilizer and the improvement of hygiene, farming and ecological environment. Since 1970 the biogas research and technology has been developing at an unprecedented high speed throughout the world and accordingly biogas producers are being promoted rapidly. The United Nations has setup a biogas research and training center in Chengdu Biogas Research Institution, China, under the ministry of agriculture. In this institution biogas exploration is advancing in a scientific approach.

India is just behind China in diffusion of biogas technology. First biogas plant was commissioned 1900 AD in Bombay. Indian Agricultural Research Institute (A.R.I.) conducted a research on biogas technology. A biogas research and training center was

established in Uttar Pradesh by the year 1976. At present the institute is endeavouring to produce biogas from water hyacinth. India has been able to bring the whole community in a village under a single community plant. In 1976 they constructed a community plant in Karnataka State from which gas was supplied to 76 households of a village. Though biogas technology is spreading rapidly in India till today, it does not have sufficient social acceptance due to some cultural prejudices.

Adoption of Biogas Technology in Bangladesh

Bangladesh thought for biogas technology for the first time in mid 70s when there was a severe worldwide energy crisis. The first biogas plant, however, was established in 1972 in Agricultural University campus. The plant was a floating dome type having a size of 3 m³. At the same time BARD, BARC, BCSIR and BUET were also conducting several studies to develop and manage the technology, taking into account the local physical and social environment. The Environmental Pollution Control Department (EPCD) was established in 1980 and one of its objectives was to popularise biogas technology. By 1984, the department constructed 109 floating dome plants and 110-fixed dome plants in different districts (Gofran, 1997). In 1976 BCSIR took a programme to construct 50,000 biogas plants. So far it has succeeded in constructing about 250 floating dome and 35 fixed dome plants only, through different NGOs and directly by its' scientists (BCSIR, 1998). After its establishment in 1984 LGED took initiative to diffuse the technology in rural areas. LGED first constructed a fixed dome plant in Kurigram in 1986. The success of the plant encouraged LGED to spread the technology all over the country. By the end of 1994 LGED constructed about 200 biogas plants. The organic inputs used varied from plant to plant. Seventy-three of the plants were based on human excreta, twenty-three on garbage, one on water hyacinth, two on poultry droppings and the rest were based on cow-dung. LGED has taken a good initiative by constructing biogas plants in the slum areas based on human excreta, under the slum improvement project (SIP). A picture of the biogas plants constructed between 1984 to 1991 with the technical assistance of LGED is shown in the following table.

Table 1. Biogas plant programme of LGED between 1984 and 1991.

No. of District	Plants Completed		Plants on Going	
	Human Excreta	Cow Dung	Human Excreta	Cow Dung
29	18	30	28	27

Source: Gofran, 1991.

BCSIR is now working with the technical aspects of the biogas plant. It has carried out large number of research projects to devise appropriate biogas technology suitable for the local environment. Recently, GOB has offered a subsidy of Tk. 5000 for the first plant in each union (*Daily Bhorer Kagaz*, 3rd March, 1998). It is believed that this would have a demonstration effect on mass people inspiring them in establishing biogas plants. By this, the government aims at attaining the target of diffusing biogas technology throughout the

country. However, there are some limitations to the government policies in popularising biogas technology.

But the policy of the government encourages only the single-owner plants. However, estimates show that construction and maintenance cost of single owner plant is not affordable individually by the middle and lower income groups despite the GOB subsidies. It is also not technically feasible for people at large. Only the rich people who have adequate money and good cattle position will be able to afford it. As a result there is doubt about achieving the government target of establishing “biogas village.” To attain the objectives of “biogas village” there is need for an approach which is affordable by rural masses.

Problems and Prospects of Biogas Technology in Bangladesh

It is necessary to go through both the social and physical environment of the respective countries to draw the actual perspective of the prospects as well as the problems of introducing biogas technology. Bangladesh, as a less developed country with a backward population – backward in terms of economy, skill, technical know-how, awareness etc.– does present itself as a good case for diffusion of biogas technology. On the other hand, due to its location, Bangladesh is vulnerable to natural disaster – especially flood, which also acts as an obstacle for the intensive adoption of the technology all over the country. For efficient operation of a fixed dome biogas plant, it is necessary to keep it away from floodwater. Entering of floodwater into the digester will break down its’ operational capacity. A large part of Bangladesh experiences flood almost every year. It is extremely difficult to prevent floodwater entering into the digester in flood prone areas, which will collapse the gas production capacity of the plant. To overcome the problem it is necessary to introduce floodwater protected biogas digester.

