UTILIZATION PATTERN OF BIOMASS FOR RURAL ENERGY SUPPLY IN BANGLADESH

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ABSTRACT

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The study was carried out through interviewing one hundred farmers in eight villages, under muktagachha & Trishal Upazilla of Mymensingh district during June –December, 2006 and September–October, 2007 to assess the availability and utilization pattern of crop biomass and identify the appropriate biomass energy saving technologies in rural areas of Bangladesh. The common biomasses are tree twigs, leaves, firewood, crop residues, jute sticks, rice husk, rice straw, sawdust, cowdung etc. and constitute about 60% of total energy consumption in rural households. The potential biomass availability in the study areas was about 291.47 GJ/yr-household of which the share of field crop biomass was about 229.61 GJ/yr-household. Fewer inputs than do annual row crops, and fast growing plants like Dhaincha, Eucalyptus, Epil-Epil, Bogamedula, etc. might also be cultivated for biomass production. Despite the heavy demand of biomass energy in developing countries, it is utilize so inefficiently that only a small percentage of its useful energy is obtained. The overall efficiency in traditional use was only about 5-15%. Energy saving technologies should be encouraged for efficient use of available biomass in the country. Biogas plants, improved cooking stoves, biomass briquettes were such efficient technologies. These technologies need to be standardized and encouraged for dissemination at rural household levels in Bangladesh. However, many households may need financial support for owning these technologies. The Government along with NGOs and private sector institutions should initiate programmes for extension and dissemination of these technologies.

Keywords: Utilization pattern, biomass, energy

INTRODUCTION

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

Renewable energy refers to the energy extracted from sources that are partly or wholly regenerated in the course of annual or solar cycle. Renewable energy sources have been established as a clean, sustainable and environment friendly. They do not get depleted like the conventional sources of energy and do not contribute to greenhouse gases and acid rains. Many renewable energy technologies are already in use and more are being developed. Solar, wind, mini/micro hydro, tidal and wave power, biomass and biogas have been successfully exploited and used in different parts of the globe with great advantages.

Bangladesh is one of the environmentally threatened countries suffering from scarcity of fuels, especially biomass fuels. Biomass fuels comprise trees, tree residues and agricultural residues, animal excreta, kitchen by products etc. The country has rather small coverage of forest (about 15% of the total area of the country) and actual tree coverage may not however, be more than 7-8% .Of the total fuel wood supply more than 90% come from homestead forest and the rust from conventional forest and other areas. Total biomass consumed per year in the country is about 39 million tones of which about 50% come from agricultural residues (Atikullah et al. Eusuf, 2005).

Majority of the population in the country lives in rural areas. In 2003, the per capita energy consumption was only 220 KGOE (kilogram oil equivalent). About 32% households have access to electricity in rural areas, where 75% of popular resides, and the availability of electricity is only 22% (BBS, 2003).

The production of rice husk is increasing in Bangladesh due to increasing of rice production. The rice husk requires additional place to store. Husks blow away in strong wind that cause dust pollution in surrounding areas while kept in an open place. On the other hand, husk is difficult to carry from one place to another due to its large volume. Husk can be used to produce briquette that reduce volume (10 times) and can be used as an alternative fuel. Briquette is a block of condensed biomass with increased volumetric calorific value for use as fuel. Such briquettes are comparable to woody biomass (with high ash content) and quite stable with long self life. Different types of biomass like rice straw or rice husk, sawdust, wheat husk, jute stick- and bagasse can be used for briquettes, but at present, mostly rice husk is used as raw materials.

Today charcoal is an important household fuel and to a lesser extent, industrial fuel in many developing countries. It is mainly used in the urban areas due to its ease of storage, high content of energy (30 MJ/kg as compared with 15 MJ/kg in fuel wood), lower levels of smoke emissions and, resistance to insect attacks make it more attractive than fuel wood.

Use of biogas as renewable energy is of great importance in Bangladesh. Biogas plants have not only the advantage of improved efficiency and multidimensional use, the GHG (Green House Gas) emissions will also be reduced and organic fertilizers will be available as a by-product. More than 25,000 biogas plants (mostly of fixed dome type) mostly by BCSIR using mainly cow dung have been installed for households (BCSIR, 2005). Institutional and commercial biogas plants have now been constructed by various agencies especially LGED, using cow dung, poultry dropping or even human excreta. Also, there is a huge potential for biogas production from municipal and other industrial wastes.

