Published with Open Access at Journal BiNET
Vol. 05, Issue 02: 50-58

Journal of Bioscience and Agriculture Research

Home page: www.journalbinet.com/jbar-journal.html

Outline of crop biomass utilization in designated rural areas of Bangladesh

Muhammad Ashik-E-Rabbani, Rafiqul Islam Sarker and Md. Abdus Satter

Dept. of Farm Power and Machineries, Bangladesh Agricultural University (BAU), Mymensingh-2202, Bangladesh

ABSTRACT

This research work has been undertaken to collect the primary data on crop biomass utilization among farm households in two selected village, under Karimganj Upazilla of Kishoreganj district. A survey was conducted through interviewing eighty two farmers. Data on cropped area, production and yield, plant and crop biomass, and utilization as biomass were collected from different farmer category. It was found that potential crop biomass availability was 222.57 GJ[1]/Yr per household (16.74 ton/Yr per household). The highest amount of crop biomass was obtained from cereal crops (158.13 GJ/Yr per household) followed by dry plant residues, oil seed residues, jute stick, pulse residues and Dhaincha (Sesbania aculeate). The average homestead fuel energy requirement was 83.86 GJ/Yr per household. Energy requirement for cooking was found maximum, which accounts 57.68 GJ/Yr per household. The utilization of crop biomass increases according to the farmer's economic condition. The utilization of crop biomass was 153.01 GJ/Yr per household in the study area, which includes both the fuel energy and the animal feed. Among the crop biomass, rice straw utilization was leading accounting 91.93 GJ/Yr per household. It was observed that there was surplus crop biomass (69.56 GJ/Yr per household) available in the study area which might be used for other purposes.

Key words: *Crop biomass, biomass energy, energy requirement and rural energy*

Please cite this article as: Rabbani, M. A., Sarker, R. I. & Satter, M. A. (2015). Outline of crop biomass utilization in designated rural areas of Bangladesh. *Journal of Bioscience and Agriculture Research,* 05(02), 50-58.

I. Introduction

Bangladesh, with a total surface area of about 147,570 km^2, is inhabited by about 152 million people, making it one of the most densely populated countries in the world (BBS, 2013). The prospective energy supply of Bangladesh, under conditions of current population growth, constitutes a formidable challenge. There is a clear need to develop indigenous energy sources, especially biomass sources in the developing countries, because of the growing energy crisis.

Fossil fuel as a modern energy carrier produces environmental hazards. Now a days, it is a global concern as an environment point of view (Klaus S. Lackner, 2010). On the other hand, biomass stands

[1] Gigajoule (GJ) is an energy measurement unit

Corresponding author email: ashiks424@yahoo.com (Rabbani, M. A.)
eISSN: 2312-7945, © Rabbani et al. (2015), Questionnaire survey

as a renewable and reliable source of energy if its production and utilization are uniquely balanced and maintained. Biomass is receiving increased attention in developed as well as in developing countries. The combination of heavy dependence on biomass fuels and high population density puts immense strains on biomass production, which must meet the need for food, fuels, building materials and for sustaining livestock from the available limited land. The dominant sources of biomass energy in Bangladesh are crops, crops residue, weed vegetation, forests, homestead plantation and animal excreta. Eusuf (1995) reported that total annual per capita energy consumption of the country in 1995 was estimated at 8.467 GJ. This was among the lowest per capita energy consumption rate in the world. Atikullah *et al.* (2005) reported that the total biomass consumed per year in Bangladesh was about 39 million tones and almost half of this was obtained from the agricultural residues. Bangladesh has achieved commendable growth in recent years. A flourishing economic growth with urbanization and continuing industrialization and development have increased the country's demand for electricity and other energy. About 60% of the total population has access to electricity with the power generation of 292 kWh[2]/person through 8537 megawatt (MW) installed capacity (GISL, 2013).