Adoption of biogas technology at the initial stage depends, to some extent, on its social acceptance. Most of the people are not aware about biogas itself. Many people believe that biogas may contain bad smell. They also think that cooking from biogas (especially produced from human excreta) may be unhygienic and unholy. To remove such prejudice cooperation of both GO and NGOs is required to build awareness of the people about the new technology.

Biogas programme in urban slums has not been a total success. Frequent disruption in supply is reported. Such failures create an adverse demonstration effect not only on the beneficiaries but also on the potential users. Many people, who do not have adequate knowledge, usually think of it as an advance technology. Such misconception often results discouraging effects on adoption the technology.

Cost is an important factor in adoption of the technology. If the initial cost of commissioning a plant is very high, people will not be interested in making investment even if it accrues handsome dividends in the long run. The initial cost of plant in Bangladesh is still not within the affordable limit of the common people.

Despite all the above limitations, Bangladesh has a bright prospect in biogas popularisation. Biogas can be produced from any perishable organic matter like cow-dung, water hyacinth, garbage, kitchen waste, human excreta, agricultural residues and poultry droppings. It may use the excreta of 2.5 million cattle, 138 million people and a significant number of poultry for biogas production, which will reduce the pressure on natural gas and fossil fuel and will ensure safety to the forest resources to a great extent (Gofran,1991). Besides, Bangladesh has the most favourable temperature (20 – 35⁰C) for biogas production biogas production.

Need for Community Plant

To maximize the benefits of biogas technology the community plant is the best option. The “community plant” approach, which ensures the accessibility of all economic groups, offers a good opportunity to share the benefits of biogas technology by masses. The “gas-output-construction ratio” rises with the increasing size of the plant. In this respect community plants are more economic. However, it requires effective mechanisms to share output and cost, mobilisation and organization of the beneficiaries, effective management and operation, etc.

For a community plant there is a need to ensure community participation. Community participation is the sharing of interests rendered by any project or activity by the people living in a specific geographic or socio-economic region. For a successful community plant, the members of a community must forge unity not only in respect of supplying inputs to the plant but also to its operation and management. The most important advantage of community plants is that it requires comparatively less establishment cost than single-owner plant. It can also adopt technology easily, show better performance with respect to operation maintenance.

Community Approach

Following is a community plant approach in outline form.

Group Formation: Group formation is the first stage of community mobilisation. For group formation, it is necessary to adopt certain principles. These are,

- every household selected as group member must have cattle,
- Every member of the group must live within close proximity,
- Every group member must supply equal amount of investment capital for the project,
- They must supply the amount of dung proportionate to the number of their family members,
- The members will share the running cost of the project, including the cost of dung collection and disposing them into the digester, collection of residue, overall operation and maintenance of the supply network.

This group formation task may be performed by some enthusiastic initiators of the area or by community leaders or by an NGO.

Technical Considerations: Technical considerations include constant supply of high quality organic material, the suitability of the ambient temperature, the availability of good-quality water with which to dilute the feedstock, the efficient use of biogas produced, and sufficient space for effluent disposal and usage. Moreover, construction and operation of a biogas plant depends upon the availability capital, personnel and materials. Since the technology is yet to be wide spread some initial technical support will be necessary for the initiating group. For technical support NGO initiative may be found very effective. However, in case of local efforts assistance of BCSIR or any concerned NGO or other relevant agencies can be sought. Besides, literate enthusiastic initiators can also study books and references on the subject or may visit similar plants and discuss with the personnel involved with to get ideas about adoption of the new technology.

Finance: Finance for the project can be generated from three different sources. First, group formed by local initiative can generate fund from its members. Second, in case of NGO initiative initial fund may be provided by the concerned NGO, which may be realised, from the beneficiaries in the form of easy installments. Third, initiators or NGO may seek credit from bank.

