

Analysis of Household Energy Consumption and Energy Consumption Cost (Bio-Fuel) in Rural Areas of Dhaka Division, Bangladesh

Mahadehe Hassan¹, Mohammad Mehedi Hasan²

¹Hydrocarbon Unit (HCU), Energy and Mineral Resources Division, Ministry of Power, Energy and Mineral Resources, Dhaka, Bangladesh

²Department of Petroleum and Mining Engineering, Jashore University of Science and Technology (JUST), Jashore, Bangladesh

Email address:

mahadehe@hcu.org.bd (Mahadehe Hassan), mehedi_pme@just.edu.bd (Mohammad Mehedi Hasan)

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Abstract: With the progress of rapid population growth, the energy demand in Bangladesh has been increasing rapidly over the years, so the main objective of the study is to know the monthly and yearly energy consumption and energy consumption price (Bio-fuel) in the rural areas of Dhaka Division. To achieve the objectives and scope of work of this study, both qualitative and quantitative methods have been used. In carrying out this study, data regarding the environment, challenges, and potential recommendations have been collected from several primary and secondary sources. To collect the primary data, a survey and key informant interviews (KIIs) using semi-structured questionnaires have been carried out on household fuel stakeholders to the rural areas in Bangladesh. To furnish the objectives, primary data on the five key peer district – Dhaka, Narayangonj, Gazipur, Munshiganj and Narsingdi-have been sourced from field data. Based on the secondary data and literature review of some several policy/regulatory and market-related challenges and barriers to bio-fuel are identified in this research. The main findings of the study are as follows-(i) Most rural households still depend on biofuels for cooking and heating. Bio-fuels are: degraded vegetation and forest reserves and agricultural residues. (ii) The smart and clean energy like LPG and electricity though present have limited use by the rural households due to high price and supply and availability of accessories. (iii) Household fuel in rural areas is a critical problem for the rural poor is that teenage boys and girls are engaged in harvesting bio-fuels from nature, hampering their education. (iv) The use of obnoxious materials as fuel is causing health and environmental damage which is causing respiratory diseases among the older and children of the family due to reasons unknown to the users. (v) Due to weak financial capacity of the households, they are deprived of access to modern smart and clean energy. (vi) In most cases housewife's have to bear all the burden of managing fuel for cooking neglecting the health and safety of children. The results of the study show that 82% of households use bio-fuels as their main source of energy, which accounts for an annual energy consumption of 4.68 MTOE in Dhaka Division and a value of \$1.435 billion. Also alternative source of energy such as castor, karanja, pithraj, mahua, jatropa, neem seed, rubber seed etc. have huge potential to be sustainable source of energy to be explored.

Keywords: Bio Fuel, Electricity, LPG, Energy Consumption, Energy Consumption Cost

1. Introduction

Bangladesh is one of the fastest growing economies in the world. Energy is universally demand for human life and livelihood. With the advancement of technology, the demand for energy has increased to improve the standard of living of the common people. The concept of 'fuel' was originally

applied only to those materials capable of releasing chemical energy. A fuel is any substance that can be made by reacting with other substances so that it releases energy as heat energy that can be used for work.

Fuels are dense repositories of energy that are consumed to provide energy services such as heating, transportation and electrical generation. It is recognized that energy/fuel is the key

ingredient to alleviate poverty and to improve the socioeconomic condition of the people of Bangladesh. The availability of fuel and energy is an important determinant of the quality of lives in human settlements. The previous study on the issue have revealed that rural households use fire woods, cow-dung, plant leaves & twigs, branches, paddy straw and rice husk as biomass energy mainly for cooking (98.3%) [1]. It is known from another study that 92% households in the rural areas use biomass, 28% LPG, 89% kerosene, 78% electricity and 27% candle as fuel types. It was found that 56% households have collected biomass from their own homesteads and/or agricultural lands.

Also bamboo, tree branches, cow dung, firewood, rice husk, plant leaves & twigs and paddy straw were found as the biomass for household energy use. In Bangladesh, 3 major types of biomass fuel resources are in common use-wood fuels, agricultural residues and domesticated animal dung. Wood fuels are obtained from different types of forests and plant resources grown in rural areas. A part of the agricultural crop residues available during harvesting of crops and a part of animal dung produced by domesticated animal are being used as fuel. Availability of these resources (agricultural residues, animal dung) as fuel depends on local situation and socio-economic condition of the residents.

An initiative has been taken to conduct a survey to analyzing household energy patterns and energy consumption cost in rural areas and the survey has been conducted by enumerators through physical visits to 306 households.

2. Approach and Methodology of the Assignment

2.1. Approach and Methodology of the Assignment

To conduct the quantitative analysis of the assignment, both primary and secondary data has been used. To capture the real scenario of the selected places, the primary and secondary data were collected. Key Informants Interviews (KIIs) was conducted with relevant key stakeholders using a semi-structured questionnaire to collect the key information.

2.2. Approach/Conceptual Framework of the Study

Our strategies for applying the approaches include several specific steps and activities for accomplishing the objectives. A conceptual framework is presented below:

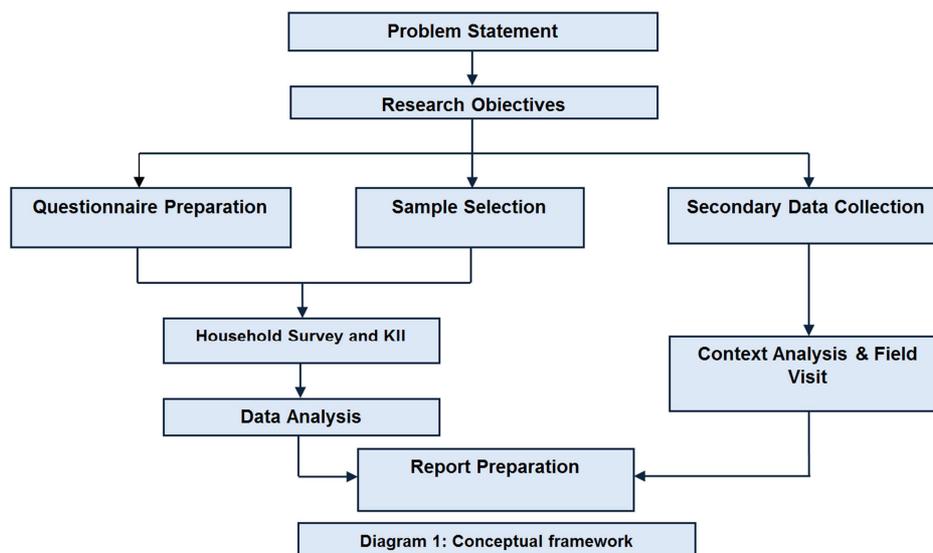


Figure 1. Conceptual framework.

