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Energy Need Assessment and Preferential Choice Survey of Matipukur Village in Bangladesh

by

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Abstract

The aim of this study is to perform a baseline energy survey to understand the existing energy demand and use pattern and to verify the feasibility of a small scale poly-generation project supported by renewable sources of energy (biogas based) in a rural area of Bangladesh. A poly-generation solution shall provide multiple output services of clean gas, electricity and arsenic free water supply. The project requires using animal dung or agricultural waste to produce biogas and electric energy. The study has analyzed the demand of domestic energy and water of the village named 'Matipukur' in the Jessore district in Bangladesh. The study also considered available biomass feedstock and energy potential surrounding the village area, as well as the socio-economic status of villagers. The case study included a door to door survey to collect relevant information. Three different economic groups in terms of income scale were investigated throughout the study to obtain better insight of the energy-water access situation, requirements and related problems in the village.

Almost 98% household of this village relies on biomass for energy due to limited access of modern fuel. The village has various biomass potential in the form of animal dung, fuel wood and agricultural waste which can be used for cooking or serve as the basis for other energy carriers. Kerosene is used for lighting. Among the different fuels, dung meets about 44% of the total demand. The contribution of other fuels for domestic use is 24% firewood, 22% agricultural waste, and 2% kerosene. The analytical observation found that the annual average energy demand of the village is 8.45 GJ per capita. The share of average demand for cooking and lighting energy is 8.24 GJ per person/year and 0.21 GJ per person/year respectively. The energy consumption varies within different income groups. This study has examined the income per capita, family size, education, agricultural land holding per capita, priorities of their annual expenditure etc. which have direct influence on the fuel consumption pattern of the household. It could be observed that expenses on energy changes as the income level increases. About awareness of biogas opportunities and willingness to provide feedstock for a poly generation project, the majority of households answered positively, that is, indicating that they would contribute. Educated respondents showed more positive attitude. Regarding changing of traditional cooking, about 95% of the respondents want to change to a more efficient and reliable cooking system to avoid health and environmental problems associated with indoor biomass cooking.

The study has revealed that only cow dung is not enough to produce clean energy according to demand so the co-digestion method is considered to producing biogas from various energy potentials (animal manure & agricultural waste). The poly-generation system could work with the scenario providing electricity and water supply for the entire household and cooking gas is limited only for 2/3rd household. Rest 1/3rd household from low income group then could be supplied with improve cook stove to meet their daily cooking demand and to minimize indoor pollutions. It is observed that, majority of household has expressed their willingness to provide raw materials for poly-generation plant though they are using.

Key Words: Energy, access, biomass, biogas, poly-generation, household, cooking, lighting, drinking water, Bangladesh.

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Executive Summary

Energy has direct influence on rural development and uplifting social life of rural people. Access to clean energy and water is therefore considered as basic requirements for social development and reducing environmental degradation. Many developing and least developing countries in Africa and Asia are relying on unsustainable energy service and resources and struggling to improve their social life by overcoming poverty trap. Therefore, the rural development strategy should incorporate the socio-economic and environmental aspects. Considering the poor energy access situation and declining availability of fossil fuel resources in respect to the rural area of Bangladesh, Energy and Climate Studies (ECS) proposed small scale "Biogas based poly-generation" technology. The system requires using available biomass resources to provide electricity for heating, cooking, cleaning of drinking water. Thus, the study performs an energy need assessment and preferential choice survey of rural people in a remote village name 'Matipukur' in Jessore district in Bangladesh.

The theoretical and conceptual knowledge from literature review brought in depth of social condition of rural living, energy-water access situation, demand and facts, scopes and challenges of developing new technology in a rural community of Bangladesh. The policy and institutional framework adopted by the country regarding accessing and developing of renewable also discussed in addition to justify the gaps of energy poverty. This research work followed "the participatory rural appraisal method" (PRA) for conducting the energy need assessment and to understand households preferences. Qualitative PRA tools used for preparing questionnaire, conduct interview of different income groups, separating gender; men/women and data collection from site survey. Results of this research work optimized from field survey data and physical observation. The thesis work carried depth insight the problem to realize the water and energy nexus inside the respective village. Various relevant parameters are discussed and investigated defending the facts throughout the report such as available energy potential surrounding the community, energy consumption pattern of households, expenses on energy, choice of technology & priorities of energy, possible economic activities which may accelerate for future if electricity is available etc. Income, education, agricultural land holding, livestock, biomass generation inside the village, knowledge of renewable, willingness to pay for poly generation, heath problem of different group (male/female/children) occurred from water and indoor biomass cooking is also examined during the work.

The thesis examined that villagers are found 'income poor' and 'energy poor'. Households only rely on free biomass consumption for cooking. The energy consumption is limiting by poor economy. Kerosene is meeting light energy demand. The rural community is away from other alternative of accessing of modern fuel. The study performed the energy consumption trend of different income group and found it varies with income of a family. It is also determined the figure of biomass residue (dung and agricultural) production of the village and cross check with the demand supporting poly generation according to current consumption pattern. Opportunities of accessing electric energy may patronize small scale business such as mobile call center, cattle/poultry farm, shop, evening education system for adult men/women etc. Finally, the research work concluded that the cattle dung and the agricultural residue available in the village is sufficient to meet the electricity and water demand of all the households in the village and providing cooking gas to 2/3rd of the household. The rest 1/3rd of low income households might be provided with improve cook stove for efficient cooking and this way they could participate to follow sustainable cooking by reducing environmental and health consequences of biomass cooking. Hence, the concern is as a new technology development poly-generation system may face challenges of financial, policy and institutional constrains and maintenance of system.

2 Introduction

2.1 Background of the study

Unsustainable resources are largely meeting the rural household energy demand in developing countries since several decades to onwards. Due to shortage and unavailability of modern energy at affordable cost, shifting of traditional fuel to modern fuel is great challenge for a developing country. In Bangladesh, about 80% percent of total population lives in rural area as well as village. Most of the villagers are farmer and households are living depending on poorly developed agriculture, fisheries and poultry field (Asaduzzaman et al., 2010). Since the country has the highest population density (745 person/km^2) and growth rate is 2.2% per year, demand of energy uses is growing significantly with the population growth. On the other hand, per capita land is decreasing. So the potential biomass resources are also declining an extreme situation due to unplanned and improper utilization of natural resources (Bari et al., 1997). Rural communities are basically are less fortunate as they are away from access to modern energy supplies. There is no other alternative around to depend on except low grade traditional fuel for cooking and lighting. The electricity production system is also costly and inefficient for those low income populations (Asaduzzaman et al., 2010). Regarding noncommercial energy use by rural population, about 5% of total households can effort using kerosene oil for lighting and cooking. All most every household burns natural wood as main energy for cooking purposes. Therefore, fuel wood requires for cooking are estimated 40 million tons per year which are significantly contributing effects on the environment, climate and land resources (Energy for rural Bangladesh). Beside fuel wood other biomass fuel i.e. agricultural residue, tree branches and cow dung etc. is also considering to meet noncommercial energy demand but it is insufficient and not properly managed.

Traditional fuel such as biomass, kerosene, electricity, candle and LPG are mainly meeting major fuel requirement of domestic energy. Biomass is counting as high potential source of cooking energy since it is solely meeting domestic energy demand (Hassan et al., 2012). Increasing demand of biomass use makes deforestation which causes of biodiversity loss and accelerating explosion of natural wealth as well. Forest contains only 13.3% reservation of total area which is completely unable to meet demand (Bari et al., 1997). Therefore, villager seeks biomass energy from their home-stead area, community plantations and agricultural land which are available around. Another important is monetary cost of biomass which is almost zero or very low cost due to free collection works (Barnes et al., 2010). Thus the actual demand and consumption is bit difficult to understand (Asaduzzaman et al., 2010). Energy consumption per capita is very lower in Bangladesh even among the south Asian rejoin. Only 3% of urban people has LPG access for cooking other then it is expensive for village living people. The country also performing lowest contributor of electricity (182 kWh per capita) as well and rural people has very rare access of it. Low income and slow economic growths are working as major constraints for rural electrification of the country. Poor residents are still relying on low grade kerosene as light energy potential although some alternative electrification program introduced very recently (Talukder, 2010). Only 50 million residents are directly enjoying electricity facilities among 140 million populations. Energy requirement and utilization basically varies with household size, socio-economic status, village condition and country overall situation. Rural people staying behind from blessings of income generation and employment scopes due to lack of modern energy access. Nevertheless, large extent of unsustainable energy uses adverse potential of health risk by indoor air pollution (Bari, 1997). It is examined that better access of clean and efficient energy technology may develop rural life style by eliminate poverty (Renewable Energy Policy of Bangladesh, 2008). There is a huge demand of energy for lightening since most of the villages still away from electrification facilities. To fulfill demand of energy supply for cooking, heating, lighting and drinking water is a big challenge for the country. The nations are deeply surviving due to lack of sufficient & sustainable energy. Clean and efficient energy production and consumption considering the socio-economic and environmental aspects is a fundamental requirement for sustainable development. Therefore, energy need assessment is a vital prerequisite of development new services in rural community.

Country is also suffering for the crisis of pure water supply for drinking and cooking as groundwater is unsafe due to arsenic contamination. Especially the rural community is suffering using of ground water directly supplied through deep tube well. Since surface water is affected by water born bacteria, country has turned to use its groundwater source but arsenic in ground water is now appearing a big threat for public health (Amy Schoenfeld, 2005). Approximately 85% ground water area is identified by arsenic contamination and overall 75 million people of the country are affected of this poison (Md. Safiuddin et al., 2012). Considering the above, rural people genuinely requires to access clean energy and services to meet their basic demand for lighting, cooking and cleaning of drinking water. The alternative renewable technologies such as solar energy, wind energy and hydropower energy etc. are comparatively expensive in Bangladesh due to its; high initial cost, higher cost of equipment, lack of awareness, weather dependence, insufficient fund and lack of established high-volume supplier-dealer chains (Nasima Akter, 1997).

Looking at the unsustainable energy and water access situation of rural living, concept of "Biogas Poly-generation technology" could be a promising solution. The system will require of using biomass resources (animal manure & agricultural waste) as its input material which is adequate inside the village to produce biogas. This biogas will use as cooking gas and beside a part of it could also be used to generate electricity as light energy and waste heat from biogas engine can be used for purifying water in membrane distillation (Khan et al, 2014). Provision of poly-generation system would facilitate villagers accessing of clean cooking gas, electric energy and water supply. Nevertheless, before implementing new technology it requires to investigating the feasibility. Therefore, this research work aimed to provide all necessary information of study population which is required to assess feasibility of poly-generation technology.

2.2 Research objectives

This research work is intended to perform an energy profile carried out from baseline and consumer preferential survey of "Matipukur" village. Result of this survey work will be examine whether the energy access situation of the study village is economically, socially and ecologically viable for developing a small scale "biogas based poly-generation" solution or not. The technological solution upon feasibility will be assessing energy potentials available surrounding the village and how it is utilizing for meeting cooking and lighting demand of households. The study also requires knowing what technology is using for cooking, lighting and reason to change etc. The baseline energy profile is made of comprising available local resources, local needs, preferences of energy & technology and other socio-economic parameters. Therefore, survey work is requiring conducting the following three main purposes:

- To determine the energy and water needs of rural households.
- To understand fuel type use, biogas potential available inside the village, energy consumption pattern and technological preferences of a household for switching of technology.
- To obtain the amount of biogas requirement for the village meeting all three demand of cooking, lighting & drinking water and amount of biogas could produce from available resource potential to run poly-generation system.

2.3 Key research questions

The following questions and relevant areas are discussed and answered throughout the research work:

- How are the energy and water access issues in the village and how energy-poverty-gender linkage is working as barrier for community development?
- How the socio-economic barrier makes differences of preferential choice for energy system and services among poor living people?
- What is the feasibility of introducing biogas based poly-generation to meet their clean energy and water demand?

2.4 Description of study area

The study village name is 'Matipukur' belongs to Navaron of Sharsha upazilla. The upazilla is situated under Jessore district and Khulna Division. The place is very close to the border of west Bengal of India and other nearby upazilla is Chugaccha, Kolaroa and Jhikargachha. The upazilla was established in 1983 and consists of 11 union parishads, 135 mouzas and 172 villages. About 70% of cultivable land of this area is under irrigation and land ownership per capita is 0.15 hectare (BBS, 2007**)**. Area occupied by forest, irrigation and river is 980 acre, 91.062 acre and 250 acre. The place is lies with the bank of Betna River which is under tidal influence. The river Betna, mainly originated from north eastern part of Jessore district and flows to south near Navaron of Sharsha upazila. Upper stream water of this river is being used for irrigation by pumping and downstream of water is navigable throughout the year. The agriculture is hindered due to salinity of water which especially found in from Jessore to Shankarpur area. The salinity problem mainly increases during winter season due to lack of water flow (Masud Hasan Chowdhury, 2012). The Betna River flowing adjoining of India and Bangladesh is known as massive flood region which causes major damage of homestead area, crops and vegetables. The problem also increases the crises of safe drinking water (Uttaran Situation Report, 2004). Other necessary information of this village is presented in table 1.

Table1: Basic data on selected aspects of the study village

Basic Information	
1. Geographical location	23°4.5'N latitude, 88°52'00"E longitude
2. Area	336.34 km^2
3. Population	61 household
4. Population density (person/km^2)	769/km^2
5. Number of household	Rural 940
6. Literacy rate (%)	25.5% (7+ years), national average of 32.4% literate
7. Average temperature	9°C to 41 °C
8. Average annual rainfall	1,537 mm (60.5 in)
9. Main crops	Paddy, jute, sugarcane, tuberose, vegetables
10. Main fruits	Jackfruit, papaya, banana, litchi and coconut
11. Cattle	97
12. Poultry	29

Source: BBS, 2007 *Information and climate data based on upazilla and nearest meteorological station

1.5 Statement of the problem

The whole study work has been presented in two parts. In first part, the study investigates socio-economic status of rural people in the village. This part also discusses the current existing energy (biomass, non-biomass) related problems, potentials & consumption patterns as well estimate the demand. Health and environmental consequences related to using of unsustainable energy and water resources are discussed. Secondly, technological preferences and choice of alternative energy has investigated. A co-relational observation between various parameters in terms of socio-economy has been performed. Opportunities of developing biogas based poly-generation system are also investigated.

1.6 Methodological approach

In this study, "the participatory rural appraisal method" (PRA) is followed for conducting the energy need assessment. The PRA is an effective and well known approach for energy need evaluation in rural community. Specially, this approach is well known for environmental concern and community development (Bhandari, 2003). Therefore, qualitative PRA tools also used for preparing questionnaire, conduct interview of different groups (households & income groups; men/women) and data collection from site survey. The qualitative research method applied to discuss various important parameters (prepare questionnaire, conduct field survey & data collection) of this research and quantitative data collected from field. Qualitative approach used because it is best way for seeking answer of research questions along with evidence; additionally provides proper understanding of research problem. This practice is very efficient for identifying social norms, socio-economic factors, gender roles etc. of a study population. The study is also descriptive and co-relational since it meets every type of queries likes what, when, where, how etc. and find out relationship of different aspects as per the requirement of research work. This is very naturalistic and realistic method which allows direct observation of population and situation and answers all of the questions in a systematic way. This is also rich, meaningful and explanatory method for social research (Mack et. al., 2005).