Shares of commercial energy (coal, oil, gas and hydropower) and biomass fuels were estimated at 3.203 and 5.264 GJ respectively (Islam, 2001). Commercial energy comprising oil, natural gas, coal and hydroelectricity accounts for about one-third of the total energy consumption. The remaining two-thirds are attributed to non-commercial renewable sources. Out of the different renewable sources, biomass, peat, solar radiation, wind and hydropower can be effectively utilized in Bangladesh (Baten *et al*., 2009). Biomass comprises material of tree origin, such as fuel wood, charcoal, twigs and leaves; agricultural residues and animal excreta. The total amount of biomass fuel consumed in the country in the year 2000 was approximately 45 million tons (Khan *et al.,* 2002). The country has limited deposits of natural gas. 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 riverine Bangladesh (Khan *et al.,* 2002). Rabbani *et al.* (2011) observed that there was about 69.56 GJ/yr per household surplus crop biomass energy available in some selected rural areas which might be utilized for further use.

It is a pressing want to estimate the total biomass production and their utilization in rural Bangladesh. But the information available on the current pattern of biomass production and its use is quite insufficient. Biomass assessment is a very complicated task and depends upon biological, environmental, farming activities, socio-economic and political factors. It varies from country to country and also from one region to another within a country. As the country is expected to remain heavily dependent on biomass resources for several decades, therefore, it is needed to formulate a crop biomass based rural energy policy for its future sustainable development and environmental protection. On the basis of the above proposition, the present study was undertaken with the objective to assess the crop biomass use pattern in rural areas of Bangladesh based on their availability.

II. Materials and Methods

Data collection

Two villages named Digharcolla and Neyamatpur of the union Neyamatpur under the Karimganj Upazilla of the Kishoreganj district were selected for data collection. The villages stretch out within the Sylhet Basin (Agro Ecological Zone 21) (TAO, 2013). A micro level study about the production of crop biomass and rural energy consumption was carried out for 82 families from the two villages according to the prepared questionnaire. Before finalizing the questionnaire, it was pretested for judging the suitability to respondent and necessary correction, modification and alterations were done accordingly. 82 farms were surveyed in the study areas. Questions were related to the farmer's family description, land ownership, land utilization pattern, cropping system, farming system and other farm activities that are related to biomass production and utilization as they usually practice. Data were collected through personal interview. The information given by the farmer was oral and from memory

[2] The kilowatt-hour (symbolized kWh) is a unit of energy equivalent to one kilowatt (1 kW) of power expended for one hour (1 h) of time

Corresponding author email: ashiks424@yahoo.com (Rabbani, M. A.)
eISSN: 2312-7945, © Rabbani et al. (2015), Questionnaire survey

because none were maintaining records about collection, production and use of biomass. Farmers were selected randomly from the study areas covering various economic groups shown in table 01.

Table 01. Farmer's category

Farmer's categories according to the lands ownership	Number of family	Percent
Landless (less than 0.2 ha)	12	14.63
Small (0.2 ha – 1.0 ha)	26	31.71
Medium (1.0 ha – 3.0 ha)	30	36.59
Large (3.0 ha and above)	14	17.07
Total	82	100

Biomass production

Biomass from different agricultural crops such as rice (usually cultivated in the Aus, Aman and Boro seasons in a year), wheat, pulses, jute, oilseeds, groundnut, sugarcane etc. and some vegetable crops were selected. Details of the crop to residue coefficients or the energy conversion factors used are shown in Appendix. The crops produce six crop residues, which were considered in the estimation were as follows:

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

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

Where,

R_S = Total rice straw production in a year, ton
$P(AU)_{LCL}$ = Production of local Aus, ton
$P(AM)_B$ = Production of broad casting Aman, ton
$P(AM)_{LT}$ = Production of local transplanted Aman, ton
$P(BO)_{LCL}$ = Production of local Boro, ton
$P(BO)_{HYV}$ = Production of high yielding variety Boro, ton
$S(AU)_{LCL}$ = 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:

$$R_h = P(R) \times S(R_h)$$

Where,

R_h = Total rice husk production in a year, ton
$P(R)$ = 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:

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

Corresponding author email: ashiks424@yahoo.com (Rabbani, M. A.)
eISSN: 2312-7945, © Rabbani et al. (2015), Questionnaire survey

Where,

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

Agricultural residues used as fuel

Crop residues 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 farmer is determined from the question to the individual farmer and the average value is calculated by the following equation:

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

Where,

F_{cr} = Average and use coefficient of a particular crop of 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 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 requirements

Farmers performed different daily activities which required energy or fuel. These activities include energy for cooking, parboiling of rice, burning in pottery works, lighting purposes, making smoke in the cowshed, room heating and so on. Types and amount of fuel required for an individual activity was recorded in kg/month and then converted for the whole year. The fuel requirement was further converted into energy by multiplying each type of fuel with its specific energy conversion factor to estimate individual homestead energy requirements.