Biomass

Biomass is a renewable energy resource derived from the carbonaceous waste of various human and natural activities. It is derived from numerous sources including the by-products from the timber industry, agricultural crop, raw material from the forest, mayor parts of household waste and wood.

The chemical composition of biomass

The chemical composition of biomass varies among species, but plants consist of about 25% lignin and 75% carbohydrates or sugars. The carbohydrate fraction consists of many sugar molecules linked together in long chains or polymers.

The Energy Scene in Bangladesh

The total annual per capita energy consumption of the country in 1995 was estimated at 8.467 GJ. The shares of commercial energy (coal, oil, gas and hydropower) and biomass fuels were estimated at 3.203 and 5.264 GJ, respectively [Islam, 2001]. The total amount to biomass fuel consumed in the country in the year 2000 was approximately 45 million tons (Mt) (Khan *et al.* 2002). The country has sizeable deposits of natural gas. According to Petrobangla, the total recoverable reserves of natural gas in 22 known gas fields are 439 Gm^3 of which 110 Gm^3 was produced up to June 2000. Net recoverable reserves in July 2000 were 329 Gm^3 (Islam, 2001). Although the gas being used has an impact on the national economy through fertilizer manufacture, electricity generation and direct energy use in some industries, it will not be economically feasible to supply the gas to the rural areas through pipelines in reverie Bangladesh (Khan, 2002).

The study was undertaken with the following objectives: To assess the present biomass resources availability, requirement and energy use pattern in rural areas of Bangladesh, to assess the utilization pattern of crop biomass in rural areas of Bangladesh, to identify appropriate biomass energy saving technologies.

MATERIALS AND METHODS

The study was conducted at eight villages namely Goary Uttar, Nandibari, Roghounathpur, Tarati, Namapara, salimpur, Dorirumpur and Birunpur under muktagachha and Trishal upazillas of Mymensingh district and economical analysis of improved biomass utilization technologies from RDA, Bogra and BCSIR in Dhaka. An interview schedule was prepared according to the objective of the research. The production of crop biomass and their utilization pattern, rural energy consumption were carried out for 100 families from the above mentioned eight villages according to the prepared questionnaire.

Development of Questionnaire

A set of interview schedule was prepared to collect various socio-economic aspects, crop biomass production and utilization pattern of the villages, and to collect detail information about RDA biogas plant and improved stove as energy saving technologies. Questions were related to the farmer's family description, land ownership, land utilization pattern, cropping system, farming system and utilization and economical analysis of biogas plant and improved stove for energy saving technology as they usually practice.

Data Collection

Data for this study were collected through personal interview during June –December, 2006 and September–October, 2007. The village leaders and scientists of RDA and BCSIR extended valuable co-operation and asked the villagers to render help and co-operation to the researcher in collecting data. The researcher also seeks advice to the Upazilla Agricultural Office about the collection of data. Farmers were selected randomly from the study areas covering various categories according to the lands ownership.

Biomass Production

The sources of biomass were divided into four groups such as: Field crop residue, Leaves & twigs, Livestock, Kitchen by product

Biomass from field crops

Biomass supply from field crop was determined by the following procedure.

Crop production

Biomass from different agricultural crops such as rice (Aus, Aman and Boro), wheat, pulses, jute, oilseeds, groundnut, sugarcane, etc and some vegetable crops were selected. The crops produce six crop residues, which were considered in the estimation, are as follows:

Crop	Residues
Rice	Straw & husk
Jute	Jute sticks
Wheat	Wheat straw
Oil seed	Oil seed straw
Pulse	Pulses straw

Total crop production is determined by the following equation:

$$P(i) = A\ (i) \text{ x } P_u\ (i)$$

Where, P (i) = Total production of (i) crop, ton
A (i) = Cropped area of (i) crop, ha and
P_u (i) = Production of (i) crop per unit area, ton/ha

Rice Straw: Total rice straw production is estimated by following equation:

$$R_s = P\ (AU)_{LCL} \times S\ (AU)_{LCL} + P\ (AM)_B \times S\ (AM)_B + P\ (AM)_{LT} \times S\ (AM)_{LT} + P\ (BO)_{LCL} \times P\ (BO)_{LCL} + P\ (BO)_{BYV} \times S\ (BO)_{HYV}$$