2.7 Structure of the thesis

Figure-1 gives idea of the structure of this thesis work. This is also established relation between each and every parts of the thesis writing. The first chapter of this report consists of background of the study, objectives of this research, key research questionnaire followed through the study. The chapter also presents profile of the study population, discussed methodological approach and analytical development. Chapter two presents theoretical concept development from literature review. Chapter three reviewed historical strategy of policy development for establish renewable energy system in Bangladesh. Chapter 4 discussed the methodological approach applied for data collection, survey and relevant investigation to obtain better inside of the problem. Results and discussion obtained from field study is presented in chapter 5 and chapter 6 discussed possibilities poly-generation approach. At the end, the study made a conclusion observing the findings of the survey result along with mentioning recommendation.

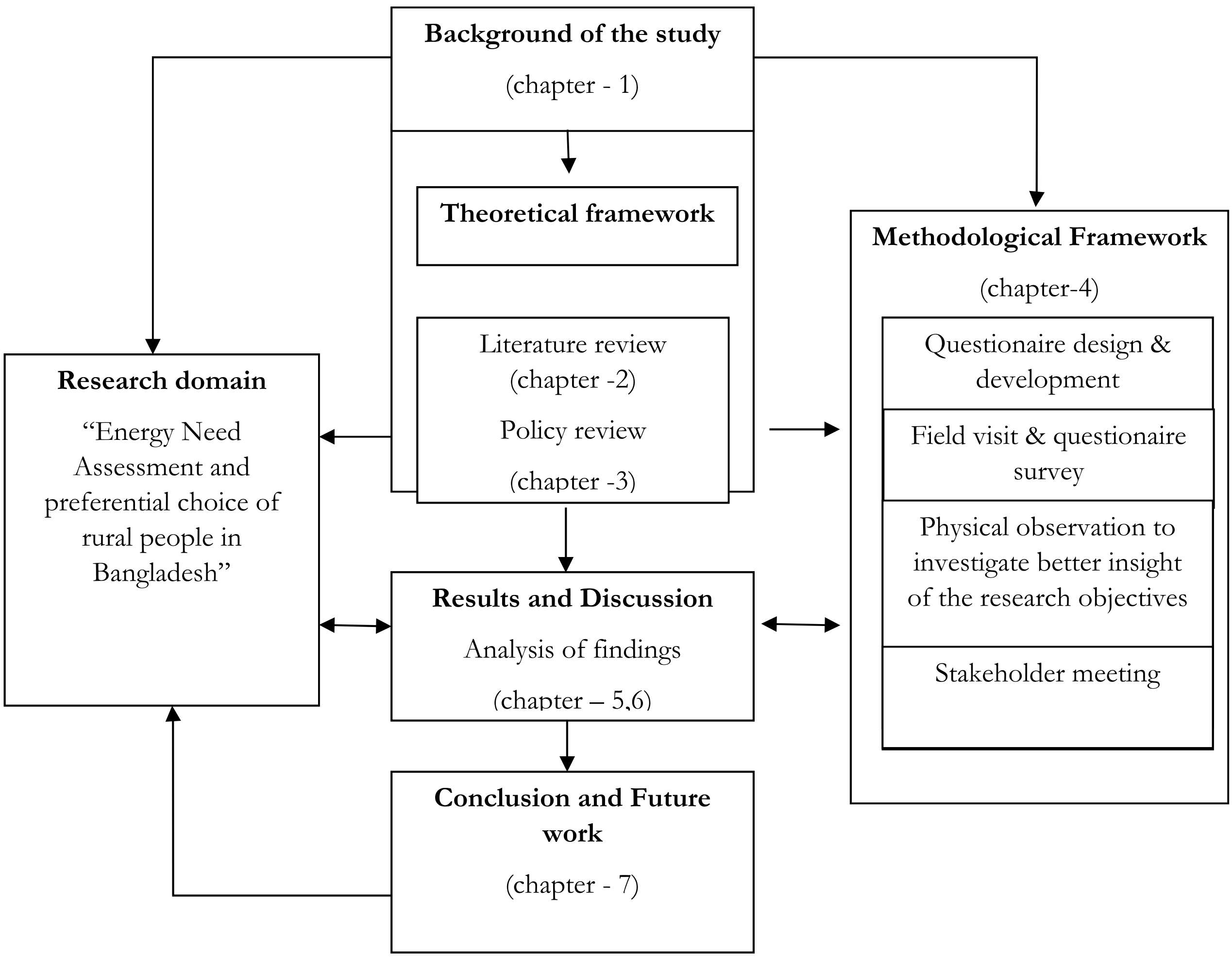

Figure 1: Structural framework of the thesis

2.8 Relevance and outcome of the research

The study performed a statistical analysis obtaining results from integrated all collected information. However, the task was complex to realized actual weight of information during field survey. Despite the facts of data collection, this research work carried out a complete base line energy profile of non-commercial energy use obtaining deeply insight energy related problems, technological preferences on basis of willingness to pay for the systems. Evaluation of energy potential surrounding the area, possible economic development and technological preferences obtaining socio-economic situation of the village has also been made. Outcomes of this study will investigate feasibility of new poly generation concept. It also helps renewable energy developer and policy makers for future development of rural energy sector in Bangladesh.

3 Theoretical framework-concept development

The theoretical concepts will provide better understanding of energy and water access scenario in rural areas of Bangladesh. Clean, efficient, affordable and reliable energy services is desirable for the social welfare. This study has performed a number of literature reviews to obtained information of energy demand and energy access situation of developing and least developing nations in general and Bangladesh in particular. This chapter also discussed relation between energy and sustainable development. Technological aspects, energy ladder and challenges of developing new technology in rural Bangladesh also reviewed throughout the literature study.

3.1 Energy demand and access situation of developing countries

In the past few years, developing countries has significantly contributing effort to improve their demographic condition through developing sustainable services to meet their basic needs. Basic needs are identified based on the development goal of environment, climate and other relevant strategies. Energy and poverty has a clear linkage with the poverty while it constrain for energy access situation. Developing and least developing countries are mainly hunted by energy poverty trap. About 50 countries are identified as least developing (LDCs) which contains 15% of world population. Three key points; low income, weakness of human resources and economic vulnerability are mainly occupied the nations luck. However, to reach the developing country status, least developing countries must have to improve at least two of three key areas. According to the report of united nations, about 1.5 billion people from developing countries are away from the access of electricity and 3 billion people are completely depends on biomass fuel (UNDP 2009). Among them 560 million and 625 million people from sub-Saharan Africa are still behind the access of electricity and modern fuel. Comparatively Asia pacific region has poor access to electricity and the region has lack of modern forms of energy access. Less than 200 million and almost 1.1 billion people of this area have less access of electricity and depend on biomass cooking respectively. Similarly, use of efficient cook stove also very limited within developing countries which are roughly estimated around 27% of biomass relied household using improve stove and only 6% of people enjoying such facilities in LDCs and sub-Saharan Africa. Rely on biomass and inefficient cooking cause's percentage of death especially children and women group are highly effected. Basically, LDCs and sub-Saharan Africa counting highest 50% of death compared to developing countries which is 38% overall. Beside this Indoor emission of solid fuel burning and traditional stove use exposes as global warming potential which are essential to eliminate through achieving energy access target. The LDCs and sub-Saharan African countries are away to reach MGD goal. Nevertheless, to reach the target requires ensure the access of more 1.2 billion people for electricity and 1.9 billion people for modern energy within 2015. It is also notable that strategy, policy and program addressing energy-poverty required improving to motivate local need of a community (Gwénaëlle Legros et al., 2009).

3.2 Rural energy-water access situation in Bangladesh

Few studies made discussion on water and energy access situation rural Bangladesh. Rural energy needs of the country are limited to cooking and lighting. Being a tropical country it does not require heating system even in winter season only few northern places of the country are exceptional (Anjuman Ara Rahman, 2000). The low inefficient biomass has occupied extensive place of rural energy sector in Bangladesh. Among the biomass supply; 7.8% energy comes from animal residue, 27.8% energy accumulated from agricultural residue and 65.2% from tree biomass. Tree biomass is using as vital energy supply sources of domestic cooking whereas kerosene is used for lighting as well as cooking in Bangladesh (World Bank report 1992). A recent statistics assess that biomass fuel meeting 65% of total domestic energy needs of the country (National Energy Policy, 2005). Despite of this high degree of dependency on traditional fuel supplies is now becoming difficult with the time because of rapidly increasing demand. Shortage of fuel wood already has been noticed in a number of places. Women and children of a family spend long time for biomass collection work which refers to insufficient energy supply and health consequences. Shortage of fuel sometimes even forced families to change eating habit one or two meal instead of three per day (Anjuman Ara Rahman, 2000).

Arsenic in ground water situation is another very common in Asian regions. The risk arises from use collecting of drinking water from shallow tube wells. Arsenic in ground water is appearing as biggest threat for Bangladesh since it conserves the highest percentage of arsenic contamination (~20 percent). About 30 million of people depend on shallow tube wells for domestic water use. The arsenic contamination on irrigation water effecting agro-ecosystem services due to land degradation (Alex Heikens, 2006). Arsenic poses with concentration of 0.05 mg/l whether WHO prescribed the standard arsenic level in drinking water that are 0.01 mg/l. Arsenic poison found in 59 districts out of 64 districts in Bangladesh. West Bengal delta region is found mostly effected area because it preserves soil deposition under tidal environment of Bengal basin. (Safiuddin et al., 2012).

3.3 Energy and sustainable development nexus in social and economic context

Energy is addressed as key focus point for developing nation and world development considering its various impact on human life and globe i.e. poverty, global warming, inequality of gender, health problem etc. Many literatures already has presented their opinion on energy-poverty-gender relationship and expressed what facts are working between and where to change or need more focus. The recent study mentioned energy poverty context and trend of energy service use. If the current trends continue then more people will away from modern energy services in 2030 (IEA, UNDP and UNIDO, 2010). Lower incomes household that are away from modern energy services and less able to for energy are mainly called energy poor. About 81% household of the country lives under poverty and are called energy poor. Sometimes non income poor are also energy poor due to unavailability of modern energy services. Energy and poverty relationship basically measured based on per capita income and consumption level. Consumption pattern makes a realization of the poverty status of a family. Consumption level is estimated through actual energy demand and end-user requirements. Type of stove use for daily cooking services is also shows the economic limitation of a household. The study mentioned poor household has no other option except traditional biomass but only scope of choices comes for use and expenditure on energy if their income rises. Findings of this study suggested that policy supporting for rural electrification may play significant role of poverty elevation (Barnes et al., 2010).

Energy and income has esteem and virtual aggregation. A deeper analysis on household energy consumption may constitute better understanding between energy and income relationship since the consumption varies with income and availability (Barnes et al., 2005). Achieve sustainable development through accessing clean energy and water is rather difficult for developing nations due to the poverty trap. Bangladesh is already preoccupied development opportunities. Energy sector is therefore considering vital area of sustainable development for the country as economic sustainability is impossible without relying on modern and efficient energy services. Modern energy access can alleviate poverty and increase economic development of the country. Poverty reduction steps may investigate empowerment of poor through influencing policies, ensuring security by addressing risk and creating opportunities of economic expansion (Elizabeth Cecelski, 2000). To utilize available local energy resources in proper way requires micro level planning to ensure sustainability of energy sector (Shweta Singh et al., 2010).

Gender bias is another concern of sustainable society development. Women group are always dominated by men in developing countries. They are putting more effort and spending rather difficult time for social & household activities compared to men. Even they are more health sufferer then men. Some serious heath diseases due to hauling heavy loads of fuel and water, and from cooking over smoky fires makes them burden to live entire life. Opportunities of income generation and education are limited for women due to lack of modern energy services. Therefore, families and communities are likely to remain trapped in poverty (UNDP, 2001). A comprehensive study of about rural sustainable development discussed of gender issues and energy linkages in relation to international sustainable development. The study recommended to incorporating gender sensitivity into energy and development policies and planning processes since the percentage of women is higher in poor group (women are holding 70% among 1.3 billion poor – UNDP, 1995). With this high degree gender bias, poverty cannot be eliminated. The study illustrates gender issues and presented linkage with energy-poverty and Millennium Development Goal. Energy and gender analysis tools are also discussed to understand of mainstreaming inequality (Yianna Lambrou et. al., 2006). Women's are key economic actor and has important role for sustainable society development. Nevertheless, quality education especially females involving income generation and education system is essential for making gender equality, empowerment of women's and sustainable development (UNDP, 2012).

3.4 Opportunities and challenges of introducing biogas based poly-generation approach to access sustainable energy and water in rural Bangladesh

The biogas technology is already established and using as alternative solution for households cooking in rural Bangladesh. Total 32500 biogas plants have been installed by different organization throughout the country (Grameen Shakti 22000, BCSIR 8000 and LGED 2500), (Mainali, 2012). Most of the biogas plants are installed and operated as domestic and few are community based. It is assumed that, large poultry based biogas plants are more economically viable and community based biogas plants has huge potential including greater environmental aspects (Islam et al. 2006). Other hand, many places of rural Bangladesh are already gained experienced of solar home system powering of television, fan and light as back up of electricity. The solar PV system has a great influence on rural living and may create provision of lighting for evening education system, communal activities, lightening & refrigeration for health care centers and to operate small scale business such as poultry & cattle firm etc. Adoption of poly-generation technology through biogas will reduce the amount of atmospheric pollution of indoor biomass cooking and fuel wood destroying within rural village. The service is fulfilling multiple facilities of clean energy for cooking & lighting and water requirement. Another consequence is economic development through electrification though it's not cost effective most of the cases due to substantial cost and comparing to other investment cost (UNDP-UNEP, 2006).

Hence, development of poly-generation solution indicates to transition from traditional fuel and technology to efficient and reliable supply and service. The transition of fuel refers biomass to biogas and kerosene to electricity and fuel efficient cooking technology. Transitions are associated with income, cost effectiveness, convenience and reliability. Another thing is, choice of technology mainly depends on economy of household (Mainali et al., 2012). The literature "Sustainable Energy for Rural India" has discussed about technological choices and its effects on rural energy sector along with explaining a case of Bhudapada, India and Zambia project. The author mentioned success of a newly developed project depends on acceptance and impact of technological choices. Cost of technology, affordability of residents by meaning whether they are able to afford by their own and maintenance services after implementation is also important variable for switching of technology (Angela Flood-Uppuluri et al., 2008). In a case study of Nepal; the writer showed that financial limitations to invest for technological changes, raw material support, public acceptance and willingness is another important challenge of developing and run a system service among the poor people (Wargert, 2009). Another case study about financing off-grid rural electrification showed; Nepal has achieved significant improvement of awareness level, adaptability of new technology and willingness to pay for renewables are increasing. The study also mentioned there is still lack of big finance between electrification cost and affordability of rural living people which need more consideration for further development (Mainali et al., 2010)

In a flash back, since the country has limitation to provide grid electricity connection and natural gas through pipeline services to remote areas due to higher cost and limited fossil fuel reserve, the best option for scattered living families is to give provision of alternative energy supply. So the biomass based technology has better scope due to availability. Though, the experience of earlier stage in biogas history was not successful because of improper effort and institutional gap (Talukder, 2010). Therefore, the study has reviewed of historical background of energy policy and its development in next chapter.

4 Policy & historical development and its implementation of rural energy sector

The chapter discussed the historical development of energy policies of Bangladesh in a context of sustainable development. The policy development required to review in relation to understanding facts and limitations of discussed in chapter 2. The strategy is connected with development of different sector prior to clean energy requirements. The country is wealthy of natural and renewable energy resources especially it has high biomass potential. Solar, wind, biomass, biogas, hydro, geothermal, tidal wave etc. are main renewable energy resource in Bangladesh. The country already gains initial experiences developing and implementing of sustainable and renewable energy program. The projects are still in pilot phase and needs more scaling up of strategy and financial mobilization to get stability. The discussion will bring understanding of current energy strategies and its opportunities of developing new technologies of rural energy sector.