III. Results and Discussion

Crop biomass availability

It was observed that abundant biomass resources were available in the research area. Available sources of biomass in the study area includes field crop residues which were cereals (straw and husk),

Corresponding author email: ashiks424@yahoo.com (Rabbani, M. A.)
eISSN: 2312-7945, © Rabbani et al. (2015), Questionnaire survey

pulses, jute, oil seeds (mustard, groundnut etc.) and from different vegetable crops. Available crop biomass is shown in figure 01 according to the farmer's category in the study area. From the figure it was observed that the production of straw and husk was directly related to farmer's category. The potential amount of crop biomass was maximum from the cereal regardless of the farmers' category. Average 158.13 GJ/Yr-household were supplied from cereals. After cereal, the availability of the crop biomass varied according to the livelihood of the farmer.

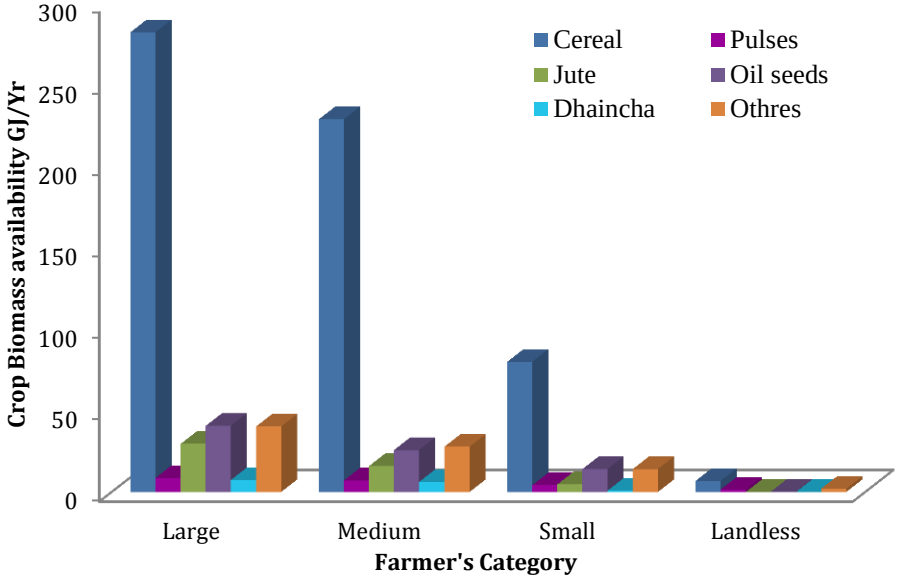

Figure 01. Potential crop biomass availability according to the farmer's category