2.3. Target Audience and Respondents Selection Procedures

The targeted households were as follows:

- 1) Sample Rural Household representatives from inside and outside of the surrounding Dhaka North and South City Corporation;
- 2) Community people from the selected study area; and Policy makers and relevant stakeholders of Power and Energy sector.

2.4. Primary Methods

2.4.1. Determination of Sample Size

The study area was first selected to conduct the assignment. Then the sample size from the population was determined. The

sample has been drawn using the following formula: (Ref. Krejcie & Morgan 1970 "Determining Sample Size for Study Activities).

$$n = \frac{Z^2 P(1-P) N}{\{(N-1) ME^2\} + x^2 P(1-p)} \times d$$

n=sample size
 N=Population size (here-10,00,000 as the size of population is unknown)
 P=Population proportion (here 0.5)
 Z=Chi – square for specified confidence interval at 1 degrees of freedom=1.96
 Q=1-P
 ME=Desired margin of error (here 5.66%)
 d=Design effect here (d =1)

Now therefore, using this formula the sample size (n) for household respondents has been calculated as follows:
So,

$$n = \frac{\{(1.96^2) \times (0.5 \times 0.5) \times 10,00,000\}}{\{(10,00,000 - 1) \times (.0566)^2\} + \{(1.96^2) \times (0.5 \times 0.5)\}} \times 1$$

$$\approx 300$$

Thus, the sample size was 300 from the study area.

However, to avoid some error 306 households were taken for individual survey.

2.4.2. Sampling Area

The following districts were selected purposefully to collect data from respective households:

Survey Sample Distributions (District wise)

Table 1. Survey Sample Distributions.

Name of District	Name of Upazila	No of respondents per Upazila	Total
Dhaka	Savar and Nawabganj		30+31=61
Munsiganj	Sirajdikhan and Gajaria		30+32=62
Narayanganj	Rupganj and Sonargaon	30	32+29=61
Narsingdi	Monohardi and Palash		32+29=61
Gazipur	Kaliganj and Kaliakair		30+31=61
Total	10 Upazilas		306

Note: Sample taken randomly and purposively from above selected no. of households. Minimum 30 samples were taken from rural households of each Upazila.

Also, we collected data and information through KII, small discussion meetings, observation/field visits.

2.5. Review of Secondary Documents

The consultants have reviewed the secondary documents related with the study. As such, secondary data sources like policies, rules and regulations, reports etc. The following secondary documents were reviewed:

- 1) Relevant existing basic documents;
- 2) Relevant policy and strategy;
- 3) Program/project documents;
- 4) Relevant Study reports;
- 5) Relevant survey Reports, Journals, Publication, Newspapers etc.

2.6. Detailed Method of Data Collection

2.6.1. Design of the Study

The study, proposed approach and methodologies. Besides, consultations were conducted with the relevant authority. The questionnaire was prepared by our team based on the objectives, scope of work, needs and indicators of with the concerned authority to cover the required indicators. The questionnaire was pre-tested in the study location and finalized with inclusion of modifications, changes and additions of important issues and reflect the indicators relevant to the objectives of the study as well as consistent with the scope of work.

Kobo Toolbox is used for field data collection for use in challenging environments. Our teams of developers and researchers are used to develop and use the apps. This toolbox stands out for its advanced features like repetitive questions, and skips logic method and has an advanced mode of questions, including photos, collecting GPS coordinates, audio, and video recordings. This tool extremely beneficial in quick and accurate data collection with implementing them. Moreover, this is very easier to collect data by sharing the questionnaire link with anyone and copying the stored data. This practice most beneficial for data collectors to collect research data as part of their study.

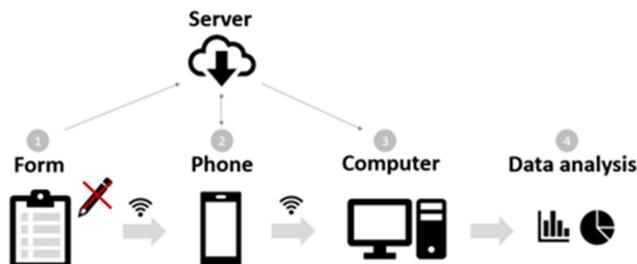
2.6.2. Household Survey

Household Survey is a type of interview with selected household owners that aims to collect detailed data and information regarding the study issues. A total of 306 households were surveyed using structured questionnaire / checklist.



Figure 2. Data Collection Method by Kobo Toolbox.

Figure 3. Data Collectors Collect Information from Household Members on Various Aspects of Fuel Consumption.



2.6.3. Field Data Collection and Field Work Coordination



All field staff has moved to the study area with required number of question/checklists, guidelines and other accessories. The performance of the enumerators was constantly monitored and supervised by the supervisors. The supervisors have checked the completed questionnaires. Most precautions were taken to avoid any drawback or misinformation in the data collection and entry of questionnaires.



Figure 4. Collecting data from fields.

Each enumerator was responsible for collection of data on an average 7/8 household respondents per day and as such 306 respondents was covered in around 7 days. The filled-up questionnaires were also checked and verify properly by the respective supervisors.

2.6.4. Quality Control Mechanism

All members of the consultant team undertake monitoring of field study activities in some places to oversee the study activities to ensure quality. Team leader have visited field to

verify and confirm the study findings with the existing situation. In addition, quality of data collection of the enumerators was monitored over cell phone by the team members as well as the supervisors.