Operation and Maintenance: Operation and maintenance has to be very effective for sustainability of the project. In fact the success of the project depends on how smoothly it is managed and how cost effectively it is run. An NGO initiator can initiate a project but for sustainable running local institution building is a must. The members for operation and maintenance may share responsibilities. In case of NGO initiative, initial operation and maintenance may be done by NGO. But in the long run the local community must take up responsibilities. For this purpose local institution building is important. For effective institution building local community must develop a sense of cooperation, mutual help, democratic norms among themselves to form an effective group. To culture these attributes among people, education will serve as an important driving force. Education will bring cultural change and develop a social attitude based on mutual cooperation, trust, responsibility and democracy, thus creating a situation favourable to operation of community based activities.

Selection of Target Community: This selection depends on some basic factors like income, expenditure, willingness to pay, attitude towards joint effort, number of cattle available, nature of agglomeration of dwellings etc.

Operationalisation of Community Plant Approach: Study on a Selected Area

It is appropriate to conduct a study before suggesting introduction of the new technology on a mass scale. The researchers carried out a study on a potential village near Khulna to determine the criteria of area suitability for establishing biogas plant as narrated below

Area Selection: Though the rural areas of Bangladesh are more or less same in nature, there are small differences in their characteristics in different regions of the country. Biogas is an intermediate but a new technology to the rural people. Moreover, its diffusion through community participation requires fulfilling some prerequisites, which have to be ensured, before adoption in a wider scale. Settlement pattern, socio-economic

condition, sources of fuel, cattle position, literacy rate, awareness about environment, NGOs, activities are very much crucial considerations for introduction of a new programme. Considering the above factors, a reconnaissance visit was conducted in three villages namely Mohammadnagar, Krishnanagar and Sharafpur of Dumuria thana of Khulna district. The intention was to choose the best among those for diffusion of the biogas technology.

After reconnaissance survey and observation, Sharafpur was found more suitable than others for diffusion of the technology. The village contains the following positive characteristics,

- Average literacy rate and high income,
- Average family size is smaller,
- Two NGOs are already working in the village.

Location, Area and Population: Sharafpur, the largest village of Sharafpur union, is located in the south-east of Dumuria Thana, about 18 km. southwest from Khulna City. This village is surrounded by the river *Vadra* from three sides (Fig. 1). Total area of the village is about 2.5 sq. mile with 70% land belonging to agricultural use. Total population of the village is 5315, consisting of 2712 males and 2603 females. The village has a number of settlement clusters.

Socio-economic Profile: Age and sex are the two vital things that influence the working groups in a community. Women are treated differently from men and they are considered the potential group for the biogas movement due to their realization about the responsibility on collecting or managing fuel materials. The highest segment of population is in the age group 11-20 and the lowest segment is in age group 51-60. A large number of populations are below 10 and above 61, who depend on others and are treated as a burden to the society. But there is a large group of young people who may serve vital roles in adaptation of biogas technology.

Occupation and income pattern is important for adoption of appropriate strategy for diffusing biogas technology. The following table shows the primary occupational pattern of the village household heads. About 1/3 of the household heads in three clusters is agriculture. About 27 per cent do small business and the rest others are van pullers (5.31%), service holders (9.07%), masons (3.31%), day labourers (7.30%) and others.

Table 2. Primary occupation of the village household heads.

Occupation	No. of Household	Per cent
1. Agriculture	165	36.50
2. Small Business	122	27.00
3. Service	41	9.07
4. Van Puller	24	5.31
5. Mason	15	3.31
6. Day Labourer	33	7.30
7. Others	52	11.50
Total	452	100.00

Source: Field Survey, 1998.