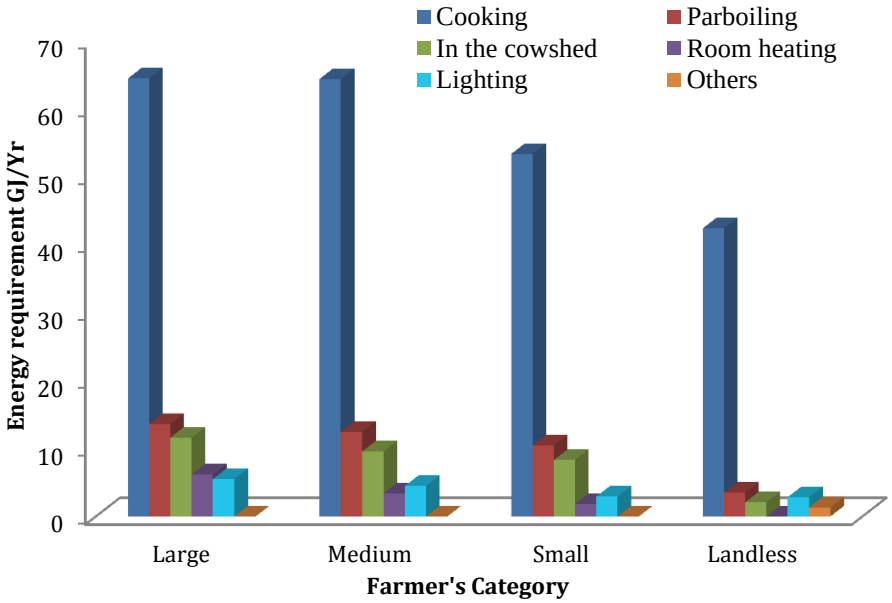

Figure 02. Homestead energy requirements according to the farmer's category

Homestead energy requirement

Energy for cooking, parboiling, room heating and making smoke in the cattle shed, and for the lightening purpose had been included as the homestead energy requirement. Average 83.86 GJ/Yr-household energy was required to meet up the homestead purposes. Homestead energy requirement per household according to the farmer's category is shown in figure 02. From the figure, it was observed that the homestead energy requirement was roughly alike for large and medium farmer and it decreased consequently for small and landless farmers. Energy requirement for cooking was maximum accounting 57.68 GJ/Yr-household. Energy requirement for parboiling for landless farmers were 3.48 GJ/Yr-household where as it was 13.64 GJ/Yr-household for the large farmer. Energy

Corresponding author email: ashiks424@yahoo.com (Rabbani, M. A.)
eISSN: 2312-7945, © Rabbani et al. (2015), Questionnaire survey

required for making smoke in the cowshed and room heating increased according to the farmer's category. Some of the landless farmers are engaged in pottery works. So they use fuel for burning in the pottery works.

Table 02. Utilization of crop biomass

Crop by-products and associates	Unitization
a. Rice straw	1. Animal feed 2. Animal bedding 3. Mulching 4. Housing material 5. Fuel
b. Rice polish	1. Poultry feed 2. Cattle feed
c. Rice husk	1. Fuel 2. Poultry bedding 3. Mud plastering
d. Wheat straw	1. Fuel 2. Housing material
e. Jute stick	1. Fuel 2. Housing material
f. Mustard plant	1. Fuel
g. Vegetable plants	1. Fuel
h. Groundnut plants	1. Fuel 2. Animal feed
i. Weeds	1. Fuel 2. Fodder 3. Compost

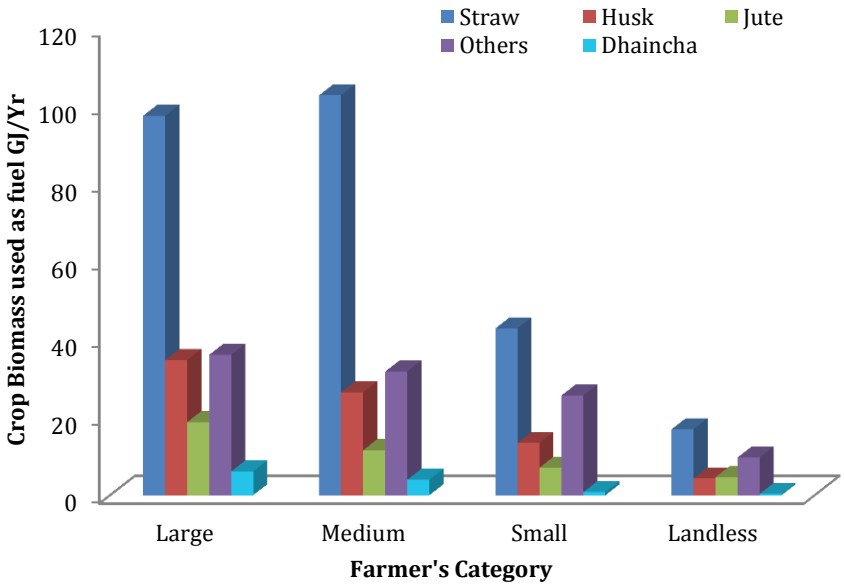

Figure 03. Crop biomass utilization as fuel according to farmer's category

Utilization pattern of crop biomass

Utilization of crop biomass includes the use of crop residues like rice straw, rice husk, jute stick, vegetable residue (dry plants) and dhaincha. Out of available 222.57 GJ/Yr-household crop biomass, an average of 153.01 GJ/Yr-household was utilized by the farmers in the study area. Among the crop biomass rice straw utilization was maximum which accounts 91.93 GJ/Yr-household, as it was available round the year, followed by dry crop residues, rice husk, jute stick and dhaincha. The utilization of rice straw and rice husk increases according to the farmer's category. Crop biomass utilization as fuel is shown in figure 03. Source wise utilization of the crop biomass is presented in

Corresponding author email: ashiks424@yahoo.com (Rabbani, M. A.)
eISSN: 2312-7945, © Rabbani et al. (2015), Questionnaire survey

table 02. Large farmers made use of crop biomass for diversified farm works such as fuel energy, animal feed, animal bedding, mulching, housing materials, etc. Rice bran was mainly utilized as animal feed. Most of the crop biomass was used as fuel for small and landless farmers.