2.6.5. Data Management and Data Analysis

Data management, processing and analysis among others include registration of the questionnaires, coding, data verification and quality control, data punching, data processing and finally the analysis to generate the required output. Registration of questionnaire have facilitated storing and handling of questionnaires during data processing stage.

Computer aided data processing and analysis techniques have been employed for which a systematic approach is followed.

3. Studies on Consequences and Parameters

3.1. Biomass Fuel

At present, Bangladesh is the seventh greatest congested state in earth and biomass offers 73% of the entire energy [13]. Biomass fuels are carbon-based materials that can be gasified in living organisms. Current biomasses of interest for gasification include microalgae, crop residues, animal waste, food processing waste, municipal solid waste, sludge waste and wood waste. But the process of gasification creates critical health hazards and air pollution leading addition of greenhouse gases (GHG) in the environment.

3.2. Sustainable and Modern Energy

Energy is one of the major factors determining the living standard of common people of the country and existing socio-economic condition. Besides, fuel is the most used energy source at the household level to manage various needs of lives and livelihood. The nature of the fuel used is almost the same in the sub-continent. There is a visible variation in types of fuel usage in rural, urban and sub-urban areas. Environmental and health issues are less considered in regard to affordability and availability of fuel to the common people. The use of green and clean energy is still a big question in many parts of the world. Our government have taken initiative to achieve the target of SDGs to bring better future for her people. Government has extended assistance to achieve SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all [8, 10]. Considering the edibility of the following sources to this end, the chance of competition between food and fuel is surely not expected. Castor, Karanja, Pithraj, Mahua, Jatropha, Neem seed, Rubber seed etc. have huge prospects to be sustainable sources of energy and not competing with food [15].

3.3. Fuel Consumption in Context of Bangladesh

Most households use biomass and commercial energy which varies due to availability, affordability, population,

usage and other factors. Here natural gas, electricity, petroleum (petrol, diesel, kerosene, etc.), solar energy, coal etc. are commercial fuel resources. Household left over is one of the main sources of biofuel generation. Household left over is a large source of solid waste, which is approximately 1718 tons/day of a proportion of 49.08% of total solid waste generation [14]. Generally, biofuel resources include forest, agricultural and animal residues along with household waste. Not only in Bangladesh but nearly half of the world's population also live in poor countries and depend on traditional biomass resources to meet their basic fuel needs [2]. This is due to the financial issue and lack of awareness among the mass people. The covid-19 pandemic and recent instability have created additional tremendous financial pressure on the common people. These adverse situations have a direct influence on use of biomass fuel. According to SDG 7: Ensure access to affordable, reliable, sustainable and modern energy are still fundamental concerns of ensuring access to electricity and clean cooking energy remain as a burning questions for Bangladesh. It's not only for our country; many other countries are still struggling with it.

Currently around 2.7 billion people worldwide are lacking in access to clean cooking and the share of the world's population with this access have increased from 57% to 62% between 2010 and 2017 [3]. At the current rate of progress, the world's share of people without clean cooking will be 30% or 2.3 billion people by 2030 [3]. Bangladesh is one of them.

Energy consumption has rapidly grown in the last two decades in the country. Further, reliance on traditional fuels is high, with over 92% of rural households depending on biomass for cooking [4]. According to the Multiple Indicator Cluster Survey (MICS)- 2012-2013 conducted by UNICEF (2015), the majority of households in Bangladesh use solid fuels for cooking (88.2%) and the use of wood plays a significant role (67.6%) [5]. The use of solid fuels is average in urban areas (58.3%) than in rural areas, where almost all households (96%) use solid fuels [5]. Around half of the urban households (50.5%) and 72% of rural households use fire woods for cooking [5].

The findings from BDHS (2014) suggest that 82% of households in Bangladesh use solid fuel, including wood, residue of crops, animal dung, straw, shrubs, grass and charcoal: 50% in urban areas and virtually all (95%) in rural areas [6].

As a result, carbon dioxide emissions and household air pollution have increased a lot and this is causing several respiratory diseases for children, women and elderly people. On the other hand, the forest area of Bangladesh isn't adequate to support this. Every year deforestation is increasing alarmingly. Here, the forest resources are unsustainable due to the high demand for firewood at the household level. This demand will create a scarcity of firewood supply shortly. Therefore, sustainable forest and energy policies must incorporate supply-side management through resource development and demand-side management through energy efficiency gains. Thus, the formulation of bioenergy-based rural energy strategies either at regional or national level requires a detailed and accurate

assessment of the range of biomass fuel choices, existing biomass fuel resources and the involvement and attitudes of people in terms of bioenergy resource development. Therefore, it is essential to explore and analyze the preferences and attitudes of rural households concerning the existing biomass fuel resources, market strategies and their acceptability.

In urban areas, solid fuel is less used at the household level. Here commercial fuels like fossil fuels, LPG and few solid fuels are used mainly. But this is unacceptable in national context. The use of clean energy has to be widely used for here. The semi-urban area here faces more challenges with the use of energy. Due to the complexity of pipeline connections and the rising price of fossil fuel, people are struggling a lot. They tend to use more biomass or biofuel to fulfill their daily household energy need. Besides, education and awareness also play a vital role in choosing the type of fuel in any region. Households whose head of the family has a higher level of education are more reliant on clean and efficient fuel [7]. With the family size, income and other parameters, educated and energy aware families also consider the issue of clean energy and prioritize the critical cost analysis with future long-term impact.

Here, health issues and safety measures play a vital role in taking such kind of decision. But the economic instability will increase the stress on fragile household survival. Localized intervention to manage renewable energy in reasonable financial conditions will change the scope of work in developing countries like Bangladesh. More research and educated persons promote more use of clean and renewable energy. Education and awareness will ensure the best use of the technology to produce green and clean energy. With the advancement of technology and the initiative from Government, the use of electricity is increasing day by day.

3.4. Comparative Analysis on Green and Clean Energy

Separating and being aware of the use and sources of energy is essential. It helps to identify the annual cost and energy consumption, which helps to reduce the unnecessary use of household energy. At the same time, one has to consider the transportation, process, labor, and management cost. We often don't consider such charges as biomass resources are available around us. But the moment we track such accounts, it will be apparent that fuel isn't cheap. Environmental issues and health hazards should also be considered in the long term. In many cases, labor cost is not considered as the women do. There is plenty of scope to work with the use of bio-mass fuel.