4.1 Energy and Millennium Development Goal (MDG) in Bangladesh

The link between energy and the Millennium Development Goals (MDGs) has been discussed extensively in the literature (see, e.g. Modi et al. 2005, Nussbaumer et al., 2011) and energy poverty is undermining their achievement. According to UNDP 2012, “Ensuring access of sustainable energy at affordable cost is central for sustainable development and poverty reduction”. That means clean energy services are not only for meeting daily energy demand but also needs to improve social life through elevating poverty and creating income opportunities (AGECC, 2010). Energy and related services has direct influence to economy, society and environmental development issues of a country. Important is that the current energy system unable to meet requirement since the source is inadequate. Though the MGD does not refer to access of clean and efficient energy system and services directly but to reach environmental sustainability, it is prerequisite to discover all of the related matter of sustainable development (Darlan F. Martí, 2010). The report about contribution of energy services to the millennium development goals and to poverty alleviation in Latin America and Caribbean discussed relation of energy services with MGD’s 3, 4, 5 & 7. All Latin American MGD report mentioned the greater extent and important of energy services except report Haiti, 2004 and Bolivia, 2008 (GTZ, UNDP, 2010). Bangladesh is on initial stage of sustainable development. The country has accepted MDG target as key challenge and putting highest effort to achieve the goal. Ensuring of clean, efficient, affordable and reliable energy services aiming towards long term goal may improve nations luck. Sustainable energy and resource use also very essential needs for limiting global warming and socio-economic development. Therefore, the government is now focusing on energy policy and subsidy revision. The govt. also working together with non-government organizations to develop clean energy and water access services for eradicate poverty and develop interface between poverty, environment and climate change. The country has already made a significant improvement of gender equality through empowering women to involving them on different activity (UNDP, 2009).

4.2 Current renewable energy strategies in Bangladesh

Looking at the three main reasons; declining of fossil fuel resources, vision climate change mitigation up to 80% by 2050 and provide energy security, The Government of Bangladesh has decided to implement policy for renewable to maintain a sustainable development in energy sector. Although, the investment for modern energy is much higher than fossil fuel but that is considered for the long term sustainability and aspects of economy, health and future environment of the country. According to the company Act 1994, the government realized to form individual Sustainable Energy Development Agency (SEDA) to linking and comprising sustainable development with renewable energy use and energy efficiency. In 2008 SEDA has been approved by the cabinet to maintaining a co-relationship and assist government taking care of all activities such as development, implementation and promotional related matter of renewable energy technology. SEDA is also responsible for monitor quality and performance of renewable energy technology and encourage people. Even SEDA will consider subsidy for infrastructure development and conduct awareness program discouraging conventional fuel use (electricity, gas). SEDA also facilitate energy efficient lighting, energy cell planning and research unit under The Ministry of Power, Energy and Mineral Resources (MEMR) (renewable energy policies in Bangladesh, 2008). The national energy policy of Bangladesh also revised in 2000 to include sustainable development facilitate to renewable energy sector. Establishing the vision of reliable and affordable energy supply at all level by 2020; Bangladesh government has improved national strategies for development of energy sector. The ambition was to increase scopes of power generation, reliabilities of supply chain, provide security and services according to the demand. Another main target was to achieve eco-friendly environment and energy efficiency through accessing low-emission energy form and renewable resources. The vision of resettlement of policies was to shortage the gap of energy access situation and to bring entire country under electrification by the year 2020 (National Energy Policy, 2005).

Though the environmental policy hasn't guided directly concerning renewable energy sector, this is framed up to protect the environment exploring sustainable fuel uses. It concerned about saving of natural forest reservation and renewable and make sure of sustainable ecological balance. It recommended using alternative energy sources instead of consuming wood and agricultural waste. Also advised to enhanced energy access of rural community through alternative energy development activities. The National Environment Management Action Plan also formed in 1995 addressing the importance of sustainable and renewable energy for environment. Bangladesh also ensures participation in the United Nations Framework Convention on Climate Change (UNFCCC) signing the Kyoto Protocol. UNFCCC is the department of Environment acts as the designated national authority (DNA) which is responsible for climate change mitigation project. According to Environment Conservation Act (ECA) 1995, a law approved to improvement of environmental standards by controlling toxic substances. Objective was designing this law was to control pollution and protect human health. If anybody affected by such activity can get remedy of environmental pollution or degradation. But the policy only highlighted for industrial pollution not for general indoor pollution activities. (Salahuddin M. Aminuzzaman, 2010). The national forest policy of Bangladesh was adopted first introduced in 1979 to save forest wealth and tuned up lastly 1994 to reduce social impacts from rapidly forest degradation. Policy measures to keep preserve of possible areas to meet basic demand for present and future generation enrich biodiversity by conserving natural habitats. Control and mitigate global warming potential from environment, desertification and the control of trade and commerce of wild life. Encourage efficient use of forest wealth and implementation of afforestation awareness (Millat-e-Mustafa, 2002). Nevertheless, the initiatives have been underwhelming and mostly not been implemented (Nur Muhammed et al., 2008).

4.3 Institutional settings for developing alternative energy in Bangladesh

Bangladesh Ministry of Power, Energy and Mineral Resources (MEMR) are the key functioning authority to control energy related activities including the renewable sectors. SEDA is maintaining co-relation activities comprising all sectors. Relevant government and non-government organization is helping to by installing, financing and developing sustainable energy program throughout the country to provide electricity and cooking energy support. Govt. and semi-autonomous government sector such as Local Govt. Engineering Department (LGED), Bangladesh Power Development Board (BPDB), Rural Electrification Board (REB), Bangladesh Centre for Scientific and Industrial Research (BCSIR), the Bangladesh Atomic Energy Commission (BAEC), Rural Electrification and Renewable Energy Development Project (REREDP), Infrastructure Development Company (IDCOL) and among NGOs; German Technical Cooperation (GIZ), Germany's development bank (KfW), Rural Services Foundation (RSF), Grameen Shakti (GS) etc. are working in this sector. IDCOL is working as non-banking financial organization with the support of International Development Agency (IDA). A number of Research and Development Centre for renewable energy technologies are also functioning in Bangladesh (Stakeholder meeting, 2012).

5 Data collection and survey

5.1 Data collection

A questionnaire based survey method applied for data collection. Primary data gathered directly from field through applying door to door interview approach. Interview session was placed during July-August, 2012. Male and female responded were interviewed separately. About 43% male and 57% female were responded from different income group. Relevant organization also visited to get data regarding alternative energy use, cost of energy, water contamination, health consequences, use of cooking technology etc. Unit cost of biomass obtained from local market. Data collection procedure followed following steps.

5.1.1 Questionnaire development and survey

A set of interview questionnaire was formed based on the objective to carry out result of this research work. Structure and development of questionnaire were reviewed from various related rural survey literature. Total 35 questions were prepared considering various aspects of study goal. Questionnaire discovered areas to obtain information about demographic situation, energy (biomass, non-biomass) access situation, resources and livestock, technology use and their preferences, water access condition and health & environmental consequences of a household. Interview session started and ended with asking open and closed ending questions. The interview was based on memory recall and estimates. Original version of questionnaire were formed in English and translated into Bengali since local communication language is Bengali in Bangladesh (appendix: A).

Households were divided into three income category 'Low', 'Medium' and 'High'. Total 61 household interviewed and among them; 20 household considered from low income group, 20 household from medium income group and 21 household of high income group were placed accordingly. The average income of each income group is calculated based on their total income (collected from survey) and divided by total number of household.

1. Low income group: average monthly income per family 3800 taka

2. Medium income group: average monthly income per family 7800 taka

3. High income group: average monthly income per family 41428 taka

5.1.2 Separate interview of male and female

Separate interview were taken of adult male and female (who knows family information very well) group to understand their demographic conditions specifically gender, education, profession and health condition. Then information gathered of socio-economic situation, existing energy resources, problem of traditional cooking, willingness of shifting to modern fuel. Vision was taking interview of women group because housewife and adult female are solely involve and spend most of the time doing household work such as cooking, washing etc. in Bangladesh. Therefore, women group is considered as major household energy consumer. Indirect and different techniques were applied throughout the interview session to obtain information.

5.1.3 Direct observation

Due to living and spending time in the village during survey work, it was really a great opportunity to observe villagers personally and know their daily life. Close attachment with rural people gave the deeper understating of their income and expenditure, social activates, livestock, energy related practices, cooking trend, biomass and non-biomass resources, water situation surrounding village. Also I observed their daily activities which helped me a lot for planning interview schedule as per their convenient time. According to the Chambers, 1997, a personal attachment within the rural area and close observation their life, asking, listening, discussion of resources is a helpful method of getting appropriate scenario and opportunities available behind.

5.2 Limitations and problem faced

Input data of this study was memory recall and estimation based. Respondents were not willing enough to share accurate information of income and resource related matter. In some cases respondent were hesitating to provide information of diseases especially female group. The villagers have time constrains due to the month of holy Ramadan during survey period. So people were fasting daylong which makes them tired. Beside this, villagers were busy to doing their daily work therefore, most cases they showed their unwillingness to give us time for interview. Other important is villagers are expecting for the blessings of rural electrification since long time. Before us few NGO's made survey for electrification purposes but still no initiative taken yet that's why people lose their faith and interest on such survey interview.

5.3 Data processing and analysis

The physical quantities and units of data from primary biomass and non-biomass resources were provided directly from survey. In this research, biomass resources are considered in four categories such as fire wood, dung, agricultural waste (crop residue, tree leaves, straw etc.) and branches. A standard energy unit was considered to measure physical quantities of fuel consumption. Biomass energy calculated in kilogram (kg), for non-biomass; kerosene counted in liter (l), torch in volts (v) and mile-ampere hour (mAh), solar PV in watt and electricity in kilowatt hour (kWh). Microsoft Excel 2010 software used for statistical data analysis, perform a co-relationship test and to observe and understanding of relations between various study parameters. To perform data analysis; firstly, obtained raw data counted in general physical unit (e.g. Kg, liter) were inputted into excel sheet. Then the total consumption in physical units, the energy contents of different fuels was converted into a uniform physical unit MJ (Mega Joules). Energy contents of biomass and non-biomass fuel were carried out from following energy conversion factors (table 2).

Table 2: Energy conversion factors

Source of fuel	Energy content (MJ per unit)
Electricity (kWh)	3.6
Kerosene (kg)	43.0
Fuel wood, traditional (15% moisture) (kg)	16.0
Crop residues (5% moisture) (kg)	13.5
Dung (15% moisture) (kg)	14.5
Leaves and grass (kg)	13.5

Source: World Bank report. *Note:* Energy content = total energy by energy source

Therefore, wood constitutes 16 MJ/kg, dung 14.5 MJ/kg, agricultural waste 13.5 MJ/kg, branches 16 MJ/kg, kerosene 43 MJ/kg and electricity 3.6 MJ/kWh respectively from calculating total consumption. Energy contents of torches and solar were calculated upon uses. Secondly, the sum of energy constitute were converted from Mega Jules (MJ) to Giga Jules (GJ). The analysis represents per capita total primary energy (bio and non-bio energy) consumption in GJ. Finally; a relationship model with different socio-economic components was constructed (e.g. graph, table) to analysis and understands connection between them.

6 Results and discussion

5.1 Social and economic status

In order to understand overall living condition of rural household, the study considered various relevant socio-economic parameters. The study determines average family size of the study population is 4.54 people. According to BBS 2010, the average rural family size is 4.53 people. The average monthly income is found minimum BDT 2000 and maximum BDT 100000. The study found that majority of household (about 85%) household has less per capita income considering the national average per capita income which is 770 USD (1 USD = 81.12 BDT) as per repot of World Bank for the year 2011 (Bank, 2012). The household income seems relatively higher in rich income group. Average monthly income of this group gets sequential break down due to having ownership of a power tiller. Few household brought power tiller for business purposes obtaining bank loan which is payable on monthly installment (BDT 25000 per month). The power tiller is using for cultivate land on rental basis from which the owner earning approximately 1.00.000 BDT/month (ref: respondent). One family has generator power supply business. About 11 families have taken generator connection and using 19 electric bulbs. About 4 family from medium income group and 7 high income family are enjoying this facility. The poor families are still behind of it. Generator electricity charge for each bulb connection is 180 BDT/month.

The major source of income generation sector is agriculture. About 55% of income generates from agricultural activities, 17% from self-employment (e.g. grocery, rickshaw puller, selling vegetable etc.), 15% wage labor, 9% from remittance and 4% from private employment (e.g. school teacher, banker). The average agricultural land area holding household^{-1} is 6768.69 square meters. The low, medium and high level household group owns 1064.32 m^2, 3169.064 m^2 and 15629.643 m^2 of total land properties. Table 3 presents the educational background of survey households distributed by respondent. According to the given information, literacy rate (48%) is bit lower than illiteracy rate (52%) among the residents. National average literacy rate is found about 55.08% in Bangladesh (BBS 2010, p.9). The literacy percentage included basic knowledge which is limited on read-write for communication and signature which is also could consider as illiteracy.

Table 3: Educational qualification of households

Education level	Number of household	Percentage (%)
Illiterate	144	52
Basic Education	37	13
Primary Education	33	12
High School Education	55	20
College/University Education	8	3
Total	277	100

Source: Field survey

Males and females on education are holding 61% and 39% respectively. Even in each income category, females are participating less than male in education (figure 2). A female has less chance to participate in education because they are spending long time for cooking, fuel collection and other household work. Attend to education basically depends on income of a household. The high income group has the highest percentage of education since they are able to pay more than low income group. Beside this, educated peoples get more earning opportunities than uneducated. Specially, education group has more earning opportunity from employment sector. Approximately 25%, 30% and 45% people are attending education from Low, medium and high income group. The low income groups are less attending to education due to limited economy and children either need to contribute for income generation or for family assistance (taking care of junior siblings and contribution to household work).

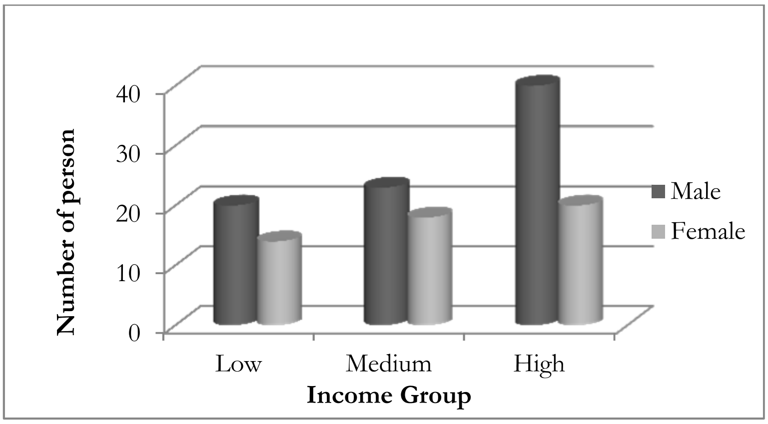

Figure 2: Relation between income and education

6.2 Preferences of Annual Expenditure

To understand the important area of annual expenses was required to assess the socio-economic condition of a household in depth. The study also realized the relation between income and expenses of a family. The observation found that priority of income expenditure of a rural family is mainly limited to fulfilling basic living needs. According to collected information from respondent, the major percentage of expenses goes to food, clothes and heath care purposes which are considering least needs of rural people. After that the priority goes to education and energy, from which residents prefer to pay less for energy than education (figure 3). Specially, the poor resident seeks the benefit of free biomass energy use for cooking. About expenses on light energy, poor and medium income household has limitation on budget. Low income group almost unable to pay and medium income household able to pay least amount compared to rich household. Observing the income expenditure pattern it is found that household's pays only 10% of their income for energy purposes.