Where, R_s = Total rice straw production in a year, ton
P $(AU)_{LCL}$ = Production of local Aus, ton
P $(AM)_B$ = Production of local transplanted Aman, ton
P $(BO)_{LCL}$ = Production of local Boro, ton
P $(BO)_{BYV}$ = Production of high yielding verity, Boro
S $(AU)_{LCL}$ = Co-efficient of straw of local Aus,
S $(AM)_B$ = Co-efficient of straw of broad casting Aman,
S $(AM)_{LT}$ = Co-efficient of straw of local T. Aman,
S $(Bo)_{LCL}$ = Co-efficient of straw of local Boro and
S $(BO)_{HYV}$ = Co-efficient of straw of HYV Boro.

Rice Husk: Total rice husk production is calculated by the following formula:

$$R_h = P® \text{ x } S(R_{h)}$$

Where, R_h = total rice husk production in a year, ton
P® = total rice production in a year, ton and
$S(R_h)$ = Co-efficient of rice husk

***Jute sticks*:** Total jute sticks production is calculated by the following formula:

$$J_s = J_p \times S_j$$

Where, J_s = Total jute stick production in a year, ton
J_p = Production of jute fibre in a year, ton and
S_j = Co-efficient of jute stick.

Other crop residues: Other crop residues production refers to the residues of the pulses, oilseeds, spices, vegetables, etc. and is estimated by the following formula:

$$CR_{other}(i) = P_{other}(i) \times S_{other}(i)$$

Where, $CR_{other}(i)$ = production of other crop residues by ith crop in a year, ton
$P_{other}(i)$ = other crop production ith crop in a year, ton and
$S_{other}(i)$ = Co-efficient of other crop (ith crop)

Agricultural residues used as fuel

Crop residue used as fuel is determined by using the following formula:

$$CR_{fuel}(i) = CR_{total}(i) \times F_{cr}(i)$$

Where, $CR_{fuel}(i)$ = Crop residues used as fuel of (i) crop, ton
$CR_{total}(i)$ = Total crop residues production of (i) crop, ton and
$F_{cr}(i)$ = percentage of the crop residues of (i) crop used by the farmer

Fraction of crop-residues used by the farmers is determined from the question to the individual farmer and average value is calculated by the following equation:

$$F_{cr} = \frac{\sum_{i=1}^{n} P_{cr}(i) \times f_{cr}(i)}{\sum_{i=1}^{n} P_{cr}(i)}$$

Where, F_{cr} = Average and use coefficient of a particular crop f certain Socio-economic class,
$P_{cr}(i)$ = Crop residues production of the (i) family, ton
$F_{cr}(i)$ = Percent of crop residues used as fuel by the (i) family
n = Number of family in a certain class.

Biomass from Droppings Leaves and Twigs

The estimation of natural dropping of leaves and twigs were based on gathering by the farmers. By field study data amount of gathered leaves and twigs per household per day was determined and then estimated the amount on year basis, multiplying the amount by the calorific value of the leaves and twigs.

Biomass from Livestock

Cowdung

The total number of cattle present in the household was recorded. The quantity of cowdung (dry basis) was calculated by multiplying the cowdung production per hard per year and the number of cattle in the household. The cowdung (dry basis) quantity per head per year was estimated as 0.49 ton for Mymensingh area (Chowdury *et al.* 1987).

Goat facieses

The dry biomass obtained from goat faces per household in the study area was also estimated by same method used in cattle. The quantity of dry biomass was estimated as 19.25 kg per goat per year (Shahjalal, 1998).

Poultry excreta

Similar method was also used for estimation of poultry excreta. According to Uddin (1991) average per head poultry excreta production was estimated as 10.95 kg per year.

