Hamidul Huq[1*]
[1] Institute of Development Studies and Sustainability (IDSS), United International University, Dhaka, Bangladesh
[*] **Corresponding author:** hamidulhuq@eco.uiu.ac.bd

SOLAR ENERGY FUELS FOR SUSTAINABLE LIVELIHOODS: CASE STUDY OF SOUTHWEST COASTAL REGION OF BANGLADESH

ABSTRACT. Electrification is one of the most crucial factors to ensure social and economic growth in Bangladesh. Being in a developing country, people from various districts of Bangladesh have been experiencing electricity crisis due to the increasing daily demand for power, which outweighs the supply of on-grid electricity. It is noted that about 30 percent of 160 million people, majority living in the rural areas are out of electricity connection in Bangladesh. Consequently, the shortage of energy hampers socio-economic development and lowers living standards of people. Since, non-renewable sources such as fossil fuels and natural gas, the primary sources of energy production in Bangladesh, are limited, usage of renewable energy technology such as solar energy efficiently can satisfy the rising energy demand and in turn improve the existing energy shortage situation. This study found that Bangladesh has been implementing Solar Home System (SHS) programs that contribute in achieving the target to reach electricity to its every citizen by 2020. As of June 2017 a total of 262,515 households do have solar home systems from which an estimated 1.6 million people are benefitted. This article is written based on a research conducted in the districts of southwest coastal region of Bangladesh where a total of 5.1 million people live of which on an average 42.6 percent are poor and 24.9 percent are extreme poor. In-depth interviews, group discussions, key informant interviews, and household survey were used for collection of data to explore the impacts of SHS on the livelihoods of coastal people of Bangladesh. This research found that impacts of Solar Home System services are both immediate and long-term oriented. SHS program contributes enriching all kinds of livelihoods assets such as human, social, financial and physical of the SHS customers. The poor and extreme poor people of climate vulnerable villages of southwest coastal region of Bangladesh are benefited in different ways from SHS programs such as save daily expenditures for kerosene, doing income generating activities in evening hours by both male and female members of family, children sit for study regularly, women feel safety from lightening of house, they can charge cell phone, they have access to weather forecasting, their social status upgraded, and they save money because they do not need to pay bill for electricity. The SHS is one time investment and they customer can pay for SHS package in installments. As the SHS program approach is environment and poor people friendly, its impacts on livelihoods are found sustainable.

KEY WORDS: Coastal region, Solar Home System, Sustainable Livelihoods

CITATION: Hamidul Huq (2018) Solar Energy Fuels For Sustainable Livelihoods: Case Study Of Southwest Coastal Region Of Bangladesh. Geography, Environment, Sustainability, Vol.11, No 4, p. 132-143
DOI-10.24057/2071-9388-2018-11-4-132-143

INTRODUCTION

Power system of Bangladesh depends on fossil fuels both in private sector and state owned power plants. About 89% of generated power comes from carbon emitting natural gas, liquid fuel, coal and hydropower. The supply of natural gas is not sufficient to meet the demand. Current gas production capacity in Bangladesh cannot support domestic needs as well as wider electricity generation for the country (Asaduzzaman et al. 2013). The existing reserve of oil and gas will be exhausted very soon by 2025. At the same time worldwide there is a demand for clean and sustainable energy. The need for developing renewable sources of energy like solar, wind, biomass, etc. has a greater sense of urgency as more than 35 percent of the population does not have the access to electricity in Bangladesh. As a tropical country Bangladesh is endowed with solar energy. In this context solar energy is are liable, affordable and secure energy for the country (Bose et al. 2009). Major people of Bangladesh live in rural areas. There is strong demand for power availability in remote villages. Bangladesh has embedded with plenty of solar energy. Bangladesh has much potential to be a solar electricity-rich country. Institutional, financial and technological capabilities act as important factors for reaching a desired level of solar electricity production and utilizations (IEA 2014).

Considering the energy demand in Bangladesh, the Solar Home Systems (SHS) are stand-alone photovoltaic systems that offer a cost-effective mode of supplying amenity power for lighting and appliances to remote off-grid households. Many villages of Bangladesh, where more than 70 percent of 160 million population live, (BBS 2012), are not connected to the grid electricity. The SHS is being used to meet a household's energy demand fulfilling basic electric needs. Solar energy is widely perceived as a promising technology for electricity generation in remote areas of Bangladesh. National grid system cannot reach the dispersed population in remote villages. Therefore the SHS are the alternative ways of electricity generation which are clean and renewable (IEA 2015).