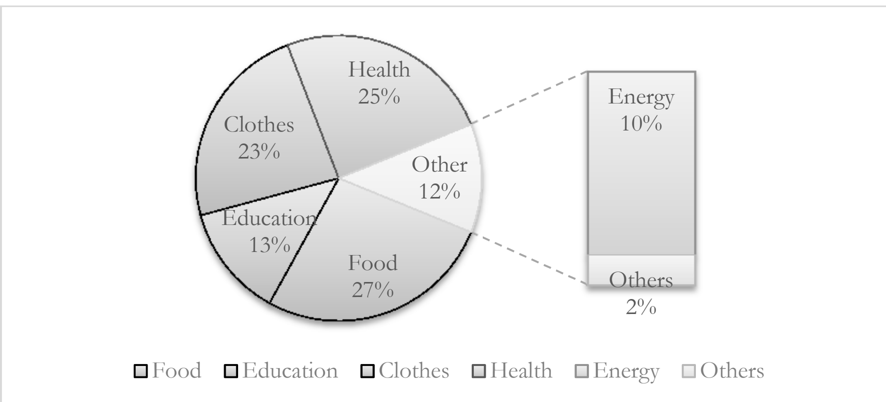

Figure 3: Share of annual income expenditure

The graph represents the annual contribution obtaining from the priorities of income expenditure of survey population (figure 4).

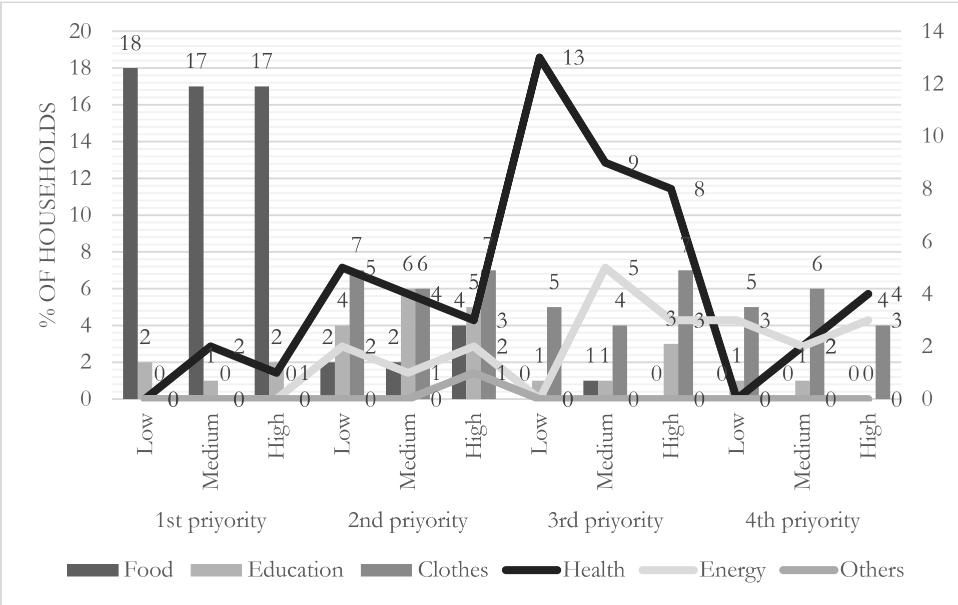

Figure 4: Priorities of income expenditure of three income groups

6.3 Types of energy use

To know the types of energy use were basically required to understand the type and availability of energy source around the village. It is found that the household relies on several types of fuel use for domestic purposes. Major percentage of fuel requirement meets by biomass. Biomass usage constitutes of fire wood, dung, agricultural waste (crop residue, tree leaves, twigs, straw etc.) and tree branches. The villager doesn't have access to LPG basically due to its higher cost (per 12.5 kg cylinder cost BDT 1320) compared to their income and expenditure on energy. Other reason works behind is lack of collection facilities, sometimes not available in local market and carrying cost involved. Biogas plant hasn't developed yet to this village due to lack of technical involvement and knowledge. For non-biomass energy; villager's depends on kerosene, solar PV, rechargeable torch (batteries) and generator electricity. Use of candles are seems relatively expensive considering the price. A small size candle cost BDT 5 per piece and large size cost BDT 10 of each (according to local market). Therefore, families of the study area doesn't use candle. Table 4 presents energy source for cooking lighting.

Table 4: Household energy types and usage

Energy types	Uses	Source of energy
Fire wood	Cooking	Forest trees, homestead trees
Dung	Cooking	Animal
Agricultural waste	Cooking	Agriculture
Branches	Cooking	Forest trees, homestead trees
Kerosene	Lighting	Fossil fuel

Solar PV	Lighting	Markets, sunlight
Rechargeable torch	Lighting	Markets
Generator	Lighting	Fossil fuel

Source: Field survey

6.4 Convenience and method of biomass acquisition

In Bangladesh, rural living people mainly exquisite biomass from their homestead, community and neighbor forest. Biomass acquisition procedures are involved with collection and buy. As per the information of respondent, residents collect 95% biomass energy and buy only 5% of total requirements. Among 95%, approximately 35% of biomass comes from their own agricultural production and rest 60% they arrange from community and forest area. Agricultural waste (crop residue, tree leaves, jute straw and branches) constitutes highest percentage of household consumption. Agricultural waste are basically depends on acquisition. Major percentage of dung used from home based cattle owning and minor percentage is collects and buy from other source. Fire woods are collection from home garden and neighbor forest. A small percentage of wood only use to buy from market (figure 5).

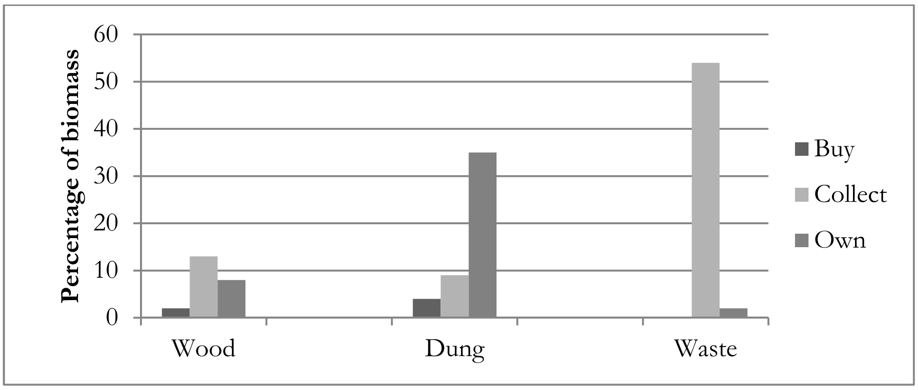

Figure 5: Distribution of biomass acquisition method

About convenience of getting cooking fuel according to the need, 69% respondent said it is difficult sometimes to get biomass according to demand. About 29% are getting biomass easily and only 2% respondent said they are not getting easily (table 5). The convenience of getting sometimes is difficult due to unavailability of resources and seasonal barrier. Especially, during rainy season is very hard to collect dry biomass. Therefore, villagers use to store dry dung for use in rainy season.

Table 5: Convenience of biomass acquisition

Reasons	Number of respondents	Percentage
Yes, easy to get	18	29
No, hard to get	1	2
Sometimes difficult	42	69
Total	61	100

Source: Field survey

6.5 Energy consumption scenario

To make a baseline energy profile of the study population, it was required to obtain total energy use and energy consumption pattern of households. Though it was difficult to understand the actual consumption however the study determined the overall living condition of rural household in order to understanding of fuel consumption pattern in their daily life. The study population was selected considering their present energy access situation. To reach the objective, a comprehensive investigation was made to realize the actual fuel consumption. The respondent informed about biomass fuel consumption on assumption basis which is verified with spot measurement. This physical measurement helped cross checking the values and relate with uncertainties. The spot measurement was taken based on primary assumption of respondent of biomass quantity consumption per day. It is found that the weight of physical quantity observation of various fuel types differs from the respondent virtual assumption. Only 5% household data was verified with physical measurement. Nevertheless, the study provided approximate values of observation which emphasized with previous study of general biomass consumption realities of rural residents in Bangladesh (Asaduzzaman et al., 2010, Kamrul Hassan et al., 2012). Therefore, the assumed biomass energy content figured out close to accurate of real energy consumption value. An insight observation of energy consumption determined that the villagers still highly relies on traditional fuel since this is available around and usage of biomass is almost free of cost. The non-availability and away of accessing modern fuel is also an important reason to relying on traditional energy.

The average biomass energy consumption per family of this village was examined 3.11 GJ per month. The low, medium and high income families consume bio-fuel average 2.5 GJ/month, 3.09GJ /month and 3.73 GJ/month respectively. Fire wood, cow dung, agricultural waste and tree branches are considered as high potential of bio-energy source. Agricultural waste constitute of crop residue, tree leaves, twigs and straws, etc. The villagers are highly dependent of dung because 61 household adopting 107 cows which means every family belongs 1.75 cows. Dung constitutes 45% of total bio-fuel consumption. Dung is not only using for direct burning; also using as fertilizer. It is calculated that the villagers using 70% of dung as fuel and 30% dung for agricultural purposes from total production. Fire wood is considering the second highest energy potential for the village as it holds 24% consumption. Agricultural waste holding 22% and tree branches usage is calculated 9% of total biomass consumption by the households. Consumption varies between different income groups. The low income group found as lowest energy consumer (26%) and consumption has gradually increased in medium and high income group (33% and 41%), (Table 6).

Table 6: Biomass fuel consumption of income group

Income category	Fuel type use	Energy content (kWh/year)	Standard Deviation	Standard Error	Consumption (%)	Consumption (%)
	Fire wood	69593.567			27	
	Dung	106075.985			41	
High (n=21)	Agricultural waste	61380.281	29075.345	±14537.672	23	41
	Branches	24250.9399			9	
	Total	261300.774			100	

Medium (n=20)	Fire wood	41991.359	32246.796	±16123.398	20	33
	Dung	104480.858			51	
	Agricultural waste	43026.187			21	
	Branches	16999.359			8	
	Total	206497.764			100	
Low (n=20)	Fire wood	41799.344	22200.772	±11100.386	25	26
	Dung	75768.561			46	
	Agricultural waste	35310.937			21	
	Branches	13951.116			8	
	Total	166829.959			100	100

Source: Field survey

The observation of non-biomass energy use found that average light energy consumption of household is 0.0805 GJ/month. The Different income group e.g. low, medium and high income household consumes 0.061479 GJ/month, 0.066448 GJ/month, 0.112063 GJ/month and the energy consumption holding 25%, 28% and 47% respectively (Table 7). The low and medium income group is lowest energy consumer comparing the rich group though mid-level group uses bit higher than poor income group. High income groups found as highest energy consumer among three income categories and the consumption showed a dramatic change of light energy consumption pattern. Kerosene is the main source of light energy since it is holding 82% of light energy. Among the other 18% energy, solar energy contains 15% and generator electricity is only 3%. Households are using rechargeable torch but the percentage is almost zero. The poor income group solely depends on kerosene (98%). Mid-level income group use 95% kerosene, 4% generator electricity and 1% torch light. The energy consumption distribution of high income group is 65% kerosene, 31% generator and 4% generator electricity. It is also assumed that the educated family requires more light energy for study comparing non education attending family.

Table 7: Non-biomass fuel consumption of income group

Income category	Fuel type use	Energy content (kWh/year)	Standard Deviation	Standard Error	Consumption (%)	Consumption (%)

High (n=21)	Kerosene	4901.67	1957.001	±978.5007	65	47
	Rechargeable torch	28.7712			0	
	Solar	2365.2			31	
	Generator	290.175			4	
	Total	7585.816			100	
Medium (n=20)	Kerosene	4228.53	1803.227	±901.6136	95	28
	Rechargeable torch	23.976			1	
	Solar	0			0	
	Generator	177.39			4	
	Total	4429.896			100	
Low (n=20)	Kerosene	4027.854	1734.017	±867.0083	98	25
	Rechargeable torch	15.984			1	
	Solar	0			0	
	Generator	54.75			1	
	Total	4100			100	100

Source: Field survey

The energy consumption trend significantly increased from low to high income family (figure 6). Lowest and medium household group using equal quantity of fire wood and the usage is bit high among rich group. Dung use varies between low and medium economic group and the medium and high economic group is consuming pretty much close. Use of agricultural waste and tree branches and light energy are gradually increased among the three consumer group. Obtaining bio energy and non-bio energy consumption situation, it is realized that the energy consumption made by the study population is 8.45 GJ per person/year. According to the study 'Restoring Balance-Bangladesh's Rural Energy Realities' of world bank, a rural Bangladeshi household usually consumes 8.9 GJ energy per person/year (Asaduzzaman et al., 2010, p-12). The report 'An Analysis of Cross-sectional Variation in Energy Consumption Pattern at the Household Level in Disregarded Rural Bangladesh' showed the lowest energy consumption of rural Bangladeshi household is 6.45 GJ per person/year comparing among four different upazillas (Kamrul Hassan et al., 2010).

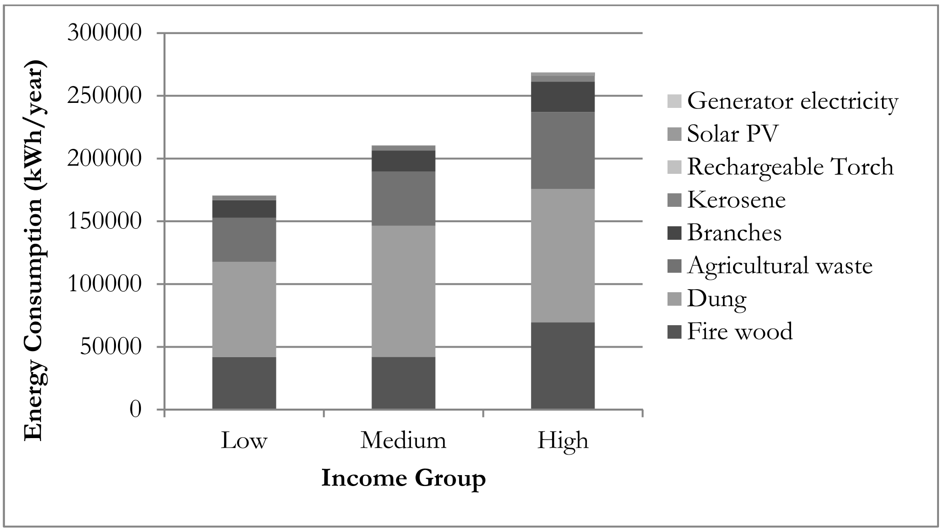

Figure 6: Energy consumption trend of income group

6.6 Distribution of energy consumption

Considering total usage of various biomass and non-biomass energy of the village, it is assumed that the village has highest demand for cooking energy comparing lighting energy. The study determined households of the villager consumed 98% of energy for cooking and only 2% for lighting from total energy demand (figure 7).