Total biomass from livestock used as fuel was calculated by the following formula:

$$W_{cd} = \frac{\sum_{i=1}^{n} P_{cr}(i)\times \mathrm{f}_{cr}(i) + G_{dp}(i)\times F_{dp}(i) + P_{dp}\times F_{dp}}{\sum_{i=1}^{n} C_{dp} + G_{dp} + P_{dp}}$$

Where , W_{cd} = Total cow dung used as fuel of ac certain class, ton

C_{dp} = Production of dried cow dung of (i) family, ton

G_{dp} = Production of dried goat faeces of (i) family, ton

P_{dp} = Production of dried poultry excreta of (i) family, ton

F_{dp} (i) = Percentage of dry dung used as fuel by (i) family, ton

n = Number of family of a certain class.

Total fuel consumption for cooking

Total fuel consumption for cooking was calculated by using the following formula:

$$T_{Fcon} = \sum_{i=1}^{n} W_{fuel}(i)\times H_{fuel}(i)$$

Where, T_{Fcon} = Total fuel consumption for cooking, kJ/year.

W_{fuel} (i) = Weight of (i) fuel for cooking, Kg/year.

H_{fuel} (i) = Heating value of (i) fuel, kJ/kg.

n = Number of fuel type.

Homestead Energy use

Homestead energy use for a particular household are estimated through different daily activities performed by the farmers. The activities include energy for Cooking, Parboiling of rice, Burning in pottery works, Lighting purposes, Making smoke in the cow shed, Room heating and Others.

Use of Stove in the Study Areas

Mainly two types of stoves were in use in the study areas for different cooking activates, such as two–mouth mud stove and kerosene stove. The average depths of the mud stoves were 35-40 cm and kerosene stove were 12.7cm. The fuel used were wood, rice straw, husk and jute stick There were no use of electric heater and other type of stoves.

RDA's Biogas Plant

The plants based on Fixed Dome concept was developed by RDA in 2001-2002. Their design is based on principle of "Semi Batch-fed Digester". A combination of batch and semi-continuous digestion is known as semi-batch fed Digestion. It also called Fixed Dome Digester. Such a digestion process is used where the manure from domestic farm animals is sufficient to operate a plant and the same time organic waste like crop residues, agricultural wastes, water hyacinths; weeds etc. are available during the season. But RDA's Fixed Dome BGP use cowdung as the major substrate. This plant has an inlet pipe for daily feeding of manure slurry from animals. The semi-batch fed digester has much longer digestion cycle of gas production as compared to the batch-fed digester. It is ideally suited for the poor or medium peasants having 6-8 cattle's or 8-10 goats to meet the major cooking requirement and at the end of the cycle it gives enriched organic manure in the form of digested sludge.

Improved Stoves

BCSIR and RDA have developed a number of models of improved cooking stoves. These stoves are reported to save 60-75% fuels when compared with the traditional ones, the maximum overall efficiency being 30%.

BCSIR developed stoves save 50-55% of fuel wood and stoves with chimney save 60-70% fuel when compared with traditional ones. RDA biogas stove is available in the local market. All mechanism is same as local biogas stove. But, a mechanism is included in the stoves to raise high pressure in the gas nozzle by closing the inlet air flow and the inlet gas nozzle holes are very fine and different from local gas nozzle hole.

Statistical Analysis

The data for the study were compiled, tabulated and analyzed in accordance with the objective of the study. Statistical measures such as number and percentage distribution, range, mean and standard deviation were used. To find out the relationships between selected variables of the farmers, Pearson's product moment correlation was used.

RESULTS AND DISCUSSION

Sources of Biomass

The villagers used crop field as the major source of fuel and biomass. The degrees of contribution of biomass fuel from the sources were not same for all farm categories. The sources of biomass in the study areas come from different field crop residues, which are cereals (Aus, Aman, Boro of Wheat), pulses (Gram), Jute, oil seeds (mustard, groundnut, etc) and from different vegetable crops. Most of the villagers meet up their biomass fuel from the crop residues (straw, husk, etc.), followed by dry cowdung, leaves and twigs, kitchen by product, etc. As there is no facility of gas, most of the farmers depend on natural sources of biomass. For lack of community forests the farmers collect fuel wood from the homestead forestry. The other sources of biogas production materials are animal excreta, human wastes, kitchen by product etc.

Availability of crop biomass

The availability of potential biomass related to the farmers' category is shown in Figure 1.