Figure 04 represents the bar graph for the utilization of crop biomass according to use. Energy requirement was maximum for cooking, which accounts 57.68 GJ/Yr-household. Energy requirement for parboiling for landless farmers were 3.48 GJ/Yr-household where as it was 13.64 GJ/Yr-household for the large farmer. Energy required for making smoke in the cowshed and room heating increased according to the farmer's category. Some of the landless farmers are engaged in pottery works. So they use fuel for burning in the pottery works.

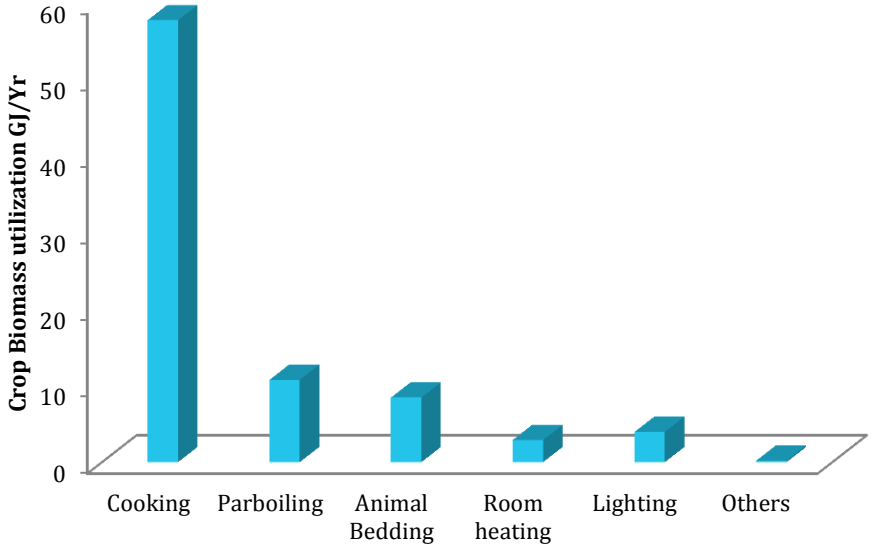

Figure 04. Utilization pattern of crop biomass according to use

IV. Conclusion

Energy is considered as one of the basic elements that are essential for the progress of civilization and all sorts of development activities. National economy is moving faster towards industrial sector than the agriculture sector, which may have resultant effects on the traditional source of energy supply in the future. Since mineral resources are negligible and the energy requirement is increasing exponentially, and thus field level measurement and experimentation are further required to utilize this enormous resource efficiently without any loss. Biomass is an imperative source of energy in rural areas. Rural people are fully dependent on biomass energy for their daily energy needs. Burning of the agricultural residue (26% of the total biomass fuel) is an indication that depletion of fuel wood resources is taking place at faster rate. This fuels over burnt most inefficiently (efficiency less than 10%) in the traditional earthen stoves. Efficient use of biomass resources should be encouraged through the introduction of biogas plant, biomass briquetting, improved cooking stoves, and so on. The rural people specially the woman should be trained for the construction and maintenance of the improved cooking stoves. The Government along with innovative people should make extension works about this technology to reuse the surplus crop biomass efficiently and effectively. The policy makers and national planners in the relevant areas of the industrial, energy and forestry sectors; agricultural development authorities; and rural development authorities are now urgently needed to bring attention on the crop biomass as it is the safe, cheaper and environmental friendly energy sources.

V. Limitation of the study

The farmers could not provide precise data of biomass production because they usually do not measure and keep records of crop biomass. The farmers were ignorant about the crop biomass, which is an enormous source of energy in the rural areas. Many of the farmers were either illiterate or little

Corresponding author email: ashiks424@yahoo.com (Rabbani, M. A.)
eISSN: 2312-7945, © Rabbani et al. (2015), Questionnaire survey

educated persons. Farmers could not provide precise information due to not maintaining any records. The illiteracy and imprecise information of the farmers retarded the speed of the work.