STUDY AREA: A PART OF SHARAFPUR VILLAGE

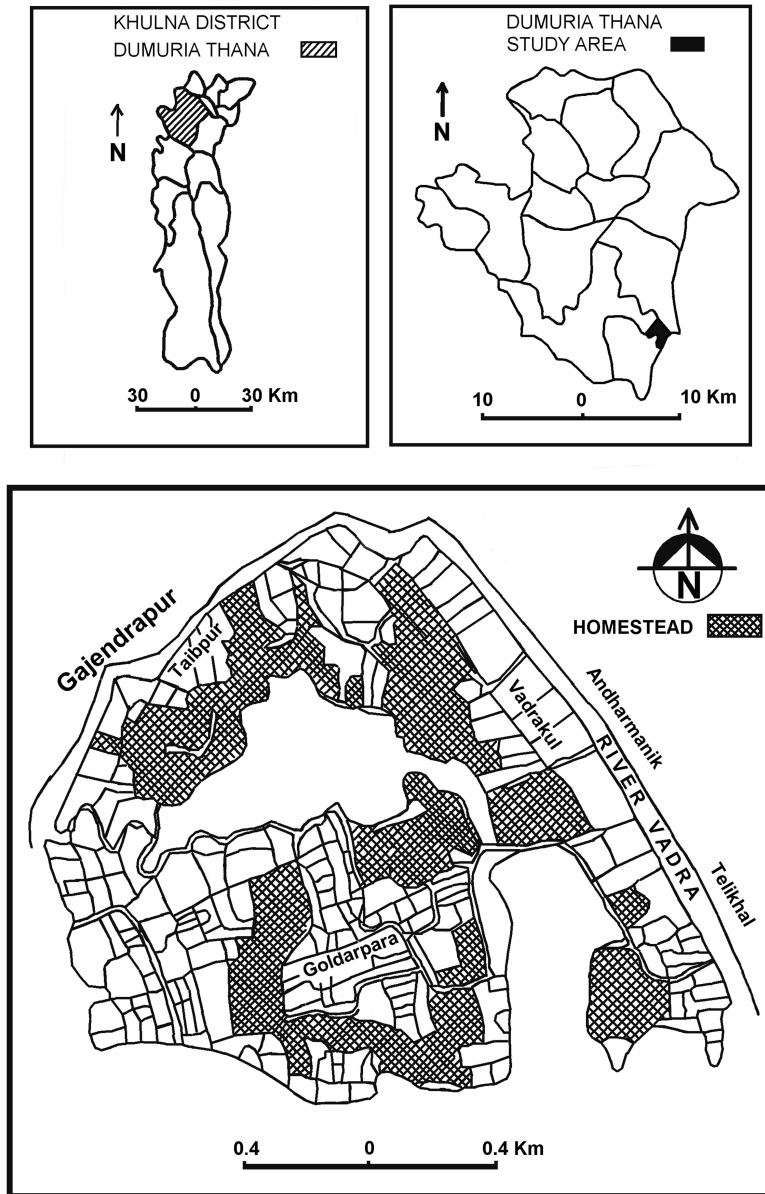


Fig. 1. Map of the study area: a part of Sharafpur village.

Like other rural areas of Bangladesh Sharafpur is predominantly an agro-based village. A vast majority of people is engaged in agriculture and it is the main economic activity of the villagers. Business is the second economic activity of the people in the study area. In this study shrimp culture and fish culture are considered a business.

Expenditure Pattern: Income has both intrinsic and extrinsic relation with expenditure as well as savings. With the change at income levels, the pattern and level of expenditure also changes. Most of the villagers expend a large amount of their income on food. Estimates show that about 30% to 45% of the family expenditure goes to food items. Fuel for cooking and lighting constitutes about 6% to 8% of the total expenditure. Expenditure for fuel materials is high for the group whose income lies between the ranges Tk. 5000-5500 per month. This is so, because average number of family member is higher in that group.

Role of Women in Economic Activities: Female participation in outdoor production activities is negligible. They mainly serve at home. Of course, this scenario is changing day by day. The women are now found participating in different income earning activities including self-employment.

Table 3. Women participation in income generating activities.

Age group	Sewing (%)	Livestock (%)	Poultry (%)	Day labor (%)	Business (%)
16-30	9	16	14	51	10
31-45	10	35	38	12	5
46-60	0	51.55	38.5	0	10

Source: Field survey, May '98.