The pipeline gas connection in Bangladesh is yet to be established. It's tough to ensure the link in every household. Again, every area doesn't have a natural gas reserve, and illegal connection in the urban area is also a matter of concern. So, for households and many industries, Liquid Petroleum Gas (LPG) is a great solution. It is recommended globally to reduce pollution and adverse health hazards. Adoption of LPG in resource-poor households such as South Asia is low and driven by many factors. In Bangladesh context, we have to depend totally on the foreign market for LPG. There is a fluctuation in the cost due to many global issues and sometimes it becomes a burden. So, before establishing renewable and affordable

energy sources keeping LPG and cylinder connection in a reasonable condition is a prerequisite. Besides, it has become a common phenomenon on the occurrence of accident in households' level while using the firewood for cooking.

It is to be mentioned that many developed countries have already become dependent on biofuel as the sources of biofuel are renewable. In contrast, it has the potential to replace fossil and biomass fuels. Among different biofuels, biodiesel has a vast prospect of being a sustainable green energy source, as many edible and nonedible sources of biodiesel are available in Bangladesh. The frequently used biofuel is Ethanol as well as Biodiesel. Biodiesel is generated in numerous states as a substitute for diesel fuel. But more research and work are needed to use biomass in an environment-friendly manner and increase the use of renewable biofuel. Before that, to reduce pollution and health hazard emphasized in the cylinder fuel, keeping its cost affordable is needed.

In Bangladesh, several studies are carried out at the village level to understand the nature and cost of household use of fuel. But understanding the monthly and annual expenses considering all parameters and finding out the alternative comprising green and clean energy is essential at this time. More studies and research are needed to understand the context and develop options in the use of energy. Keeping those in mind, we have carried out a field-level study beside the available literature review to understand the nature and cost of household fuel used in urban areas. Emphasizing alternative sources have also been considered during the field study, which will help us to compare and understand the existing situation.

4. Result and Discussion

4.1. Socio-Economic Profile of the Respondent

a) Respondents Gender

To understand the field-level condition and household fuel consumption and costing, a field study was carried out. Out of 306 respondents, 170 (56%) people were male and 136 (44%) were female. So, the Male -Female ratio is 14: 11.

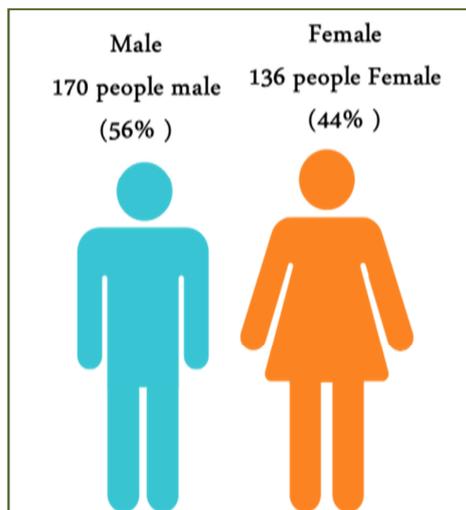


Figure 5. Ratio of the Respondents According to Gender.

b) Respondents Age Range

Table 2. Respondents According to the Age Range.

Age Distribution	Number	%
15-30	71	23
31-45	144	47
46-60	77	25
61-75	13	4
75 above	1	0
Total	306	100

The respondents were from different age ranges. According to the age range, there were 5 groups. 23% of people were in between 15-30 years, 47% of people were in between 31-45 years, 25% of people were in between 46-60 years, 4% of people were between 61-75 years, and one respondent was above 75 age.

c) Geographical Coverage

Data were collected from 49 villages of 28 Union, 10 Upazilas and 5 districts respectively which is presented below.



Figure 6. Data Wage Category.

d) Educational Background of Respondents

It is observed from the survey that 37% respondents have SSC level, followed by 34% primary level, 24% HSC and 6% graduate level. There was no postgraduate level education. It is important to note that there was no illiterate respondent in the survey.

Educational background of Respondents

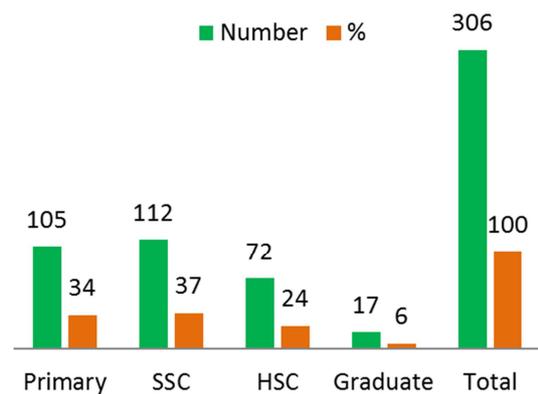


Figure 7. Educational background of Respondents.

e) Occupations of Respondents

It is observed from Figure 4 that majority of the respondents was housewives (39%) followed by 22% businessmen. There were 14% agricultural farmer and 11% private job holders followed by student (3%), drivers (3%), Govt. service (2%), mechanic and carpenter (2%) and other profession (4%).

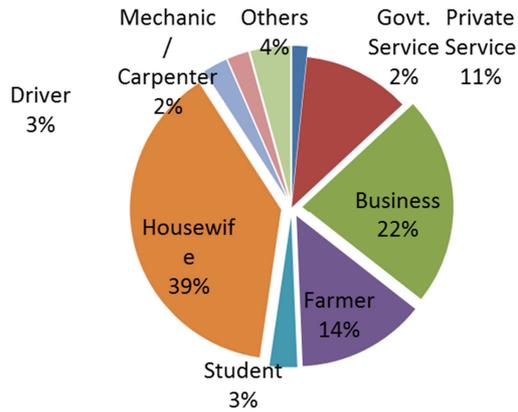


Figure 8. Number of respondents according to occupations.

f) Number of Members in the Household

The number of members in the households under survey is presented below.

Table 3. Number of members in the household.