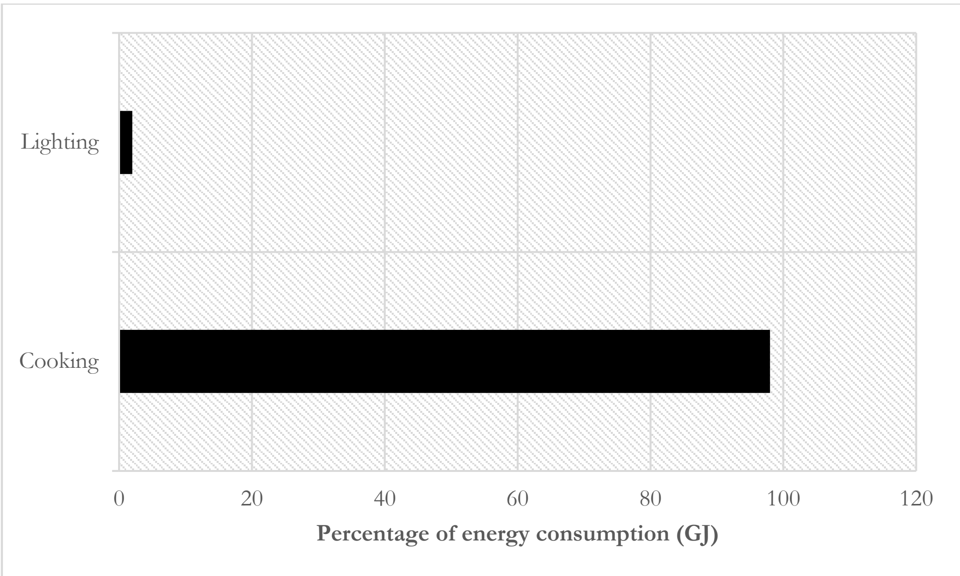

Figure 7: Share of total cooking and lighting energy consumption

Figure 8 shows the demand of biomass fuel and non-biomass fuel in kWh/year of the village mentioning types of energy use.

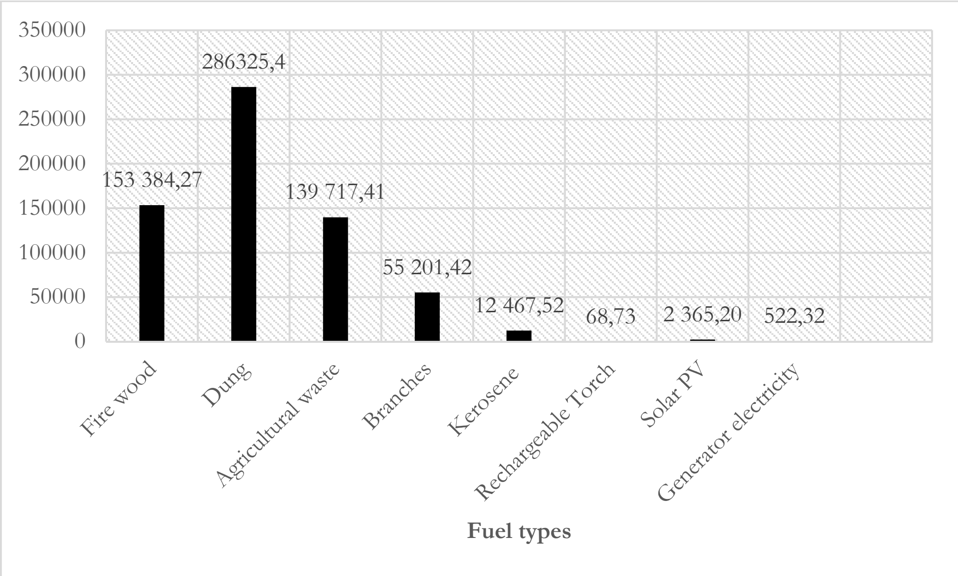

Figure 8: Types of fuel consumption by the households (kWh/year)

Among the biomass and non-biomass energy dung constitute 44% of total energy demand, fire wood, agricultural waste and tree branches holds total 54%, kerosene 2% and non-grid electricity placed almost in 0% (figure 9).

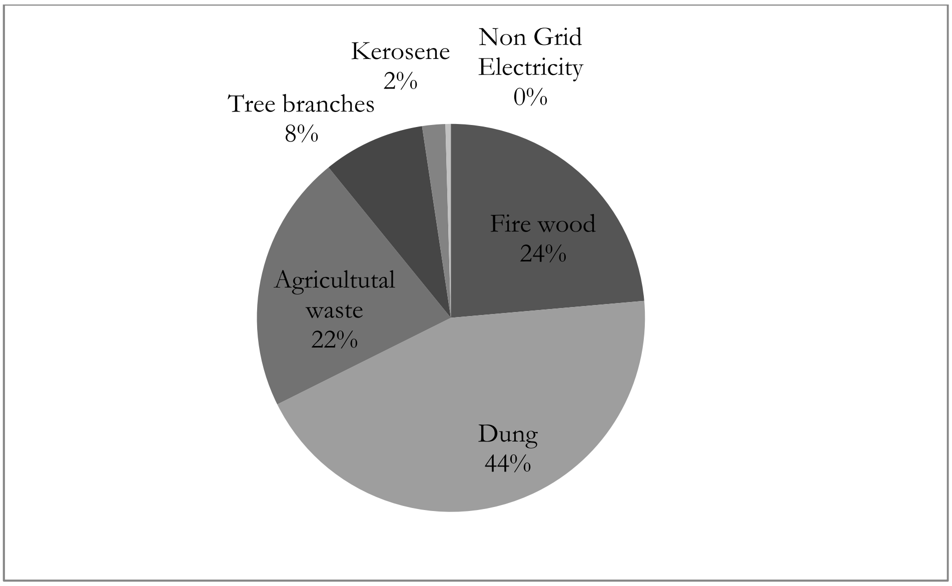

Figure 9: Share of total energy consumption

5.7 Expenses on energy

The rural household seems to spend lowest percentage on energy from their monthly income considering amount of usage and monetary cost of biomass. Most of the household collects biomass from their own production or homestead which is almost free of cost. However, the monetary cost of biomass use assumed average monthly BDT 153.25/household according to the local market value. The low, medium and high income households are spending average BDT 125.39, BDT 155.31 and BDT 179.06 per month/family. The cost of light energy is calculated average BDT 137 per month/family. The low, medium and high economic household spending average BDT 77 month/family, BDT 87 month /family, BDT 240 month/family. The households are spending 37% on solar, 28% on kerosene, 19% on torch use and 16% on generator electricity from their energy budget (table 8).

Table 8: Monthly expenditure on energy by socio-economic group

Household category	Biomass	Kerosene	Torch battery (rechargeable)	Solar	Generator	Total
Low (n=20)	125.39 (±550.57)	36.58 (±158.86)	19.18 (±142.29)	0	21.6 (±309.26)	202.75
Medium (n=20)	155.31 (±501.75)	34.84 (±151.69)	21.31 (±169.16)	24.48 (±715.80)	7.2 (±144.89)	243.14
High (n=21)	179.06 (±664.67)	42.51 (±221.46)	36. 53 (±260.01)	123.81 (±1540.86)	37.71 (±554.67)	801.47

Note: Parenthesis denotes the standard error of mean

5.8 Willingness to pay for renewable energy

Majority of interviewer showed their willingness to pay for renewable. About willingness to pay for cooking energy, 23% household of different income group denied to pay any cost (low=5, medium=3, high=6) and rest 77% household willingly pay based on their capability. As per the information of respondent, the households are willing to pay for cooking gas are average BDT 168 per month/family. For light energy, only 5% household rom low and high income group denied to pay. Low income household denied to pay because they cannot effort. High income households denied because they newly installed solar home system for electricity. They are paying monthly installment for solar system which they can use free of cost after two years when monthly installment being terminate. Rest households willingly pay average BDT 308 month/family. Figure 10 mentioned the amount could pay by each income group in relation to their average monthly income. It also indicates the percentage of their monthly income they are able to pay. Comparing the willingness to pay for cooking and lighting energy, it seems villagers are basically more interested to pay on light energy then cooking.

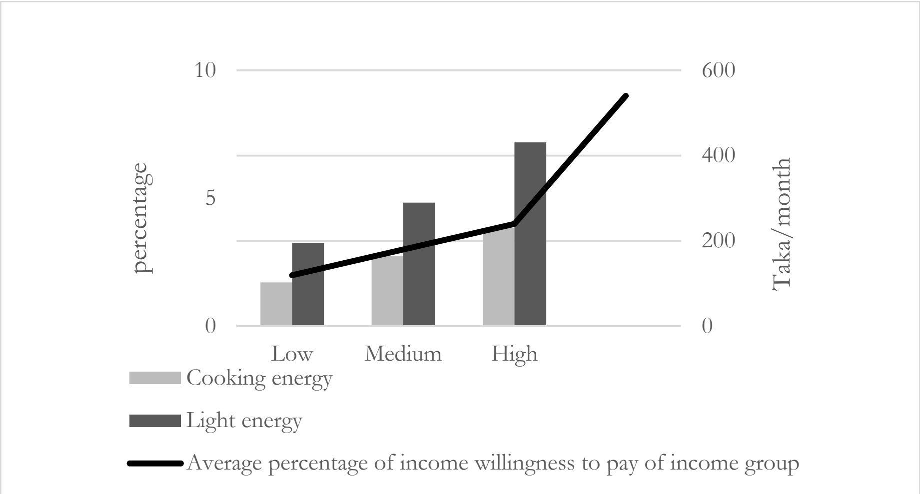

Figure 10: Willingness to pay amount of money (BDT/month) for clean energy services

5.9 Use of important appliance's if electricity is available

The respondents were asked about some important electric appliances which they are interested to use and can effort if they get electricity facility. The question was formed to know the additional demand and scope of electricity use. The households of this village basically require daily average 4 hour electric energy. Regarding important electric appliances requires to use if there is electricity; they poor group informed they have limitation using light energy within electric bulb and fan, the medium and high income group additionally demands TV, refrigerator, water pump and computer. Figure 11 presents types of electric appliances required based on priority of usage if electricity is available in the village. About preferences, household's showed 1st priority on light, 2nd priority on fan and 3rd, 4th, 5th and 6th priorities goes to television, refrigerator, water pump and computer.

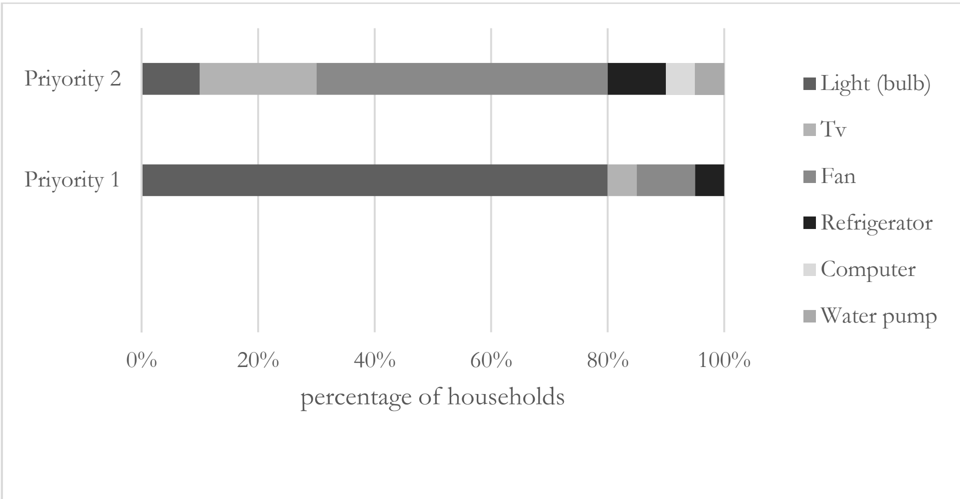

Figure 11: Priorities of household electric appliances

5.10 Knowledge of biogas and willingness to provide biomass for poly generation

Asking of familiarity with biogas technology, 23 respondents replied 'Yes' and 38 respondents said 'No'. The biogas technology has not developed yet into the study community due to absent of technological involvement and knowledge. About asking willingness to provide bio-waste to the poly-generation plant; 62% respondent said they will contribute happily, 18% respondent said they are using but they are willing to contribute, 17% respondent said they do not know and rest 3% said they cannot provide since they are using as fertilizer (table 9).

Table 9: Willingness to provide raw materials

	Number of Respondent	Willingness (%)
happily contribute	38	62
I am using	2	3
Using but will contribute	11	18
Cannot say	10	17
Total	61	100

Source: Field survey

5.11 Cooking technology use and reason to change

Households of the study are basically relies on mud stove for cooking purposes since there is no alternative choice left. Every family using traditional mud stove and only 4 families also using improve cook stove beside traditional stove. Only those families who are using single improve cook stove, said their first preference is to use improve stove due to better efficiency than traditional stove. Most of the family using 1-pot or 2-pot mud stove depends on family size. Big families are using 2-pot mud stove on regular basis and holds an extra 1-pot mud stove to use if in case for additional support.

Households are willing enough to change their current cooking system. Among the 61 respondent, 95% respondent want to change and only 5% respondent do not want to change due to the cost associated of switching. The reason working behind to change traditional cooking system is safety, smoke level, cost of fuel, collection time and difficult to cook traditional food. The study determined and ranked the most important reason which is essential requirement for changing current traditional cooking system. The investigation made on the basis of information obtained from percentage of respondent who are willing to change their cooking pattern. The different relevant problems of indoor biomass cooking were investigated accordingly (figure 12). The 1st problem identified of using traditional cooking technology is indoor smoke level, 2nd problem is not safe enough, 3rd problem is huge collection time of biomass and 4th is difficult to cook traditional food. The problems are ranked based on respondent's opinion.

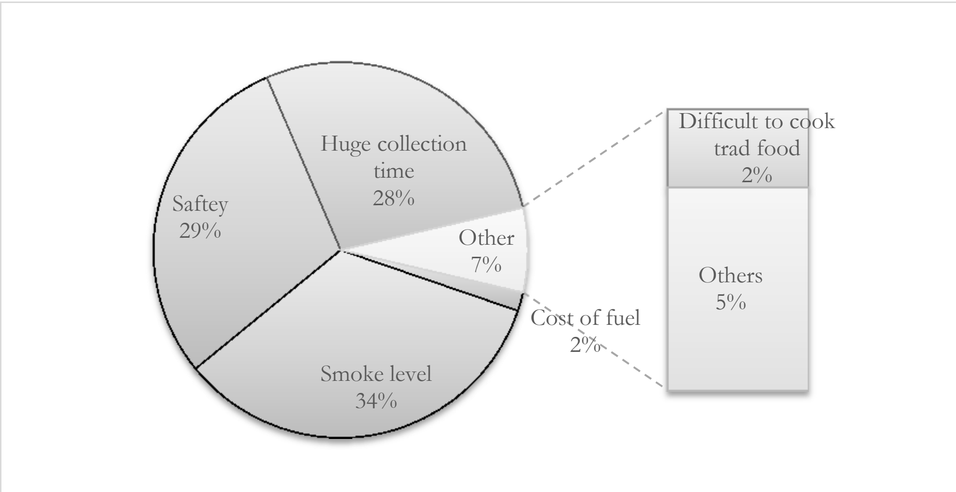

Figure 12: Reasons to change cooking technology

5.12 Water consumption and facts

A general observation found that domestic water consumption is average 3 liter water person^{-1} day^{-1} for domestic requirement which is similar to world health organization report (Guy Howard et. al., 2003). Therefore, rural family consumes water 13.62 liter per person/day for household use and drinking purposes. The source of water for domestic services are tube well, pond, river etc. People of this village are mainly collecting water from their own tube well and community tube well to meeting the daily demand of cooking and drinking water. About 59% household using own tube well and 41% household using community tube to collect water for daily consumption. Based on the given information by respondent, tube well water contains 83% iron contamination and 17% arsenic contamination. Few community tube wells were installed by BRAC Wash (N.G.O) few years back to provide arsenic free water supply to the villagers (ref: respondents). The house that has iron or arsenic contamination on their own tube well therefore collects water for drinking and cooking from arsenic free community tube well.