Collection of Dung as Fuel: Many rural households collect cow dung from the field, for producing *masal* (a kind of dung cake produced by the villagers). This *masal* is used for everyday cooking. Whenever a family produces any surplus, they sell them in the market, because there is good demand for cooking fuel. The collection of dung and making *masal* is a secondary or tertiary occupation of the poor of the study area. Usually, children and women take part in collecting cow-dung from the grazing land. The dung collectors usually go to the *Beel* in the afternoon to collect dung. It takes 2-4 hrs to collect their required amount.

Table 4. Information about dung collection.

Collection of dung (kg./day)	Working hour (Average)	Monthly economic return	
		Dry season	Rainy season
22.5	3.18	147 Tk.	88 Tk.

Source: Field survey, May '98.

Cow dung is available in the dry season. But it becomes scarce in the rainy season as it is washed off owing to rain. So, for the sustainable uninterrupted operation of biogas plant, continuous collection of dung should be ensured in the rainy season. Variation of monthly income of a dung collector in different seasons is given in Table 4. The table also indicates that the dung collector spends an average of 3.18 hour per day for

collection of dung. They generally collect dung from the *beel*, uses it to produce *masal*, which are marketed in the local market after meeting their own need.

NGO Activities: NGO organizations organize the rural poor for different productive activities. They offer loans to the rural poor, which may act as a means of poverty alleviation through income generation. At present there are two NGOs working in the study area, namely, *PODIPAN* and *Nijera Kari*. Only *PRODIPAN* offers micro credit for the poor. *Nijera Kari* works for building awareness among the rural poor. Following is the details about credit facilities offered by *PRODIPAN*.

Highest amount of loan:	Tk.10,000.
Lowest amount of loan:	Tk. 1,000.
Annual Rate of interest:	10%.
Repayment:	Tk. 22/week.
Installment:	50 (50 week).

Qualification for Loan: Any group member can get loan after three months of joining the NGO. By this time he has to prove that his performance is not against the rules and regulations of the NGO. The amount of loan depends upon his requirement and affordability. The following table shows the NGOs loan status in the study area.

Table 5. Information about loan recipients.

Number of person received NGO loan	Average amount of money (Tk.)	Utilisation of the loan (%)							Repayment status	
		Livestock	Housing	Rural transport	Agriculture	Small trade	fisheries	Grain husking	Satisfactory	Unsatisfactory
84	4042.85	22.8	11.9	5.3	28.6	6	18	7.40	81	19

Source: Field survey '98.

The above table shows that most people invested their loans in agricultural sector and a significant number of them bought cattle. A good number of loaners are females and they like to invest their loans in safe as well as productive sectors where regular monitoring is possible by them. Table 5 also indicates that about 81% loan repayment recorded, which is quite satisfactory level. The intention of such information is that the common people of the area hold ability to repay loans and if loan for biogas connection is offered in the area, the repayment will not be difficult for them. Though the middle and high-income groups are treated as the potential group for proliferation of biogas facility, it may be possible to popularise the system among the poor as well as through initial credit finance and also if the cost of production can be reduced.

Selection of Appropriate Cluster: It is comparatively easy to supply gas to the households living in a cluster if there is a large agglomeration of households. The length and cost of pipe will be reduced if the consumers are closely located in a cluster. Moreover, the pressure of gas in the pipe decreases after a certain length. Hence

settlement pattern and density is important to make the project cost effective. The settlement pattern of the village may be divided into three types,

- Concentrated type of settlement,
- Linear type of settlement,
- Scattered type of settlement.

The concentrated type of settlements are called *para* where maximum village services are available. When houses are located on both sides of an embankment or road, it is a linear settlement. In scattered type of settlement, houses are located near the agricultural land of the farmers. Almost equal number of houses lie in linear and concentrated type of settlements, while there are only a few houses found in scattered settlements in the village. Three chunks in the village, namely, Vadrakul, Goldarpara and Taibpur belonging to linear and concentrated type were selected for further investigation. Vadrakul is linear type while Goldarpara is concentrated type. Taibpur has mixed characteristics of the two. Adoption of community plant depends on some basic criteria, like, economic status of the beneficiaries, number of family members, number of livestock and poultry bird availability, existing expenditure on fuel consumption etc. All communities may not fulfil all these conditions. Table 5 shows the status of three communities with respect to selected criteria.