SL	Number of Family Member	Households	Percentage
1	2	15	6%
2	3	45	16%
3	4	79	26%
4	5	75	24%
5	6	42	14%
6	7	20	6%
7	8	16	5%
8	9	7	2%
9	10	4	1%
10	12	2	1%
11	13	1	1%
Total	79	306	100%

It is observed from the above Figure that 26% households have 4 members, 24% have 5 members followed by 16% 3 members and 14% 6 members. It is important to note that 6% and 5% households have 7 and 8 members respectively. The households even had 10-13 members. Major households (24+26= 50 %) households possess on average 5 members which is in line with national household survey data.

g) Monthly Household Income of Respondents

The income of the households under survey is presented below:

Table 4. Respondents' Monthly Income.

Households Monthly Income	Number	%
Less than \$ 95	34	11
\$ 96-\$190	107	35
\$191-\$ 285	122	40
\$ 286-\$ 380	29	9
\$ 381-\$ 475	8	3
More than \$ 475	6	2
Total	306	100

It is observed from the above Table that 40% households have income \$191-\$ 285 followed by 35% \$ 96-\$190 and 11% less than \$ 95. On the other hand, 9%, 3% and 2% households have income \$ 286-\$ 380; \$ 381-\$ 475 and more than \$ 475 respectively. More than 75% households have income \$ 96-\$ 285. Two percent households had income more than \$ 475.

h) Monthly Household Expenditure of Respondents

The data on household monthly expenditure is presented below:

Table 5. Monthly Expenditure and Household Number.

Household Monthly Expenditure	Number	%
Less than \$ 95	69	23
\$ 96-\$190	134	44
\$191-\$ 285	93	29
\$ 286-\$ 380	8	3
\$ 381-\$ 475	2	1
Total	306	100

It is observed from the above Table that 44% household have spent \$96-\$190 per month for fulfilling basic needs of family followed by 29 % for \$191-\$ 285; 23% for less than \$ 95. Besides, 3% and 1% have spent \$ 286-\$ 380 and \$ 381-\$ 475 respectively. The expenditure incurred by the households in rural areas under survey is acceptable.

i) Monthly Household Savings of Respondents

The data on household monthly Savings is presented below

Table 6. Monthly Savings and Household Number.

Household Monthly Savings	Number	%
Less than \$ 95	282	92
\$ 96-\$190	20	7
\$191-\$ 285	3	1
\$ 286-\$ 380	0	0
\$ 381-\$ 475	1	0
More than \$ 475	0	0
Total	306	100

It is observed from the above Table that 92% household have savings less than \$ 95; per month for fulfilling basic needs of family followed by 7% for \$ 96-\$190; 1% for \$191-\$ 285; Besides, 0% savings for \$ 286 - more than \$475. The savings incurred by the households in rural areas under survey is acceptable.

The monthly expenditure of the households is obligatory for fulfilling basic needs such as food, clothes, medicine, education, social events, energy cost etc. of the family members. If the expenditure is less than the income of a family, then it would help to savings of the family.

4.2. Ownership of Land

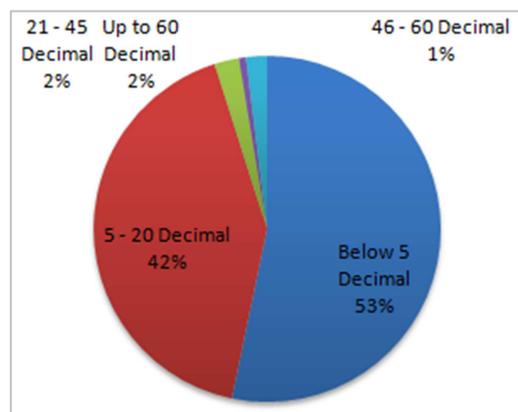


Figure 9. Household ownership land.

80.54% of people in rural areas own houses [9]. Hence, the data on ownership of land is presented in Figure 8. It is observed from the data that 53% household have less than 5 decimals of land followed by 42% for 6-20 decimal of land. Negligible proportions (1%) have 46- 60 decimal of land in their possession.

4.3. Different Energy Sources

The data on sources of energy of the households is presented in Figure 10. It is important to mention here that the respondent had the option to respond with multiple answers. It has been found that the household owners have used energy (cooking) for domestic purpose from different sources. Thus, it is observed that 82% households have used bio-fuels followed by 8% electricity and 7% LPG cylinder. Two percent households have equally used petroleum oil (Kerosene) and Piped line natural gas. On the other hand, 0.75% and 0.25% household have been using solar energy and bio gas for domestic purposes.

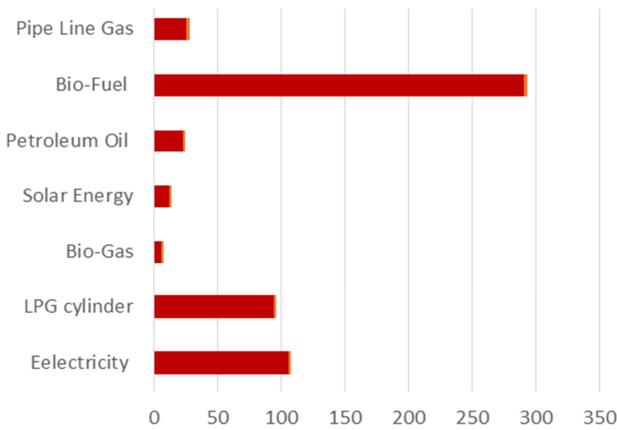


Figure 10. Uses of Different Energy Sources.

It has been noted that the better socio-economic status of a house hold has the option to choose the cleaner energy as the uses of electricity 8%, LPG cylinder 7% and petroleum oil and piped natural gas connection 2%.

So, it is clear that bio-fuel (Forest, Animal and Crops etc.) is the main source of energy for the poorer people of the community. At present our country has 100% household with electricity connection facilitating the use of electric devises for cooking such as rice cooker, magic cooker etc. by the household owners. The availability of LPG cylinder in the nearby market places has promoted the users for their cooking purposes. Besides, petroleum- mainly kerosene is also being used by the user for their cooking purposes. It has been noted that at least 0.25% households are using bio-gas for cooking purpose; which is produced from the fermented slurry of cow dung. A rural house hold uses bio-fuels as well as electricity and LPG cylinder for cooking purpose.