5.13 Health effects of air and water

Common air borne diseases of the village are asthma, respiratory infection, headache, eye irritation and burn problem. According to the collected information approximately 88% household are effected by air born disease. The women are found in high risk because they are responsible biomass cooking. Similarly children are also found in serious condition to being with women during biomass cooking. Children are high sufferer of asthma (51%), about 32% child has eye irritation and rest 17% carrying of respiratory infection. About 40% female said they has burn problem which occurred due to accident and direct heat absorbing to the skin and body from long time biomass cooking. Other than 23% female has asthma, 16% has headache problem. Males found serious sufferer of asthma, respiratory infection and headache of problem parallel. Male are also bearing eye irritation due to air smoke (figure 13).

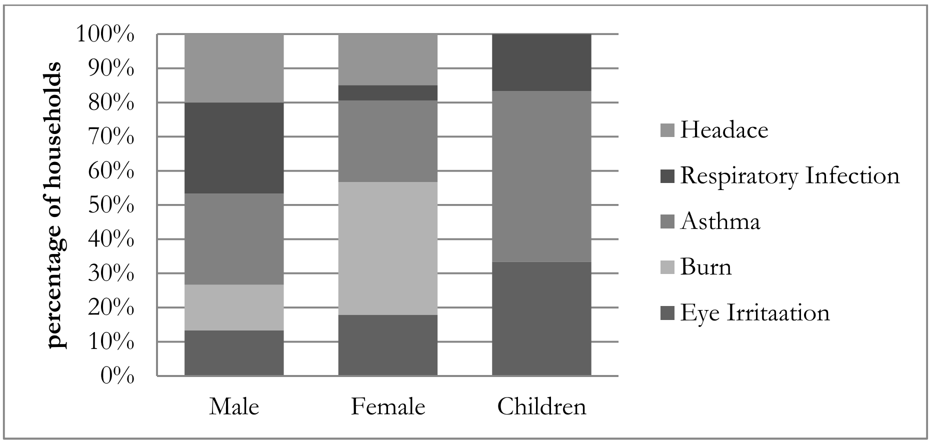

Figure 13: Air born disease and effected group

Some common diseases from water contamination are found diarrhea, black teeth, numbness and skin problem. The skin disease is highly seen among the residents specially women and men are suffering high due to arsenic contamination. The village also has iron contamination in ground water. Among the diseases, about 82% of male and 75% women holding of skin problem, 10% male and 12% women has black teeth problem, 8% male and 3% female has are suffering for diarrhea and about 10% female are suffering for numbness. Children are mostly effected equally (50%-50%) of skin disease and diarrhea (Figure 14).

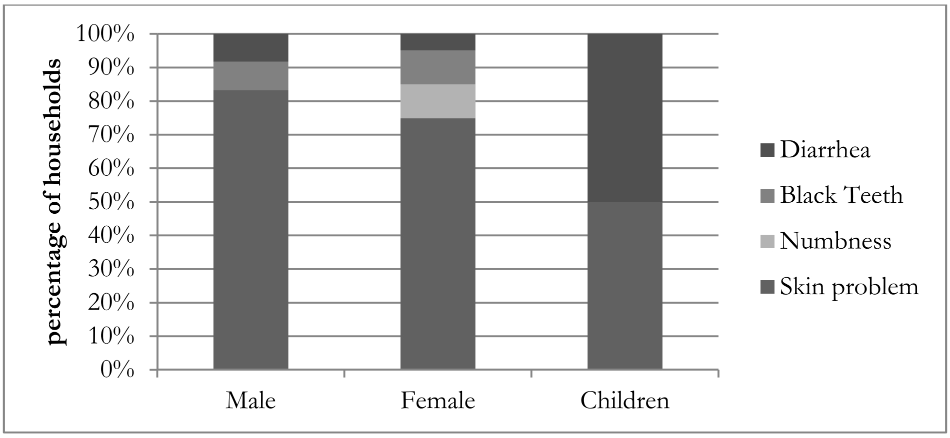

Figure 14: Water born disease and effected group

7 Feasibility analysis of poly-generation system

7.1 Biogas demand for poly-generation system

The biogas based poly-generation system is designed to provide three multiple output together of clean energy (cooking, lighting) and safe drinking water to meeting major demand of rural living people. The biogas will be used as cooking gas; at the same time electricity will be produce from biogas generator and released flue gas from gas generator will then use for produce arsenic free water through membrane distillation plant. Therefore, the poly-generation system is aiming to utilize available biomass resources inside the village to produce biogas.

To run the poly-generation project, it is required to know how much biogas is needed to serve all facilities together to bring whole village under poly-generation system. To understand the feasibility, the study calculated amount of energy potential available inside the village from various biomass resources. The demand of total biogas for the village is investigated using the current biomass resource utilization pattern.

The below calculations in table 10 showed the cooking energy demand of the survey village. Various types of biomass calculated and presented in kWh/year with energy values. The observation also checked with cooking fuel efficiency and cooking stove efficiency which is seems lower since the low grade biomass fuel has quite low efficiency and traditional cooking system perform as lower efficient technology than the biogas cooking stove.

Table 10: Efficient cooking energy demand of the village

Biomass resource	Total Energy Demand (kWh/year)*	Cooking Stove Efficiency (%) **	Efficient Cooking Energy Demand (kWh/year)
Dung	298288.86	12	35794.66
Fuel wood	223586.89	15	33538.03
Agricultural residue	147311.16	12	17677.34
Total	669186.91		87010.03

*Survey data, **World Bank report conversions.

The total cooking energy for the whole village is calculated 669186.91 kWh/year including the fuel efficiency and then total useful energy demand of the village is obtained 87010.03 kWh/year considering the value of cooking stove efficiency.

Total cooking energy demand of the village is comes out 22467.78 m^3/year which used the value 1m^3 biogas could meet the demand of cooking 3 meal for 5-6 person/ day (Karthik R. et al., 2012). The average electricity demand is considered 27 kWh/person/month (Khan et al., 2012). To produce 27 kWh electricity per month and average 3 liter clean drinking water per person each day, the biogas will be require 38886.54 m^3/year. Therefore, total biogas requirement for clean cooking gas, electricity and water is figured out 61354.32 m^3/year (table 11).

Table 11: Total biogas demand for the survey village (cooking, electricity & clean water)

Description	Values
Total cooking energy demand for the village (kWh/year)*	669187.91
Total useful cooking demand for the village (kWh/year)**	87010.03
Useful cooking energy demand (kWh/person/day /2 meals)*	0.430
Secondary cooking energy demand (kWh/person/day /2 meals)**	0.677
Cooking gas (biogas) demand (m3/person/day/2 meals)*	0.22
Cooking gas (biogas) required for the village (m3/year)*	22467.78
Biogas required for electricity and water for the village (m^3/year)*	38886.54
Total Biogas demand (m^3/year)	61354.32

*Survey data, **World Bank report conversions

6.2 Energy potentials and Biogas production from animal resources

Almost every family of this village has livestock. Total livestock available in the village is, cow=107, goat= 144 and poultry=443 in number. However, livestock population of village is seen quite poor. Study found livestock holding situation differs with economic condition of a household. Livestock holding trend significantly increased from lowest to highest income group. The low income group has 27%, mid-level income group has 32% and high income group holds 41% of total livestock population. Cattle or poultry farm is absent in the village due to lack of electricity supply.

Therefore, cow dung is considering main biogas potential of the village. All of the cows of this village are local cow. A local cow generally produces 10 kg dung each day (Khan et al., 2012). Therefore, total dung potential available in the village is 390550 kg/year. Though the number of poultry and other cattle in the village is lower however, it is investigated for available potential calculation. Matured goat (each goat) produce manure (solid) 19.25 kg /year and each poultry produce manure 10.95 kg /year (M.R.A. Mamun et. al., 2008). Total manure calculated in the village is goat = 78840 kg/year and poultry= 16169.5 kg/year.

The calculations of total biogas production of the village from cow dung and poultry manure has performed in table 12. The biogas production rate varies with types of raw material use, percentage of solid content involve and gas generation possibilities from the solid part. To calculate biogas production from cow dung, this study followed the following formula (Biswas & Lucas, 1996).

Biogas (m^3) = raw material (kg) X total solid content X gas generation rate per unit of solid (m^3/kg) eel….1

The study is counted the solid content of cow dung is 17% and gas generation rate is 0.34 m^3/kg by (Biswas & Lucas, 1996). Therefore, the total biogas production available from cow dung is estimated 22574 m^3 in the survey village. The amount of biogas production from cow dung is not sufficient to produce biogas for the whole village meeting all three demands together (cooking, electricity and clean water supply). Thus the study seeks energy potential available from poultry and goat in account. It is calculated that biogas generation comes out from got manure and poultry droppings are 3646.35m3/year and 1455.25 m^3/year respectively (Lie Guo Guo, 2010). Total biogas production from available cow dung including poultry manure comes out 27676 m^3 which also quite far from total biogas demand of the village. Nevertheless, this study only has a look on but didn't consider the amount of biogas production from goat and poultry since the village doesn't have any poultry or cattle firm. So manure cannot be collect from scattered living animals. Meanwhile that amount biogas from poultry and goat population could add value to poly-generation services if those are carrying organized way.

Table12: Energy potential available and biogas generation from cattle and poultry

Type of animal	No. of livestock in the village	Energy production from each animal (kg/day)	Total Biogas potential (Kg/year)	Total solid content (%)	Gas generation rate (m^3/kg)	Biogas production (m^3/year)
Cow	107	10	390550	17	0.34	**22574**
Goat	144	1.5	78840	18.5	0.25	3646.35
Poultry	443	0.1	16169.5	30	0.3	1455.25
Total						**27676**

6.3 Energy potentials and Biogas generation from agricultural resources

The village is mainly rich of agricultural production. Rice, maize, jute, mustard and vegetables are common and potential crop of this village. Among the different type of crops rice contains the majority of total agricultural production of the village. Production of rice is placed 67%, maize holds 15%, vegetable 12%, jute 5%, mustard seed 1%, wheat production is almost 0% of total production per year. Table 13 is shows the calculation of residue potentials available for biogas production from agricultural resources. Based on collected data on agricultural production per year total residue generation of each product is investigated counting with the residue generation rate i.e. residue production rate of rice is 1.8, maize 2.5, jute 1.6, wheat 1.6 and mustard 2.0 (Ravindranath et al., 2005). Usable amount of residue potential from each type of crop has taken in account for biogas production such as in case of rice only 20% of residue is considered since major percentage is using for feeding of animals. Similarly case of wheat, maize & mustard 60% potential of total residue is considered. About 90% of jute and only 10% of total vegetable waste is counted as well as useful for biogas production.

Table13: residue potential calculation of agricultural resources

Crops	Residue to product ratio	Amount (kg/year)
Rice	1.8	206964
Maize	2.5	63200
Jute	1.6	13792
Wheat	1.6	2048
Mustard	2.0	2640
Vegetables (10% of total production)		4635
Total		**288644.1**

Source: field survey

6.4 Biogas from co-generation

Since the amount of biogas from animal dung and manure is not sufficient enough to meeting biogas energy demand of the village. To increase the energy production the study therefore, investigates the opportunity of meeting biogas energy demand from co-generation process. The study found the amount of total biogas could be generate from co-digestion process is about 59388 m^3/year whereas; the total biogas for the whole village is identified 61354 m^3/year. However, gas production may increase through co-digestion depends on mesophilic conditions and utilization cogeneration technique. Nevertheless, the amount of biogas production through co-generation still not sufficient for meeting all three energy demand together for the whole village.

6.5 Utilization of available biogas production through poly-generation services

The village has limited feedstock meeting of total biogas demand for the village. Thus, the three services of poly-generation plant (clean cooking gas, electricity and drinking water) may not possible to distribute together to all household. Therefore, three scenarios of utilization of available biogas production through poly-generation services are discussed and suggested in table 14. Scenario I show the demand and available resources doesn't match and deficit of biogas is comes around 1966 m^3/year. In this situation the poly-generation project is unfeasible since the demand of biogas couldn't meet. Scenario II considered the total amount of available biogas that available from production could be distribute among the households where, every households of the village will get electricity and water supply services together but cooking gas could be possible to supply upto 90% household. In this circumstance, it might be a risk utilization of whole amount of biogas and to maintaining continuous biomass supply in different season throughout the year i.e. during rainy season it's difficult to collect cow dung and agricultural resources from field. Scenario III is providing the alternative solution of utilization biogas production from poly-generation plant. This solution would more appropriate for this case. Here, all household will be supplied electricity and clean water together and cooking gas will be distributed to 2/3rd household. Rest 1/3rd household from poor income group will be shifted to improve cooking stove for meeting their cooking demand since the cooking gas limited and moreover poor households are not able to pay for biogas cooking.

Table14: Utilization & distribution scenarios of available biogas production and services of poly-generation system

Alternative Scenarios	Total biogas Demand (m^3/year)	Total biogas Available (m^3/year)	Biogas Deficit (m^3/year)	Remarks	Recommendations
Scenario I Biogas services for Cooking gas+electicity+water	61354	59388	1966	Demand and available resources do not match	(Unfeasible)
Scenario II Electricity+water services for all household and cooking gas services to 90% household	59388			The available resources is just sufficient to meet this demand	All household of the village will get electricity and water supply and 90% will get access to clean biogas fuel (There is a risk of maintaining the continuous supply of feedstock in different season)
Scenario III Electricity+water services for all household and cooking gas services to 2/3rd Household	53353			All household will get electricity and clean drinking water and 2/3rd household could facilitate with biogas cooking	1/3rd households of poor income group may provide improve cook stove instead biogas for cooking

7 Conclusion and Future work

Household energy access situation of 'Matipukur' village is relatively worse as other rural area in Bangladesh. Households of this village are income poor as 70% income generates from agricultural sector. Opportunity to access low-density traditional biomass and limitation to reach modern energy services made their luck as energy poor. Even high income residents are also away from modern energy facilities due to unavailability. Energy requirements are mostly restricted to cooking and lighting. Though few middle class and high income families has access to moving fans and entertainment appliances as powering of radio or TV set however, moral less people have less scope to enjoy comfortable life. Low efficient technology use and lower grade fuel consumption insist them to live under poverty. Even environmental degradation and serious health risk occurred due to rely on traditional fuel and non-efficient technology.

The villagers are found lowest energy consumer and used to of free biomass use. Even the villagers are consuming light energy least due to cost involvement. The observation found energy consumption pattern changes with economic status and increase when income rises. The study has estimated biomass and non-biomass energy consumption for cooking and lighting in this study village is 8.45 GJ per person/year. Total biogas demand for the poly-generation project is estimated 61354,32 m^3/year including all three facilities of cooking gas, electricity and clean water supply whereas, the village has possibility to provide biogas up to 59388 m^3/year from the available resource. That means the village has deficits of biogas is 1966 m^3/year. Due to unavailability of biomass resources the amount of biogas production couldn't reach the demand. However, considering the probable amount of biogas generation from available biomass resources, the poly-generation project could run within the condition; every household will provided electricity and water supply and only 2/3rd of households from medium and high income group will be included to cooking gas services. The low income group (1/3rd household) will not include to cooking gas service since the project has limitation to provide.

The study has found that residents of the respective village are willing enough to pay for clean energy services. To obtain multiple (clean gas, electricity and water) services from poly-generation technology, about 72% respondent are willing to pay based up to their capability. More than 65% respondent showed their interest to pay for light energy. The preferences are high for electricity demand rather than cooking energy services since grid electricity connection is absent in the village and nearby villages. Scope of connecting the village with grid electricity is also has no probability within next few years since the government hasn't take any initiative for electrification. Important is high technological cost would appear with this infrastructure development and may demand of high paying energy supply service which may not effort such root level user even with subsidy adjustment. Due to free biomass access opportunity, households are less interested to pay for cooking services. However, about 77% respondent is showed willingness to pay for biogas around BDT 168 per month/household in average considering environmental and health consequences of indoor cooking. For lighting energy purpose, they are ready to spend BDT 308 per month/household (average). Even high income households are willing enough to pay more for light energy. Though respondents expressed their high interest to pay for renewable services but observing their income expenditure pattern, it is assumed that energy services has the lowest preference in their annual income expenditure. It is found that expenses on energy increases with the income level.