The Vadrakul cluster is linear shaped. This kind of settlement entails greater costs in distribution network. Besides, it is the poorest of all the three communities with monthly income of Tk. 4500/ and average household land ownership of only 7.83 *bighas*. The average household also has the lowest household assets. Goldarpara is a concentrated type of settlement with households owning about 25 *bighas* of land on average, the highest of the three clusters. The households have average monthly income of Tk.6015. Taibpur is a cluster of mixed settlement pattern. It has the highest monthly income of Tk.7266. The average arable land is 14 *bighas*. It has the highest household assets. From the point of view of affordability, the pattern of settlement and cattle ownership Goldarpara and Taibpur are found to be the most appropriate settlements where community based biogas plants can be run effectively. However, despite presence of all the positive factors in a settlement, the cost of production will continue to remain to be the most decisive factor in adoption of the technology.

Table 6. Socio-economic profile of three clusters.

Name of the Para	Settlement Pattern	Average Monthly Income	Land Ownership		Average Household Assets	Average Family Member
			Arable Land (<i>bigha</i>)	Homestead (<i>katha</i>)		
Vadrakul	Linear	Tk.4500	7.83	18.33	3.88	5.9
Goldarpara	Concentrated	Tk.6015	25.38	8.4	2.17	5.5
Taibpur	Mixed	Tk.7266	14	26.66	2.62	5.3

* Household assets are wood, cattle, ornament, poultry and vehicle which remains in every family and people use it only the period of great depression. If the households have the above five elements are ranked 1, and like this the family who have only one element is ranked 5 in the above table. Source: Field survey '98.

Cost Estimation: To have some idea about expenditure of installation of biogas plant, we can conduct a case study of a small community of 10 families having 10 members in each, on average. The numbers of cattle owned by families vary between 6 and 12, totaling 90 cattles. The total gas requirement per person/day is estimated at a rate of 0.3m equivalent to 10.60 cft. (Yong). Thus for a community of 10 families a day's gas requirement is calculated as 381 cft. According to BCSIR a gas plant of this capacity would cost about Tk. 38,000. The cost items of the project have been broadly classified as fixed and operational. The following table shows item wise calculation of the fixed cost.

Table 7. Fixed cost of community biogas plant producing 400 cft. gas/day.

Material	Amount/Number Required	Unit Cost (Tk.)	Total Cost (Tk.)
1. Earth cutting (cft)	2100	700/1000 cft.	1,470
2. Brick (Ps)	49000	2700/1000 ps	13,230
3. Sand (cft)	175	8/cft.	1,400
4. Wax (Kg)	4	50/kg	200
5. Brick Bats (cft)	90	25/cft	2,250
6. Charge for Mason (1)	18	100/day	1,800
7. Gas Pipe (ft)	500	5/ft.	2,500
8. Cement (Bag)	3	2,500/bag	7,500
9. PVC Pipe (ft)	12	25/ft.	300
10. Iron Rod (kg)	95	1800 /ton	5,035
11. Labour	28	60/day	1,800
12. Gas Valve ¾"	1	150/pcs.	150
13. Burner (Single)	10	40/pcs.	400
Total:	-	-	37,915

Source: PWD Rates.

In the above table the fixed cost comes out to be Tk. 37,915.00. The fixed cost, however, may vary according to the nature of initiative and settlement pattern. In case of a cooperative initiative, the cost of earth cutting and labour cost can be overcome through voluntary service by the beneficiaries. When the homesteads in settlements are scattered, pipe length will increase to establish a network.

Operational Cost: The operational cost of the project will includes -

- Rent for land,
- Charge for dung collection,
- Maintenance of plants.

In the financial analysis it is customary to include the charge of land in the cost items. This cost can be overcome if any member of the group contributes land for the project. Due to greater supply of land around homestead and its low value it is easier to get such contribution. Procurement of dung for continuous feeding into the digester will involve some costs. Calculations show that procurement of dung from the beneficiaries will incur a cost of Tk. 350/ a month where labour charge will be the main cost item. Using dung as a raw material will, however, necessitate at least 89 cattles by the beneficiaries. Dung can, however, be substituted either with 42-52 cft. Human excreta or 60-70 cft. Kitchen waste. Maintenance cost of the plant has been estimated at Tk. 30/ month.