4.4. Piped Line Natural Gas Connection in Locality

In response to connection of natural gas in the household, 99% of the respondents informed that they don't have a pipeline connection in their locality (Figure 10). So, almost all

the households under survey is beyond the piped line connection of natural gas. Though it is available in the urban areas in district and upazila level.

Piped Line Natural Gas Connection in Locality

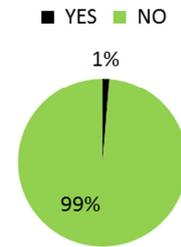


Figure 11. Piped Line Natural Gas Connection in Locality.



Figure 12. A rural family is using cylinder gas for cooking.

4.5. Main Source of Bio-Fuels in Locality

The information on the source of bio-fuels is presented below:

Main Source of Bio fuels/Alternative Energy

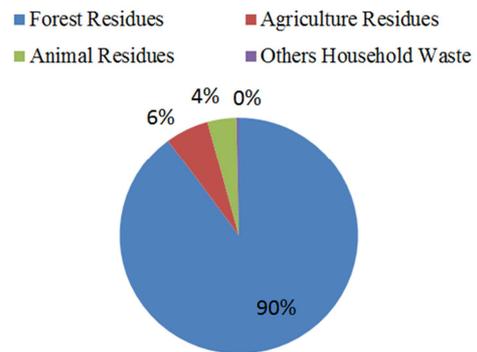


Figure 13. Main Source of Bio-Fuels.



Figure 14. Family that cooks with forest.

It is observed from the above Figure that bio-fuel mainly consist of forest residues (90%) followed by agricultural residues (6%) and animal residues (4%) and few other household wastes. It is important to mention that the bio-fuel consists only 4% animal residues because most of the households don't rear any domestic animals.



Figure 15. Family that Cooks with Agriculture.



Figure 16. Family that Cooks with Animal.



Figure 17. Family that cooks with other household residues.

4.6. Different Forest Residues

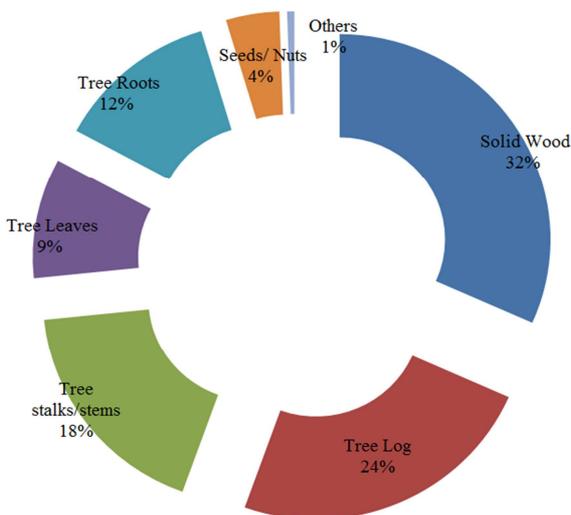


Figure 18. Respondent's Number Using Different Forest Residues.

It has been observed that every parts of a tree are being used as fuel which includes solid wood, tree log, tree stalks/stem, tree leaves, tree roots, seeds/nuts and bark of trees etc. So, nothing is left of a tree in the soil after it is cut down.

4.7. Agriculture Residues/Waste

Except the edible portion of cereals, fruits, vegetables, the remaining portion of the agriculture crop are used as fuel which include straws, leaves, husks/peels, roots, stem/stalks, seeds/nutshells and roots are being used as fuels. The data is presented bellows:

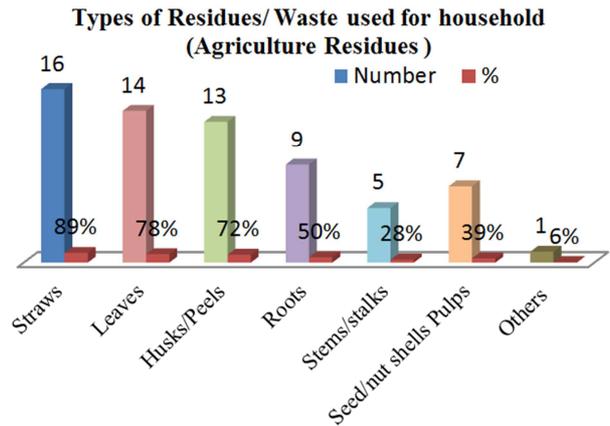


Figure 19. Sources of Agriculture Residues Based on Respondents.

The straws 89% and leaves 78% followed by husks/peels 72% and roots 50% are being used mainly as bio-fuels by the respondents. Thus, the use of agriculture residues/wastes depend on the availability of the ingredients.

4.8. Animal Residues as Bio-Fuels

The dung of cows and buffaloes are mixed and layered on a jute or bamboo stick and then sundried before using it as a bio-fuel.

These are mainly used for cooking purpose. Sometimes the poor women purchase the cow or buffalo dung from dairy farm and prepare this type of bio-fuel and sell it to the users. But in most cases, the cow or buffalo dung is sundried and used as bio-fuel.

The data on using animal residues is presented below:

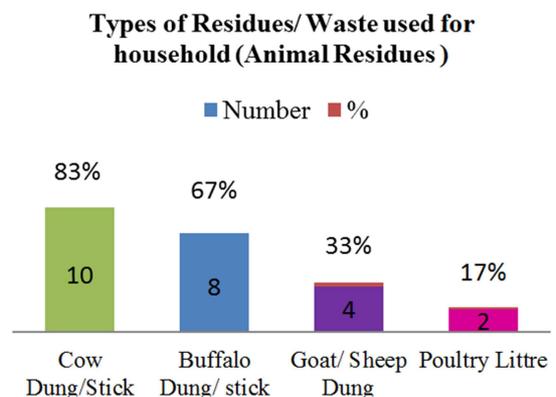


Figure 20. Sources of Animal Residues Based on Respondents.