Regarding provision of poly-generation technology; poor households are too poor to effort shifting of alternative energy service but the study village extremely need of alternative energy system to develop socio-economic condition. Changes of cooking technology, shifting to modern fuel could enhance employment opportunities for youth and women. Gender empowerment through clean energy services may play a significant role to change the future life style of the villagers. Another important is policy regarding renewable access needs more tuned up betterment of poor. Though the policies and institutional settings for this sector are scaled up phase but still it requires more flexible access among the poorest nation.

Future work

Since the village itself doesn't contain sufficient energy potential for biogas requiring of poly generation system and it require investigate other source of energy potential. Therefore, examining of human excreta for co-digestion could be in addition to run large scale biogas plant though here is a concern of people's perception. The future work also may focus on vegetable waste since the area has fertility of vegetable production. Vegetable waste contains high carbohydrates which accelerate maximum gas production through anaerobic digestion process. It is mentionable that, vegetable and fruit contains 3% of waste. Neighbor country India generates 50 million tons of wastes per year from 150 million tons of fruits and vegetables (Dhanalakshmi Sridevi V. et al., 2012). Nevertheless, not only garden waste, market based vegetable and fruit waste may contribute a big share of fuel mixing in near future**.**

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Appendix: A

Energy Need Assessment and preferential choice survey of rural people in Bangladesh

Questionnaire to households

We, Nasrin Akter and Ahmed Hassan, are Master's students from KTH - Royal Institute of Technology, Stockholm, Sweden. We are currently working on our master's thesis evaluating the potential for using biogas in villages of Bangladesh. For that, we are conducting a survey to better understand the energy use among households in the village, and their preferences. We are particularly interested in the possibility of using household waste and animal dung for producing biogas. The biogas could provide cooking gas, electricity and clean water. In addition to serving as the basis for our academic work, our study will be used in a larger feasibility study being conducted by KTH in collaboration with Grameen Shakti (local partner) in Bangladesh.

Your help and support in filling up this questionnaire would greatly help us in our endeavor. We thank you in advance for your time and cooperation in this matter.

More information on the project can be obtained from Brijesh Mainali, researcher and project coordinator, Energy and Climate Studies, KTH-Sweden (brijesh.mainali@energy.kth.se)

Instructions

Please, use (✓) to indicate your answer among the options provided for each question (one or more). Please write N/A if the question is not applicable to you.

Rank your preferences (1,2,3...) where required – 1 as the highest rank and so forth.

General information of households

1. Name of the Respondent (Optional): ______________________________

2. Total number of members in the household:

Members	Number
Adults	
Children between 12 and below 18	
Children below 12	
Total	

3. How much is the total average monthly income of the household as a whole?

Please, specify____________________ taka

4. What are your priorities **for annual income expenditure**? Rank your options with 1 for the most important.

Items	Ranking
Food	
Education	
Energy	
Clothes	
Health care	
Religious functions	
Entertainment	
Other specify	

5. Which fuel type do you use for cooking in your home?

Fuel type	Kerosene (litter)	Biogas (cft)	LPG (cylinder)	Firewood (kg)	Dung (kg)	Agricultu re residue (kg)	Coal (kg)	Charcoal (kg)
Amount of consumption								

6. Is it easy to get hold of the fuel you need for cooking? Mark (✓)

 ______Yes / ______No / ______ Sometimes difficult

7. When you choose a fuel, what is most important to you? Please, rank your preference 1-6, with "1" for the most important factor, and so on.

Items	Ranking
Fuel Price	
Convenience to use	
Cost of the stove (Technology)	
Low smoke level	
Effects of health and environment	
Safety	

8. If you use biomass, how much do you collect or buy?

	Wood (kg)	Agricultural waste (kg)	Dung (kg)	Charcoal (kg)

Collect				
Buy				
Cost per kg				

Remarks:

10. Do you use dung as fertilizer in your field? Mark (✓)

    Yes ( ) specify _______kg/month No ( )

Remarks:

11. What type of stove do you normally use for cooking? Rank your choice with "1" for the mostly used and so on; ignore those that you do not have or use.

Stove types	**Rank**
Traditional mud stove	
Improved mud stove	
Pressurized Kerosene stove	
Wick kerosene stove	
LPG burner	
Biogas stoves	

12. If you use a traditional stove, what type of traditional cooking technology do you use? (Respondent will be facilitated with color photos of stove types)

    3-stone fire ( ) Luo mud-stove ( )

    Bylaw stove ( ) Charcoal stove ( )

13. If you use a improved stove, what type of improved stove technology do you use for cooking and heating? (Respondent will be facilitated with color photos of stove types)

    6-brick stove plastered ( ) 1-pot mud stove ( ) 2-pot Lorena stove ( )

14. If you have kerosene stove, what type of stove is it? Mark (✓)

    Wick ( ) Pressurized ( )

15. Would you like to change the way you cook today? Mark (✓)

    Yes ( ) No ( )

16. If "Yes", why do you want to change? Rank giving "1" for the strongest reason and so on.

Reasons	Ranking
Too costly fuel	
High level of smoke	
Safety risk for the children	
Collecting fuel takes long time	
Cannot cook typical food	
Other, specify:	

Remarks:

17. Would you be willing to pay more to change the cooking fuel? Mark (✓)

    Yes ( ) How much more? ________________ No ( )

18. Which of these fuels do you use for lighting? Please, specify the amount of fuel you consume of each every month. Mark (✓) for fuels you use sporadically.

Type of Source	Amount	Sporadically (✓)
Kerosene	liters/month	
Solar	kWh/month	
Car Batteries	Amp-Hour	
Dry Batteries	Amp- Hour	
Candles	nos/month	
Diesel (Generator)	Liters/month	
Electricity	kWh/month	
Other (Specify)________		

Remarks:

19. How many hours do you normally use lighting daily? Specify_______

20. If you have electricity, which and how many appliances do you have?

    Specify: ____

21. Which other appliances would be important to you?

Type of appliances	Mark(✓)	Ranking

Bulbs		
Television		
Fan		
Refrigerator		
Computer		
Water pump		
Other(Specify)________		

Remarks:

22. If you use appliances/equipment in your farm or small business at your house, what equipment do you use? How much energy does that demand?

Specify the purpose:

Type of appliances/equipment (Ex: light, fans, motors)	Number	Fuel	Amount of fuel/month	Cost per month

Remarks:

23. Would you be able to pay more for energy if you could have electricity provision? Mark (✓)

Yes ( ) If Yes then how much________ taka/month No ( )

24. Do you use fuel heating?

Yes ( ) Please, specify what _________________and how much _________________

No ( )

Remarks:

25. What is the source for drinking and cooking water?

Tap water ( ) Public Tap water ( ) Own tube well ( ) Ponds ( )
Community tube well ( ) River ( ) Other (specify) ________________________

26. How much water do you use in your household? Please, specify the daily requirement.

Water usage	Cooking	Drinking	Washing	Other (specify)_________
Amount (liter/daily)				

Remarks:

27. Do you have problems with the current drinking/cooking water in your home?

    Yes ( ) Specify ________________ No ( )

28. Are you familiar with the biogas technology?

    Yes ( ) if yes, go to question 29 No ( )

29. If a biogas plant is set up in the village for producing cooking gas, electricity and clean water for entire village, would you contribute animal dung and other biomass resources to the plant?

yes, very happy to do that ( )

no, I am using for my own purpose ( ) specify: ________________________

I am using dung for other purposes now but I can contribute for the project ( )

Cannot say at this stage ( )

30. Indicate the source of income of your household? Please mention the occupation if not in the list. Also rank the sources of income including showing the main income source with 1 for most important source and proceeding onwards accordingly.

Source of income	Mark (✓) if appropriate	Rank the main source
Farmer / Fisherman		
Government Employee (Teachers, Postman, Health worker, other ________________)		
Self/Private Employee (Labour, driver, rikshaw puller, shop keeper, business, carpenter, other _________________)		

Remittance Monetary assistance from relative working abroad		
Retired(Pensioner)		
Other(Specify)________		

Remarks:

31. If you are a farmer, mark what best explains your working condition?

Have my own land ( ) Lease someone else's land ( ) works on wage ( )

32. Could you give us your production of various cereal and other agriculture products?

Descriptions	Yearly Production in Kg
Rice	
Wheat	
Mustard seed	
Maize	
Vegetables	
Jute	
Sugarcane	
Other (specify)	

Remarks:

33. Do you own any livestock?

Yes ( ) No ( )

If 'yes' Please indicate type and number of livestock owned.

Type of Livestock	Cow	Buffalo	Goat	Poultry	Duck	Other Specify____
Number						

34. What is the educational status of the family (for members above 18 years)?

Members	Basic knowledge (read/write name & signature)	Primary (level 1-5)	High school (level 6-10)	College or university	Other
Male					

Female					

Remarks:

35. Which of the following common diseases the household is suffering or suffered from in the past? Please mark (✓) and specify number of members suffering/suffered from each disease.

Name of the diseases	**Suffering households**		
	Man (number)	Woman (number)	Children (number)
Diseases associated with Cooking/lighting fuel (Asthma, Tuberculosis, Eye disease, Pneumoconiosis, Skin disease, Acute Respiratory Infections, Burn)			
Diseases associated with Water (Skin disease, Diarrhea, Numbness in the hands and feet, black and weak teeth and nails)			
Other (specify)			

Remarks:

36. What are the main challenges do you think are related to community based biogas plant. Rank your opinion with "1" for the most important and proceed with less important options.

Main Challenges	**Rank**
Collection of Feedstocks	
Operation and Maintenance	
Distribution of gas	
Management of system	
Safety of supply	
Initial cost of plant	

Biomass supply to plant	
Price of gas	
Other (specify)________	

(Bengali version)

বাংলাদেশের গ্রামীণ মানুষের জ্বালানী চাহিদা মূল্যায়ন এবং জ্বালানী নির্বাচনের ক্ষেত্রে তাদের পক্ষপাতমূলক পছন্দ জরিপ করার উদ্দেশে প্রস্তুত প্রয়োজনীয় প্রশ্ন ও উত্তর।

আমরা (নাসরিন আক্তার ও হাসান আহমেদ) স্টকহোম, সুইডেন এর KTH–রয়্যাল ইন্সটিটিউট অফ টেকনোলোজি এর মাস্টার্স প্রোগ্রাম এর ছাত্রছাত্রী। আমরা বাংলাদেশের গ্রামে বায়োগ্যাসের ব্যাবহারের ভবিষ্যৎ সম্ভাবনার উপর আমাদের মূল্যায়ন পত্র তৈরি করছি যেটা আমাদের Masters (মাষ্টার্স) এর গবেষণা পেপার হিসাবে প্রকাশিত হবে। আমরা গ্রাম এলাকায় গৃহস্থালির কাজে জ্বালানী ব্যাবহার ও জ্বালানী সম্পর্কিত তাদের পছন্দ জানার জন্য একটি জরিপ চালাচ্ছি। বিশেষ করে আমরা বায়োগ্যাস উৎপাদনে গৃহস্থালির বর্জ্য ও গৃহপালিত পশুর গোবর ব্যাবহারের ব্যাপারে আগ্রহী। বায়োগ্যাস আমাদের রান্নার গ্যাস, বিদ্যুৎ উৎপাদনে ও পানি পরিশোধনের কাজে লাগতে পারে। এই প্রশ্ন ও উত্তরপত্রের তথ্যগুলো আমাদের পড়াশোনার কাজে ব্যাবহার করা হবে এবং এগুলো KTH ও এর বাংলাদেশের স্থানীয় প্রতিনিধি গ্রামীন শাক্তির সমন্বয়ে আরও বড় পরিসরে এই প্রকল্পের সম্ভাবনা যাচাইয়ের কাজে ব্যাবহার হবে ।

এই প্রশ্ন ও উত্তরপত্র পুরনে আপনার সাহায্য ও সমর্থন আমাদের এই প্রয়াস কে সফল করে তুলবে। এই বিষয়ে আপনার সময় ও সমর্থনের জন্য আপনাকে আমাদের আগাম অভিনন্দন।

এই প্রকল্প সম্পর্কে আরও তথ্য সংগ্রহের প্রয়োজনে যোগাযোগের ঠিকানাঃ ব্রিজেশ মাইনালি, গবেষক এবং প্রকল্প সমন্বয়কারী, এনার্জি ও ক্লাইমেট স্টাডিস, KTH–সুইডেন (brijesh.mainali@energy.kth.se)

নির্দেশাবলীঃ

প্রত্যেকটি প্রশ্নের বিপরীতে অনেক গুলো উত্তরের মাঝ থেকে দয়া করে এক বা একধিক ঘরে টিক (√) চিহ্ন দিয়ে আপনার উত্তর নির্বাচন করুন। যদি প্রশ্নটি আপনার উপযুক্ত না হয় তাহলে উত্তরের জায়গায় প্রযোজ্য নহে লিখুন।

আপনার পছন্দের বা অগ্রাধিকারের ক্রম গুলোকে (১,২,৩...) সাজান এবং লক্ষ্য রাখুন ১ নং দেয়া মানে হচ্ছে আপনি আপনার মতামতটিকে সব চেয়ে বেশি প্রাধান্য দিচ্ছেন।

পরিবার সম্পর্কিত সাধারন তথ্যঃ

১। তথ্য প্রদান কারীর নাম (বাধ্যতামূলক নহে) ____________________

২। পরিবারের মোট সদস্য সংখ্যাঃ

সদস্য / সদস্যা	সংখ্যা
প্রাপ্ত বয়স্ক পুরুষ/মহিলা	
বালক/বালিকা (১২ থেকে ১৮ বছর এর কম বয়সী)	
শিশু (১২ বছর এর কম বয়সী)	
মোট	

মন্তব্যঃ

৩। আপনার পরিবারের মাসিক গড় আয় কত? দয়া করে উল্লেখ করুন ________________ টাকা।

৪। বার্ষিক খরচের তালিকায় আপনার প্রাধান্য কোনটি? সর্বাধিক বিবেচনার বিষয়টিকে ১ ধরে বাকি গুলোকে ক্রমানুসারে সাজানঃ

খরচের খাত	অগ্রাধিকারের ক্রমানুসারে নাম্বার প্রদান
খাদ্য	
শিক্ষা	
জ্বালানি	
বস্ত্র	
স্বাস্থ্য সুরক্ষা	
ধর্মীয় কাজ	
বিনোদন	

অন্যান্য (উল্লেখ করুন) ______	

৫। বাড়িতে আপনি কোন ধরনের জ্বালানী রান্নার কাজে ব্যবহার করেন এবং রান্নার জন্য প্রতিমাসে আপনার কি পরিমান জ্বালানী ব্যাবহার হয়?

জ্বালানীর ধরণ	কেরোসিন (লিটার)	বায়োগ্যাস (সিএফটি)	এলপিজি (সিলিন্ডার)	জ্বালানী কাঠ (কেজি)	গোবর (কেজি)	কৃষি উচ্ছিষ্ট (কেজি)	কয়লা (কেজি)	চারকল (কেজি)
টিক (√)								
ব্যাবহারের মাত্রা								

মন্তব্যঃ

৬। আপনার বাড়িতে রান্নার জন্য যে জ্বালানী ব্যবহার করেন সেগুলো কি চাহিদা অনুযায়ী সহজে পাওয়া যায়?