Table 8. Operational cost per month.

Cost Item	Amount/month (Tk.)
1. Rent for Land	50
2. Cost for Dung	350
3. Maintenance Cost	30
Total :	430
Total Cost /Year	430 x 12 = 5,160

Cost of Production and Pricing: The total output under the current project has been estimated as 400 cft. of which 380 cft. will be sold to the group members and the rest 20 cft. is assumed to be system loss due to the transportation through the pipe network. The cost of production per cft. is estimated as Tk. 0.033, while the price is determined at Tk.0.041. Here, the price per cft. gas has been set at a point where producers and buyers NPV (Net Present Value) become equal (Chandra, 1996).

Cash Flow Analysis: We can calculate the investment worth of the project using a simple mathematical calculation based on discounted cash flow. Discounted cash flow of a project is calculated from the discounted value of total cost and the discounted value of total benefits over the project period.

The discount is carried out to solve the problem of inter-temporal comparison of the costs and benefits taking place at different time periods. There are several methods of determining investment worth of a project. We shall use here the DBCR (Discounted Benefit Cost Ratio) method, which is given by the following formula:

$$DBCR = \frac{\sum (Qt/(1+r)^t)}{\sum (Ct/(1+r)^t)}$$

Where, Qt = sum of output to be received in period t
 Ct = sum of costs in period t
 r = rate of interest

Using the above formula it is possible to work out the DBCR of the project from the following cash flow table. The rate of interest has been considered 15%, while duration of the project has been assumed as 30 years.

Table 9. Cash flow analysis of the project.

Year	Total Cost (Tk.)	Discounted Cost (Tk.)	Total Benefit (Tk.)	Discounted Benefit (Tk.)
Establishment	40,000	40,000	-	-
1-3	16,326	12,340	31,872	24,000
3-6	17,522	11,520	33,840	22,250
6-9	19,148	10,900	35,920	20,520
9-12	21,170	10,500	38,040	18,910
12-15	24,855	10,750	40,255	17,400
15-18	27,528	10,340	42,780	16,080
18-21	30,025	9,800	45,040	14,720
21-24	33,705	9,580	46,580	13,270
24-27	36,648	9,050	48,970	12,100
27-30	40,230	8,640	15,210	11,000
Total (Tk.):		1,43,430		1,70,260

$$\text{DBCR} = \frac{1,70,260}{1,43,430} = 1.19$$

As the ratio comes out to be positive or more than 1, the project is considered economically feasible for investment. Feasibility of the project is sensitive to the price of cow dung. It has been estimated that 12% increase in the price of cow dung may jeopardize the project. To make the project viable from economic point of view it is necessary to reduce dependence on resources whose supply is scarce and unsustainable, like, cow dung. Hence, as an alternative measure the plant can be located at the optimum distance of 3 to 4 latrines and the digester is needed to be linked with the outlets of the latrines. Moreover, the group members may dump their agricultural residue and kitchen waste in the digester to minimize the pressure on cow dung.

Conclusion

Introduction of any new technology is always a difficult task. It involves a tedious and lengthy endeavour of persuasion and motivation. In absence of appropriate institutional set up in rural areas for dissemination of biogas technology, the government and NGOs will have to play key roles not only in popularisation of the new idea but also in financing and institution building. Government may take up pilot projects to study the feasibility of community-based projects in line with the ideas expressed above. If found feasible appropriate programmes may be prepared to sanction fund and disburse them to groups as soft credit through NGOs. Affordability is a major aspect in the proliferation of the new technology. Without adequate level of income, access to the new technology on a mass scale, cannot be ensured. Therefore, attempt should be made to reduce the cost of production of biogas to popularise it among the large number of low-income rural families. Cultural prejudices are sometimes found as a handicap (in case of using human excreta as input) in many cases. This may be gradually eradicated through cultural development attained by promotion of education. In the face of increasing demand for energy against depleting supply of biomass, there is hardly any option to biogas as a renewable source of energy in our rural areas. Popularisation of biogas will not only protect environment but will also become a sustainable source of energy on other sources most of which are fund resources.

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