VI. Reference

[1]. Alireza Khoshr, (2014). Energy use pattern and greenhouse gas emission of wheat production: a case study in Iran. *Agricultural communications*, 2014, 2(2), 9-14.

[2]. Atikullah, S. M. & Eusuf. M. (2005). Biomass crisis and improved stoves in Bangladesh. Bangladesh center for advanced studies (BCAS), Dhaka. Energy Newsletter-8.

[3]. Bala, B. K. (1997). Computer modeling of the rural energy system and of commissions for Bangladesh. *Energy oxford*, 22(10), 999-1003.

[4]. Baten, M. Z., Amin, E. M., Sharin, A., Islam, R. & Chowdhury, S. A. (2009). "Renewable energy scenario of Bangladesh: physical perspective," International Conference on the Developments in Renewable Energy Technology (ICDRT) 2009, Dhaka, Bangladesh.

[5]. BBS, (2013). Statistical yearbook of Bangladesh. Bangladesh Bureau of Statistics, Statistics & Division, Ministry of Planning, Govt. of Bangladesh.

[6]. BEPP, (1987). Rural Energy and Biomass Supply, Vol. IV, Bangladesh Energy Planning Project, Planning Commission, Dhaka.

[7]. Binning, A. S., Pathak, B. S. & Panesar, (1983). The energy audit of crop production system research report. School of energy studies for agriculture, Panjab Agricultural University, Ludhiana, Panjab (India).

[8]. Eusuf, M. (1995). ''Dissemination of renewable energy technology in Bangladesh'', paper presented at the workshop on *Renewable Energy Sources: Social Acceptance and Economical Prospects in Bangladesh*, German Cultural Centre, Goethe Institute, Dhaka, 8-11 January.

[9]. GISL, (2013). Present power scenario of Bangladesh. Green Infrastructure Service Limited. http://greeninfrabangla.com/593/.

[10]. Islam, M. N. (2001). Energy crisis: Bangladesh aspects, Gono Mudran Limited, Shahid Rafique-Jabbar Highway, Nayarhat, Dhaka-1344, Bangladesh.

[11]. Khan, A. H. M. R. (2002). ''Renewable energy research in Bangladesh and contribution of BCSIR'', paper presented at workshop on *The Emerging Role of Science and Information & Communication Technology in Bangladesh Development Context*, BCSIR, Dhaka, 24-25 June.

[12]. Klaus S. Lackner (2010). Comparative impacts of fossil fuels and alternative energy sources. Issues in environmental science and technology, 29. Carbon Capture: Sequestration and Storage. Edited by R.E. Hester and R.M. Harrison, Royal Society of Chemistry, Published by the Royal Society of Chemistry, www.rsc.org.

[13]. Rabbani, M. A., Satter, M. A., Inoue, E. & Sarker, R. I. (2011). A case study on the availability of crop biomass in the rural area. The 2nd International Conference on Environmental Aspects of Bangladesh (ICEAB). September 10-11, 2011, Kitakyushu, Japan. Bangladesh Environmental Network, Japan (BENJapan).

[14]. TAO, (2013). Annual report of agriculture, Karimganj Upazilla, Kishoreganj, January 2014.

Corresponding author email: ashiks424@yahoo.com (Rabbani, M. A.)
eISSN: 2312-7945, © Rabbani et al. (2015), Questionnaire survey

Appendix

Energy conversion factors for some crops and crop residues

Crop or crop residue	Energy conversion factors (GJ/t)	Reference
Rice biomass	16.74	Eusuf, 1995
Jute biomass	19.62	
Wheat biomass	16.87	
Dhaincha biomass	19.28	
Banana biomass	15.79	
Crop residue	13.00	BEPP, 1987
Arhar	20.00	
Jute stick	12.76	
Rice straw	12.23	
Rice husk	12.76	
Bagasse	14.50	
Fire wood	15.40	
Twigs and leaves	15.40	
Grain paddy	14.57	Bala, 1997
Grain wheat	14.7	Alireza Khoshr, 2014
Grain mug bean	14.03	Binning *et al*., 1983

Corresponding author email: ashiks424@yahoo.com (Rabbani, M. A.)
eISSN: 2312-7945, © Rabbani et al. (2015), Questionnaire survey