ক. হ্যাঁ ( ) খ. না ( ) গ. কখনও কখনও কঠিন ( )

৭। আপনি জ্বালানী নির্বাচনের ক্ষেত্রে কোন বিষয় কে সর্বাধিক গুরুত্ব দেন? আপনার অগ্রাধিকার গুলো ১-৬ নাম্বার দ্বারা উল্লেখ করুন, সর্বচ্চ গুরুত্তের বিষয় কে ১ নং দিন।

বিবরণ	অগ্রাধিকার এর ক্রমআনুসারে নাম্বার প্রদান করুন
জ্বালানীর দাম	
জ্বালানী ব্যাবহারের সুবিধা	
জ্বালানী উপকরণের দাম	
কম ধোঁয়ার মাত্রা	
স্বাস্থ্য ও পরিবেশগত প্রভাব	
নিরাপত্তা	

৮। বিশেষত জীবাশ্ম শক্তি (বায়মাস) আপনি কতটুকু পরিমানে সংগ্রহ করেন বা ক্রয় করেন?

	কাঠ (কেজি)	কৃষিজাত বর্জ্য (কেজি)	গোবর (কেজি)	চারকল (কেজি)

সংগ্রহ				
ক্রয়				
প্রতি কেজি এর মূল্য				

মন্তব্যঃ

৯। চাষাবাদের জমিতে কি আপনি সার হিসেবে গোবর ব্যাবহার করেন? টিক (√) চিহ্ন দিন।

ক. হ্যাঁ ( ); উল্লেখ করুন___________কেজি/মাস খ. না ( )

মন্তব্যঃ

১০। রান্নার জন্য আপনি কি ধরনের চুলা ব্যবহার করেন? সর্বাধিক ব্যাবহৃত চুলা কে ১ নং দিন ও ক্রমানুসারে বাকিগুলাতে ব্যাবহারের ক্রম আনুসারে নাম্বার দিন। যেইটা ব্যবহার করেন না সেখানে নাম্বার দেয়ার দরকার নাই।

চুলার ধরণ	টিক (√) চিহ্ন	ব্যাবহারের ক্রম
পুরানো মাটির চুলা		
উন্নত মাটির চুলা		
কেরসিনের পাম্প চুলা		
নিন্ম মানের কেরসিনের চুলা		
এলপি গাসের চুলা		
বায়োগ্যাসের চুলা		

১১। যদি পুরানো চুলা হয়, কি ধরনের পুরানো উপকরন (চুলা) আপনি রান্নার জন্য ব্যাবহার করেন? ছবি দেখে উত্তর দিন।

ক. তিন পাথরের আগুন( ) খ. কাদা মাটির চুলা ( )

গ. বাই লও চুলা ( ) ঘ. কাঠকয়লা চুলা ( )

১২। যদি উন্নত চুলা হয়, কি ধরনের উন্নত প্রযুক্তির উপকরন (চুলা) আপনি রান্নার জন্য ব্যাবহার করেন? ছবি দেখে উত্তর দিন।

ক. ইট সিমেন্ট এর চুলা ( ) খ. এক পাত্র মাটির চুলা ( )

গ. দুই পাত্র লরেন চুলা ( )

১৩। যদি আপনার কেরোসিনের চুলা থাকে তাহলে তা কি ধরনের?

ক. কুপি বা সলতে দিয়ে চালানো চুলা ( ) খ. পাম্প দিয়ে জ্বালানো চুলা ( )

১৪। বর্তমান রান্নার ধরণ কি আপনি বদলে ফেলতে চান? টিক (√) চিহ্ন দিন

ক. হ্যাঁ ( ) খ. না ( )

১৫। যদি হ্যাঁ হয়, তাহলে কেন আপনি এই পরিবর্তন চান? সর্বোচ্চ গুরুত্তের সমস্যা কে ১ নং দিয়ে ক্রমানুসারে সাজানঃ

সমস্যা সমূহ	সমস্যার ক্রমআনুসারে নাম্বার প্রদান করুন
জ্বালানীর দাম অনেক বেশী	
ধোঁয়ার মাত্রা বেশি	
বাচ্চাদের জন্য ঝুঁকি স্বরুপ (নিরাপদ না)	
গতানুগতিক জ্বালানী সংগ্রহে সময় বেশি লাগে	
গতানুগতিক খাবার রান্না করা যায় না	
অন্যান্যঃ	

মন্তব্যঃ

১৬। জ্বালানী পরিবর্তনের জন্য আপনি কি অতিরিক্ত টাকা ব্যয় করতে ইচ্ছুক? যদি হ্যাঁ হয়, তার পরিমান কত?

ক. হ্যাঁ ( ) ____________ টাকা খ. না ( )

১৭। ঘরে আলোর জন্য আপনি কোন ধরনের জ্বালানী ব্যাবহার করেন? অনুগ্রহ করে উল্লেখ করুন মাসে কি পরিমান জ্বালানী আপনি ঘর আলোকিত করার জন্য ব্যাবহার করেনঃ

জ্বালানীর ধরণ	পরিমান	টিক (√) চিহ্ন
কেরোসিন	______________লিটার / মাস	
সোলার	______________কিলোওয়াট আওয়ার	
গাড়ির ব্যাটারি	______________এম্প-আওয়ার	
শুকনা কোষের ব্যাটারি	______________এম্প-আওয়ার	
মোমবাতি	______________টি / মাস	

বিদ্যুৎ	_______________কিলোওয়াট আওয়ার	
ডিজেল জেনারেটর	_______________লিটার / মাস	
অন্যান্যঃ		

মন্তব্যঃ

১৮। স্বাভাবিক ভাবে প্রতিদিন আপনার কত ঘন্টা আলোর প্রয়োজন হয়? উল্লেখ করুন_____________

১৯। যদি আপনার বাসায় বিদ্যুৎ থাকে, তাহলে আপনার কোন ধরনের এবং কি পরিমান বৈদ্যুতিক যন্ত্রপাতি আছে? উল্লেখ করুন

____

২০। অন্যান্য কোন ধরনের বৈদ্যুতিক যন্ত্রপাতি ব্যবহার করা জরুরী? অনুগ্রহ করে আপনার প্রয়োজনীয় যন্ত্রপাতির তালিকাইয় টিক (√) চিহ্ন দিন এবং অতিপ্রয়োজনীয় টিকে ১ নাম্বার দিন।

প্রযুক্তির বিবরণ	টিক চিহ্ন (√)	গুরুত্তের ক্রম
বাতি (লাইট)		
টেলিভিশন		
বৈদ্যুতিক পাখা		
রেফ্রিজারেটর		
কম্পিউটার		
পানির পাম্প		
অন্যান্য (উল্লেখ করুন)________		

মন্তব্যঃ

২১। আপনি যদি বাড়িতে ছোট পরিসরে কোন ব্যাবসা পরিচালনা করেন (যেমনঃ মুরগীর ফার্ম) তাহলে সেখানে কি রকমের বৈদ্যুতিক যন্ত্রপাতি ব্যাবহার করেন? এবং সেগুলো ব্যাবহারের জন্য কি পরিমান জ্বালানীর দরকার হয়?

কারণ উল্লেখ করুনঃ

বৈদ্যুতিক যন্ত্রপাতির ধরণ (যেমনঃ লাইট,	সংখ্যা (টি)	জ্বালানীর ধরন	জ্বালানীর পরিমান / মাস	মাসিক খরচ

পাখা)				

মন্তব্যঃ

২২। যদি আপনি বিদ্যুৎ সংযোগ পান, তাহলে জ্বালানী বাবদ আপনি বর্তমানে যে পরিমান টাকা খরচ করছেন তার চেয়ে অতিরিক্ত টাকা কি আপনি বিদ্যুৎ এর জন্য খরচ করতে সক্ষম ?

ক. হ্যাঁ ( ) ________টাকা/মাস খ. না ( )

২৩। উষ্ণতার জন্য আপনি কি কোন প্রকার জ্বালানী ব্যাবহার করেন?

ক. হ্যাঁ ( ); জ্বালানীর নাম এবং ব্যাবহারের পরিমান ______________

খ. না ( )

মন্তব্যঃ

২৪। আপনার পরিবারের খাওয়ার ও রান্নার জন্য পানির উৎস কি?

ক. কলের;পাইপ লাইনের পানি ( ) খ. এলাকার কলের পানি ( )

গ. নিজেদের চাপ কলের পানি ( ) ঘ. এলাকার চাপ কলের পানি ( )

ঙ. পুকুরের পানি ( ) চ. নদীর পানি ( ) ছ. অন্যান্য _________

২৫। বাড়ির কাজে দৈনিক কি পরিমান পানি আপনি ব্যাবহার করেন?

পানির ব্যাবহার	রান্নার কাজে	খাওয়ার জন্য	ধোয়া-মোছার কাজে	অন্যান্য__________
পরিমানঃ দৈনিক/লিটার				

মন্তব্যঃ

২৬। বর্তমানে আপনার বাসায় রান্নার ও খাবার পানিতে কি কোন সমস্যা আছে?

ক. হ্যাঁ ( ); কি ধরনের সমস্যা তা উল্লেখ করুন ____________ খ. না ( )

২৭। আপনি বায়োগ্যাস প্রযুক্তির সঙ্গে পরিচিত?

ক. হ্যাঁ ( ); ২৮ নং প্রশ্নের উত্তর দিন খ. না ( )

২৮। যদি আপনার পুরো এলাকার জন্য রান্নার গ্যাস, বিদ্যুৎ ও পরিস্কার পানি সরবরাহের জন্য কোন প্লান্ট স্থাপন করা হয় সেখানে কি আপনি গোবর এবং অনান্য জৈববস্তু স্বেচ্ছাই অনুদান দিবেন? টিক চিহ্ন (√) দিন।

ক. হ্যাঁ, আনন্দের সাথে করব ( )

খ. না, আমি আমার কাজে ব্যাবহার করব ( )

গ. যদিও বর্তমানে আমি ব্যাবহার করছি, তারপরও আমি অনুদান দিব ( )

ঘ. এই মুহূর্তে বলতে পারছিনা ( )

২৯। নিম্নলিখিত তালিকায় প্রদত্ত আয়ের উৎস হতে আপনার পরিবারের সদস্যদের আয়ের উৎসটি তে টিক (✓) চিহ্ন দিন। এবং আয়ের উৎস যদি একাধিক হয়, তাহলে দয়া করে পরিবারের প্রধান আয়ের উৎস যেটা সেই ঘরে ক্রমিক নাম্বার ১ এবং পরবর্তী গুলিতে যথাক্রমে ২, ৩, ... দেন।

আয়ের উৎস	টিক চিহ্ন দিন (✓)	প্রধান আয়ের উৎস ক্রমানুসারে
কৃষক / জেলে		
সরকারি চাকুরীজীবী (শিক্ষক, পিয়ন, স্বাস্থ্য কর্মী, অন্যান্য ____________)		
আত্মকর্মসংস্থান/বেসরকারি চাকুরীজীবী (দিন মজুর, গাড়ি চালক, রিক্সাওয়ালা, দোকান্দার, ব্যাবসা, তাঁতি, কামার, অন্যান্য ____________)		
বৈদেশিক মুদ্রা		

(বিদেশ থেকে আত্মীয় স্বজনদের পাঠানো আর্থিক সাহায্য)		
পেনশন		
অন্যান্য (উল্লেখ করুন)______		

মন্তব্যঃ

৩০। আপনি যদি কৃষক হন তাহলে নিম্নের কোনটি আপনার জন্য প্রযোজ্য?

ক. আপনার নিজের জমি আছে ( ) খ. জমি লিজ নিয়েছেন ( ) গ. দিনমজুর ( )

মন্তব্যঃ

৩১। আপনার উৎপাদিত বিভিন্ন খাদ্যশস্য ও কৃষিজাত পন্যের নাম এবং বাৎসরিক উৎপাদনের পরিমান উল্লেখ করুন।

ফসলের নাম	বাৎসরিক উৎপাদন (কেজি)
ধান	
গম	
সরিষা	
শাক-সব্জি	
ভুট্টা	
পাট	
আঁখ	
অন্যান্য (উল্লেখ করুন)______	

মন্তব্যঃ

৩২। আপনি কি কোন গৃহপালিত পশু প্রতিপালন করেন?

ক. হ্যাঁ ( ) খ. না ( )

যদি হ্যাঁ হয় তাহলে গৃহপালিত পশুর ধরণ ও সংখ্যা উল্লেখ করুনঃ

গৃহপালিত পশুর ধরণ	গরু	মহিষ	ছাগল	মুরগী	হাঁস	অন্যান্য
সংখ্যা (টি)						

৩৩। পরিবারের শিক্ষার অবস্থা (১৮ বছরের উপরে সদস্যদের জন্য প্রযোজ্য)

সদস্য/সদস্যা	জ্ঞানের ভিত্তিমূল (লিখতে পারা, পড়তে পারা এবং স্বাক্ষর জ্ঞান)	প্রাথমিক পর্যায় (১-৫)	মাধ্যমিক পর্যায় (৬-১০)	কলেজ অথবা বিশ্ববিদ্যালয়	অন্যান্য
ছেলে/পুরুষ					
মেয়ে/মহিলা					

৩৪। গৃহস্থলির কোন ধরনের সাধারণ রোগ নিকট অতীতে বা বর্তমানে আপনাকে বা আপনার পরিবারের সদস্যদের পীড়া দিয়েছে?

সদস্যদের রোগাক্রান্ত হওয়ার সংখ্যা উল্লেখ করে দয়া করে টিক (√) চিহ্ন দিন ।

রোগের নাম	রোগাক্রান্ত সদস্য সংখ্যা		
	পুরুষ (সংখ্যা)	নারী (সংখ্যা)	শিশু (সংখ্যা)
জ্বালানি ও রান্না সক্রান্ত রোগ বালই (বক্ষব্যাধি, ফুসফুসের রোগ, চোখের রোগ, চর্ম রোগ, শ্বাস জনিত সমস্যা এবং শরীর জ্বালাপোড়া ইত্যাদি)।			
পানি বাহিত রোগ (চর্ম রোগ, পানি শূন্যতা, হাত ও পায়ের অসারতা ও ক্ষয় এবং দাত ও নখ কাল ও দুর্বল হওয়া ইত্যাদি)।			

অন্য সমস্যা (উল্লেখ করুন) ___________			

মন্তব্যঃ

৩৫। আপনার মতে এলাকা ভিত্তিক বায়োগ্যাস প্লান্ট স্থাপনের গুরুত্তপূর্ণ দিক গুলো কি কি? সবচেয়ে গুরুত্তপূর্ণ মত কে ১ নং দিয়ে বাকি গুলোকে নিম্ন ক্রমানুসারে সাজান।

প্রতিবন্ধকতা সমূহ	প্রধান প্রতিবন্ধকতার ক্রম
গবাদি পশুর বর্জ্য যোগাড় ও প্লান্ট এ সরবরাহ করা	
গাছগাছালি ও রান্নাঘরের বর্জ্য যোগাড় ও প্লান্ট এ সরবরাহ করা	
প্রকল্প এর দৈনন্দিন কার্যক্রম পরিচালনা ও রক্ষনাবেক্ষন করা	
গ্যাস ও বিদ্যুৎ বন্টন করা	
প্রকল্পটির সঠিক বাবস্থাপনা নিশ্চিত করা	
প্রকল্পের প্রাথমিক ব্যায়	
নিরাপদ সরবরাহ নিশ্চিত করা	
গ্যাসের দাম	
অন্যান্য (উল্লেখ করুন)____________	