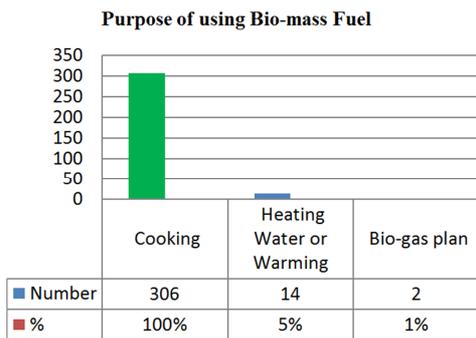
Figure 21. A few Families Are Drying Cow Dung in the sun at Munshiganj's Gazaria.

The cow dung is used by 10 (83%) household followed by buffalo dung used by 8 (67%) households. Few households use goat/sheep dung and poultry liters as bio-fuel.

4.9. Purpose of Using and Negative Impact of Bio-Mass Fuel

a) Purpose of Using of Bio-Mass Fuel

The data on using bio-mass fuel is presented below:



All the household owners informed that they use the bio-mass fuel for cooking purpose. The bio-mass fuel is also used for heating water (5%) and run the bio-gas plat. The presence of bio-gas plant in the survey area is important and symbol of adoption of advanced technology.

b) Negative Impact of Biomass Fuel

Regarding the negative impact of use of biomass fuel, the respondent has negatively opined (12%) followed by positive impact (31%) and 57% opined that they are not aware about the impact (Figure 22).

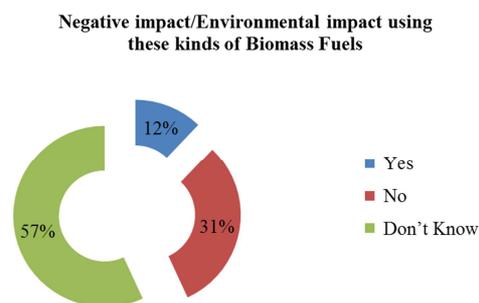


Figure 22. Negative impact/Environmental impact using these kinds of Biomass Fuels.

Hence it is clear that majority respondents are ignorant about the release of CO₂ in the air due to burning of bio-mass and emission of black smoke. This is also responsible for creation of respiratory problem among children and older people in the family.



Figure 23. Individual's Response to the Negative Impact of Biomass Fuel.



Figure 24. Individual's Response to the Negative Impact of Biomass Fuel.



Figure 25. Individual's Response to the Negative Impact of Biomass Fuel.

4.10. Result

a) Average Use of Bio-fuel (kg) and Cost (USD) in Different Upazilas in per Month

The data is presented on average use of fuels/month and average cost in the following Tables 7 & 8 below.

Table 7. Upazila wise average use (kgs) and cost of bio-fuels (USD.) 1USD= 106 BDT.

Name of district	Name of Upazila	Number of Household	Average Number of Family Member	Average use of Bio-fuels (Kgs)/Month	Average Cost of Bio-fuels USD. /Month
Dhaka	Savar	30	05 Nos	154	22.30
	Nawabganj	31	05 Nos	192	18.27
Narayanganj	Rupganj	32	05 Nos	156	17.72
	Sonargaon	29	05 Nos	203	20.66
Gazipur	Kaliganj	30	05 Nos	169	15.48
	kailiakoar	31	05 Nos	158	20.89
Narsingdi	Monohardi	32	05 Nos	201	23.78
	Palash	29	05 Nos	191	25.60
Munshiganj	Gazaria	32	05 Nos	187	24.95
	Sirajdikhan	30	05 Nos	142	16.48
	Average	01	05 Nos	176	20.62

From the above Table 7, it is observed that the household owners used on average 176 kgs of bio-fuels per month with average cost of USD. 20.62. The respondent informed that the bio-fuels available in these areas are used by the household owners as per their demand for domestic purpose. A major portion of the bio-fuels like agricultural residues and animal wastes are collected from the household. In the absence of agricultural residues, the household owner would have to purchase it from the market. A mentionable amount of bio-fuels is also collected from the common forest resources and roadside bushes. The fallen leaves of trees are also a good source of bio-fuels and are collected by the teenage girls and

boys to be used as bio-fuels. In rural areas, the poor household owners who can't afford to buy the bio-fuels from the market is forced to collect the bio-fuels from here and there and it became the responsibility of the teenage boys and girls of the family. In such a situation, the education of the children is seriously hampered. As the forest resources are reducing day by day, the collection of bio-fuels is becoming a challenge and the poor households would have to bear the cost of bio-fuels in addition of their feed items. In regard to price of the bio-fuels, Savar upazila stand topmost with USD 22.30 per month due to limited availability of bio-fuels in the upazila.

Table 8. District wise average use (kgs) and cost of bio-fuels (USD.).

District	Number of Family Member	Average use of Bio-fuels (Kgs)	Average cost of Bio-fuels (USD)
Dhaka	05 Nos	173	20.29
Narayanganj	05 Nos	180	19.19
Gazipur	05 Nos	164	18.19
Narsingdi	05 Nos	196	24.69
Munshiganj	05 Nos	156	20.72
Average	05 Nos	176	20.62

The price of bio-fuels in Dhaka district is the highest amounting USD 20.29 and lowest in Gazipur USD. 18.19. It is important to mention here that the households with minimum amount of monthly income and incapable to shift to other source of energy like LPG cylinder, electric oven etc. are forced to use the bio-fuels for their domestic purpose. The cost of the cylinder with cooker is still beyond the purchasing

capacity of the poor household owners.

A detail study is required to know the energy use by the rural household for their domestic use. The most of the rural areas by this time has been brought under electricity supply with intense initiative from the government. The limitation in the supply and price of electricity is still a barrier to use for cooking and heating purpose.

**Figure 26.** Small Group Discussion with Households Owners.

b) Consumption and Consumption price of Bio-fuel for cooking per year in Rural areas of Dhaka Division

After verifying the report of the Bangladesh Bureau of Statistics, the development research institute BIDS has released the final report of the census and household census. According to that information, the total population of Bangladesh is 16,98,28,911 people [11] Among them the total population of Dhaka Division is 4,56,43,995. The total population of Dhaka City Corporation area within Dhaka Division is 1,02,78,708 people [11].