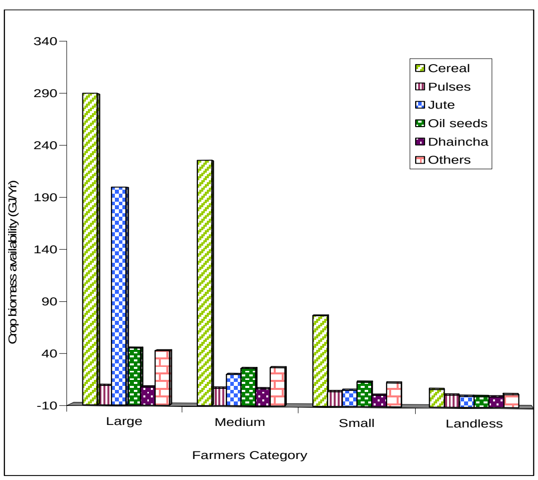

Figure 1. Potential crop biomass availability related to farmers category (GJ/Yr-household)

From Figure 1, it is evident that the production of straw and husk is directly related to farmers' category, as the utilization of land for crop cultivation increases with large land holdings. Therefore, the production of straw and husk increases with the increase of land holdings. Landless farmers and some small farmers do not cultivate Jute for the crisis of land. Medium, large and some small farmers cultivate Jute. So, Jute stick biomass availability increases according to farmers' category except for landless farmer. Dhaincha stick is an alternative of Jute stick in terms of biomass consumption. Large and medium farmers are advanced to produce Dhaincha stick. Small and landless farmers are less advanced to produce Dhaincha stick because of their lands are occupied with other crops. Among the entire farmers category the potential amount of crop biomass are maximum from the cereal. Average 163.36 GJ/Yr-household is supplied from cereals because rice grows in almost 66% of the total cultivated land here. After cereal the position varied according to farmers' category.

Availability of Total Biomass

The potential availability of total biomass is shown in the Figure 2 related to the farmers' category. The average amount of potential biomass availability is 291.47 GJ/Yr-household. Field crops provide maximum amount of potential biomass, 229.61 GJ/Yr-household followed by leaves and twigs, kitchen by product and animal excreta. The total amount of biomass is greater for larger farmers having large land areas. The potential amount of biomass from the leaves and twigs and from the animal excreta are comparatively greater for landless and small farmers, as they have small land holdings. The landless farmers in the study areas emphasize on animal husbandry as an alternative to crop production. Therefore, they obtain large amount of milk and animal dung. Availability of poultry litter is more or less equal for each category of farmers, because every household has on an average 7 to 8 numbers of poultry. The amount of kitchen by product obtained from each category depends on the number of family member and the types of vegetables they consume. Average 17.91 GJ/Yr kitchen by-products per household are obtained from the study areas. The kitchen by product availability for the large farmer is less because of their alternative use and for less number of family members.

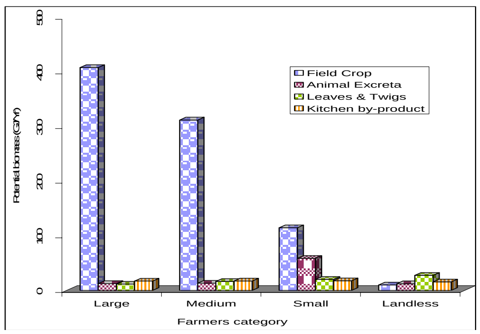

Figure 2. Potential amount of biomass related to farmers category (GJ/yr-household)

Homestead Energy Use

The homestead energy use includes the energy for cooking parboiling, room heating and smoking in cowshed and for lighting purposes. The average homestead energy consumption is 91.41 GJ/Yr-household. Homestead energy use is almost same for large and medium farmer where as it decrease for small and landless farmers accordingly. Energy use is maximum for cooking which accounts 64.34 GJ/Yr-household. Energy use for parboiling increases with the increase in size of the farm holdings. For landless farmers it is 4.40 GJ/Yr-household because of smaller agricultural production, where as, it is 15.64 GJ/Yr-household for the large farm holdings. Energy use for making smoke in the cowshed and room heating increased with the increase of land holdings. The homestead energy use per household related to farmers' category is shown in the Figure 3.