So total population of Dhaka Division excluding Dhaka City Corporation $(4,56,43,995 - 1,02,78,708) = 3,53,65,287$ people.

Therefore, the total population of the local area of Dhaka Division is 3,53,65,287 people.

As 82% of people in rural area use bio-fuel for cooking.

So the total population of bio-fuel utilization in rural area of Dhaka division $(3,53,65,287 \times 82\%) = 2,89,99,535$ people.

I assumed that the number of people per family is 05 people.

Therefore, the number of household's consumption of bio-fuel in the rural area of Dhaka division is $(2,89,99,535/5) = 57,99,907$.

Each family in the rural area of Dhaka Division consumption an average of 176 kg of bio-fuel per month.

So 57,99,907 families in the rural area of Dhaka Division consumption of bio-fuel on average per month $(57,99,907 \times 176) = 102,07,83,632$ kg.

Energy production from 1 kg of dried bio-fuel is 16 Mega joules [16].

So energy production from 102,07,83,632 kg of bio-fuel per month is $(102,07,83,632 \times 16) = 1,633,25,38,112$ Mega joules.

Therefore, 1,633,25,38,112 Mega joules of energy = 0.39 MTOE [17].

So, Rural area of Dhaka division consumption of bio-fuel for cooking per year $(12 \times 0.39) = 4.68$ MTOE

Each family in the rural area of Dhaka Division consumption an average cost of 20.62 USD of bio-fuel per month.

So, Cost of bio-fuel for cooking per year in rural areas of Dhaka Division = $(57,99,907 \times 20.62 \times 12) = 1,435.13$ Million USD.

5. Major Observations

- (i) Most rural households are still dependent on bio-fuels for cooking and boiling purpose. The use of bio-fuel is responsible for deterioration of plants and forest reserve and consumption of the agricultural residues for cooking purpose.
- (ii) The smart and clean energy like LPG and electricity though present have limited use by the rural households due to high price and supply and availability of accessories.
- (iii) The use of obnoxious materials as fuel is hazardous to health and environment which is unknown to the users. In some cases, it is even responsible for respiratory diseases among the older and children in the family.
- (iv) The rural households are still dependent on the natural

bio-fuels for their cooking purpose and stands behind the modern sources of energy. The weak financial capacity of the households is depriving them from using the modern smart and clean energy. The scenario is changing with time but at a slow rate.

- (v) In most cases the housewives have to bear all the burden of managing the fuels for cooking through engaging her children.
- (vi) It is observed that 95% households use bio-fuels as main source of energy followed by 35% electricity. The LPG cylinder though available in the market is used by richer household owners. So, most of the households still use bio-fuels and one fifth household use electricity as main source of energy (cooking).
- (vii) The rural household at present is spending average USD. 22.62 per month, consumption average 176 kgs bio-fuel per month for fuel purpose and average 5 family numbers are 5 approximately, but it is to be mentioned here that a large portion of the fuel is supplied from his own natural assets and agricultural residues. Here the price of bio-fuel has been calculated on the basis of labour and the estimated price of materials in the local market.
- (viii) The use of alternative source of energy such as castor, karanja, pithraj, mahua, jatropha, neem seed, rubber seed etc. have huge prospects to be sustainable source of energy should be explored.
- (ix) Household fuel in rural areas is a critical problem faced by the rural poor inhabitants. The teenage boys and girls are engaged to collect the bio-fuels from nature hampering their education.

6. Recommendation

- i. The marketing and supply of LPG cylinder should be increased through reducing the price. Government should facilitate the use of LPG cylinder for upgrading the living standard of common people;
- ii. More study is recommended to find out the alternative fuel sources for domestic use with reasonable pricing for the common people.
- iii. Shifting of the rural households from biofuels to other sources of energy is no doubt a challenge to the planners and policy makers. But it is a national demand to reduce the GHG emission to the environment and save the forest and plant resources for a greener and developed Bangladesh in future.
- iv. Emphasis has been given to increase the use of affordable and clean energy in achieve (SDGs # 7) for common people. Bangladesh has put efforts to achieve the targets of SDGs through investment of resources. This is the high time to plan program on the use of clean energy which would be affordable to common people for their use.
- v. The Policy makers and planners should give emphasis on the production of bio-fuel (Bio gas, Bio ethanol and Bio diesel) to be used by common people as resources

of energy (Cooking);

- vi. Police maker, industrialist and academia should be cooperated and collaborated to develop a sustainable national plan/ program on use of energy (Cooking) and formulate a road map for its implementation;
- vii. Hydrogen fuel is an alternate and sustainable options addressing renewable energy to reduce carbon emission & Green House Gas (GHG).
- viii. According to Paris agreement, World's temperature rise should not be exceeding 2 degrees in the next century. To reduce carbon emission, supply of clean and sustainable energy should play an important role for healthy environment and it should be within affordable price.
- ix. Bio fuel can be produced from a variety of plants like rapeseed, mustard, corn, sunflower canola algae, soybean, pulses, sugarcane, wheat, Maize and palm. The most popular option for producing bio-fuels is from non-edible oilseed bearing trees.
- x. Commercial production and use of renewable energy should be emphasized so that people could use it for their domestic purpose including cooking. It would also reduce the dependency on import-based energy (electricity) production and ensure energy security in the country;
- xi. Biogas plant should be scattered and established more in number as Bangladesh is now self-sufficient in milk & meat production.
- xii. The production and supply of electricity have to be increased so that the rural household could use it for their household use.

7. Conclusion

Bangladesh has already achieved the status of mid-level developed country. The lives and living standard of common people of Bangladesh has improved and expected to achieve the status of developed country by 2041. The consumption level of fuel is an indicator of living standard. There is no doubt that shifting of the rural households from biofuels to other sources of energy is a challenge to the planners and policy makers. But it is a national demand to reduce the GHG emission to the environment and save the forest and plant resources for a greener and developed Bangladesh. Both short- and long-term program has to be undertaken to introduce the use of affordable and clean energy (SDG-7) for common people. Bangladesh has put all efforts to achieve the targets of SDGs through investment of resources. This is the high time to undertake a program on the use of clean energy which would be affordable to common people.

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