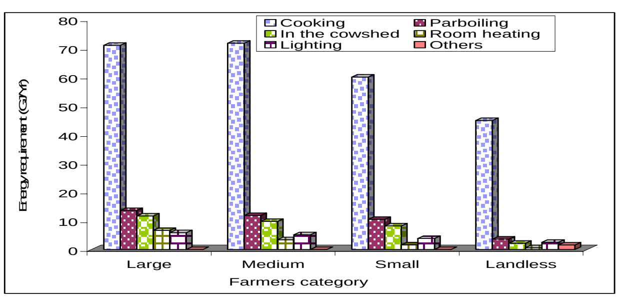

Figure 3. Homestead energy use related to farmers category (GJ/yr-household)

Utilization Pattern of Crop Biomass

The sources and utilization pattern of the crop biomass are shown in Table 1. The utilization of crop biomass includes the use of rice straw, rice husk, jute stick, crop residue (dry plants) and dhaincha. From Figure 4, it is found that most of the farmers use rice straw, as it is readily available. The utilization of rice straw and husk increases with the increase of land holdings of the farmers.

Table 1. Source and utilization of biomass in the study areas

Primary source	Product	Utilization
A. Crop by-products and associates	1. Rice Straw	i. Animal feed ii. Animal bedding iii. Mulching iv. Housing material v. Fuel
	2.Rice Polish	i. Poultry bedding ii. Cattle feed
	3.Rice Husk	i. Fuel ii. poultry bedding iii, Mud plastering
	4. Wheat Straw	i. Fuel ii. Housing material
	5. Jute Stick	i. Fuel ii. Housing material
	6. Mustard Plant	i. Fuel
	7.Vegetabale plants	i. Fuel
	8. Groundnut plants	i. Fuel ii. Animal feed
	9. Weeds	i. Fuel ii. Fodder iii. Compost
B. Animal excreta/waste	1. Cow dung	i. Manure ii. Fuel
	2. Poultry excreta	i. Manure
	3. Cattle bedding material	i. Compost
	4. Goat faceces	i. Manure
C. Homestead plantation	1. Leaves, twigs and branches	i. Fuel ii. Fencing
	2. Wood	i. Furniture ii. Fuel iii. Implement
D. Household waste	1. Kitchen waste	i. Manure ii. Animal feed

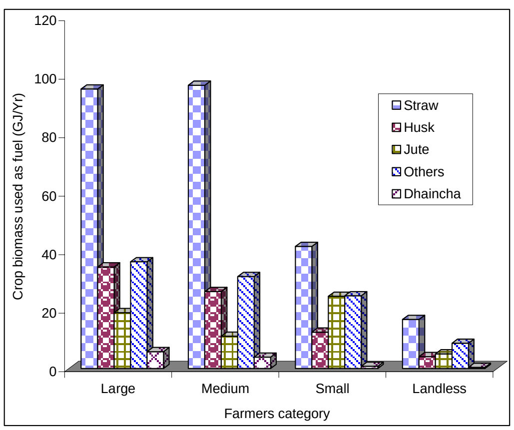

Figure 4. Use of crop biomass fuel related to farmers category (GJ/yr-household)

The utilization of crop biomass is 154.65 GJ/Yr-household in the study areas' where as the potential biomass availability from field is 229.61 GJ/Yr-household. Among the crop biomass rice straw utilization is maximum which accounts 90.93 GJ/Yr-household followed by the dry crop residues, rice husk, Jute stick and Dhaincha. Though there is no availability of Jute stick and Dhaincha at landless farmers' level but they consume it by gathered from the large or medium farmers by selling their labour. Large farmers use crop biomass for diversified works, such as fuel, animal feed, mulching, housing materials etc. The rice bran is mainly used as animal feed. Most of the crop biomass is used as fuel by the small and landless farmers.

Utilization Pattern of Biogas

Utilization pattern of biogas was observed from RDA, Bogra. RDA biogas digester supply biogas to 21 families, 1 VIP guest house for cooking and 1 cowshed for water boiling. On demand this gas is also used for 4KVA biogas generator for production of electricity for engineering workshop.

Economic Analysis of RDA's Biogas plant

The total gas production of RDA bio-gas plant per day was estimated 26.12 m^3 at 150 millibar pressure. The estimated biogas fuel cost of RDA developed BGP (Bio-Gas Plant) was Taka 34658 per month. The return from this biogas plant was estimated as Taka 134400 per month of which return from biogas was Taka 12,000 and selling price from manure was Taka 1, 22,400. Biogas plant produces slurry as byproduct, which produces bio-fertilizer. The return from bio-fertilizer was found much higher than the return from bio-gas. The overall benefit-cost ratio of the bio-gas plant was found 2.87, which was very promising.

The cost of supply of bio-gas per family per month at RDA was estimated as Taka 1506.85, whereas, the cost of supply of LP gas per family per month was Taka 1723.35. Therefore, the RDA is benefited by Taka 216.50 per family per month by supplying bio-gas to its households. However, the RDA authority is subsidizing Taka 1006.85 per family per month by collecting Taka 500 from each household per month and allowing each household a benefit of Taka 1223.35 per month.

Benefits of improved stove

The annual savings would be Taka 20,000 million, if the average biomass price is assumed to be Taka 1.0 per kg. This is about 5% of our national budget. Several attempts have been made by BCSIR for the dissemination of improved stoves under projects financed by the Government of Bangladesh. The total number of improved stoves setup so far is around 3, 00,000. This is a drop in the ocean in consideration of total number of households being 25 million. BCSIR has to do a stock taking. Why the dissemination rate is so slow. It is a mater of common sense that, if the improved stoves save more than 50% biomass fuel compared with the traditional ones, the people should simply jump on it. But the solution is obviously different. There may be a miss-match between the improved stoves design and the types of fuel used. The traditional stoves are usually 15-18 inches deep, in which all kinds of fuels are burnt. None the less there is a lack of public awareness about improved stoves.

Seasonal Variations in Biomass Consumption

There are variations in seasonal consumption of different types of biomass fuel and it depends on the basis of availability, storing advantage, scope of gathering and type of stoves used for cooking. Farmers use cowdung cakes and fuel woods during flooding season, where as, rice straw, day woods, dry cowdung and groundnut plants are used by the farmers during dry or cropping season. The same reasons are equally applicable to the quantitative variation of consumption of biomass fuel per farmer per day during the two different seasons of the year. More over, during the cropping season, few small and medium and all large farmers employed seasonal or daily labours to perform farming activities, which were also responsible for higher per day per farmer consumption of biomass fuel in comparison to that of flooding season. In case of landless farmers, the higher consumption of biomass fuel during the cropping season may be due to type of biomass fuel used, easy availability of this and higher cost of purchasing biomass fuel during flooding.

Problems of Biomass Fuels

The landless farmers have no or little land to obtain crop or plant residue. Their collection of biomass fuel is mainly through gathering and purchasing. The shortage of biomass fuel therefore, in landless farmers' category is expected. For the same reasons, to lesser extent, biomass fuel shortage is observed in the medium and large farmers during December-February is mainly due to their engagement in crop planting and have little scope to procure and shortage in rice straw make it hard to prepared cowdung cakes. The cowdung, which in the forms of cowdung cakes, dry cowdung and cowdung sticks, is used to cook food, which otherwise could be used as manure or soil nutrient enrichment, which in turn would lower the need for chemical fertilizer.

Similarly, except the other uses of rice straw, its use as fuel could lower the availability of rice straw as feed for cattle. The sale out of cattle after harvesting, mostly in the landless and small farms and in few medium farms are observed which with other reasons, may be due to feed shortage.

A number of barriers hold back a large scale development of biogas plants are commercial technology for agriculture (the largest resource base) is not available. It is difficult to make biogas plants cost-effective with sale of energy as the only income. Moreover, planners and decision-makers have little knowledge on biogas technology and it's potential.

CONCLUSION

Biomass is playing an important role for daily energy needs of rural households in Bangladesh. The biomass (such as, tree twigs, leaves, firewood, crop residues, jute sticks, rice husk, rice straw, sawdust, cowdung etc.) constitutes about 60% of total energy consumption in rural areas of Bangladesh. The overall efficiency in traditional use is only about 5-15%. Energy saving technologies should be encouraged for efficient use of available biomass in the country. Biogas plants, improved cooking stoves, biomass briquettes are such efficient technologies. These technologies need to be standardized and encouraged for dissemination at rural household levels in Bangladesh. However, many households may need financial support for owning these technologies. The Government along with NGOs and private sector institutions should initiate programmes for extension and dissemination of these technologies.

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