Bangladesh government has established 'Infrastructure Development Company Limited (IDCOL)' in May 1997, licensed by the Bangladesh Bank as a non-bank financial institution (NBFI) in January 1998, playing a major role in bridging the financing gap for developing medium to large-scale infrastructure and renewable energy projects in Bangladesh. The company now stands as the market leader in private sector energy and infrastructure financing in Bangladesh (Komatsu et al. 2011). The IDCOL started its SHS program in January 2003 to fulfill basic electricity requirement of the off-grid rural people of Bangladesh as well as supplement the Government's vision of ensuring access to electricity for all citizens of Bangladesh by 2021. As of May 2017, about 4.12 million SHSs have been installed under the program in the remote areas where electrification through grid expansion is challenging and costly. Thus, the program has ensured supply of solar electricity to 18 million people i.e. 12 percent of the country's total population who previously used kerosene lamps for lighting purpose. The IDCOL has a target to finance 6 million SHS by 2021 with an estimated generation capacity of 220 MW of electricity (IDCOL 2017).The latest coverage of SHS in this study area are 87,518 in Khulna, 77,732 in Bagerhat and 98,262 in Satkhira districts (Source: Field note).

About two million people live in Khulna district where 38.8 percent people are poor

and 21.2 percent people are extremely poor. Almost 1.5 million people live in Bagerhat district where 42.8 percent people are poor and 24.0 percent people are extremely poor. About 2 million people live in Satkhira district where 46.3percent people are poor and 29.7 percent people are extremely poor (Mohideen et al. 2013). There are five districts under administrative coverage of southwest coastal region of Bangladesh and the districts are Khulna, Bagerhat, Satkhira, Jessore and Narail. This research was conducted in Khulna, Bagerhat and Satkhira districts to assess how SHS impact on their livelihoods.

Access to electricity through SHS installations brings positive impact on living standards along with some non-economic benefits such as more leisure time for watching a black-and- white TV in the evening and increased social security due to household lighting. Rural electrification by SHS's installation also ensures improvements in the health and education sector as well as eases poverty by allowing income generation activities (Akikur et al. 2013). Since solar energy through SHS is a clean and environment friendly renewable form of energy, adopting SHS can help to save fossil fuels reserve as well as save cost of energy by replacing kerosene and diesel for lighting purposes causing reduction of environmental hazards (Akpan et al. 2013).

Considering the remarkable rate at which SHS installations have incremented over last few years, the prospect of SHS expansion is anticipated to be successful and booming in Bangladesh. The Government of Bangladesh (GoB) has made energy policies recently to ensure effective utilization renewable energy resources to meet the demand for power. By the year of 2020, the government has aimed to produce 10% of total energy through renewable sources (Bhattacharyya et al. 2014). This type of policies promises to result in the exponential growth of SHS ensuring better prospect in various areas in Bangladesh in terms of the size of the SHS market and its economic potential (Bhattacharyya et al. 2015). The objective of this study is to explore the growth of Solar Home System (SHS) in the southwest coastal region of Bangladesh along with explaining how SHS users are benefited by enhancing their livelihood in sustainable manners.

METHODOLOGY:

This study was qualitative and primary data were collected through in-depth individual interviews (43) of family heads having SHS facilities, visiting house to house randomly; group discussions (8) with participations of 5 – 11 men and women, among from SHS customers and five key informant interviews was conducted with the in-charge of IDCOL's Khulna Regional Office. In addition, a total 120 households survey had been conducted using semi structured questionnaires.
The data collection for this study was carried out in the Mongla, Morrelganj, Batiaghata, Paikgacha and Shyamnagar Upazilla in southwest coastal region of Bangladesh. These areas are under coverage of Solar Home System (SHS) programs of Bangladesh government through its public limited company, which is known as Infrastructure Development Company Limited (IDCOL).

RESULTS:

Impacts of Solar Home Systems Services on Sustainable Livelihoods:

Findings of this research show, Solar Home Systems have significant contributions in livelihoods of the rural poor households in southwest coastal region of Bangladesh. The uses of SHS services by the households/ customers are of manifolds, which work as inputs in the processes of generation of livelihoods assets with immediate, short-term and long-term effects.

Fig. 1 shows, 100 percent SHS customers use it for illumination of their house. A big percentage of households (65 percent) use SHS services for study purpose of their children in the evening. Large number (85 percent) of customers uses SHS service for charging their mobile phone set. As many

as 51 percent respondents use fan and 41 percent respondents watch television using energy from SHS. A good number of (19 percent) customers use solar home systems for business of tailoring, shop-keeping and home based poultry farming. Some school teachers and village college graduates use of solar home systems service in the evening in their private tuition from which they earn some income. Some people use SHS services to run fan, operate rice cooker, and for lighting aquaculture pond that are located on vicinity of house.

Findings of this research suggested that uses of solar energy benefit the rural poor households in the forms of increasing livelihoods assets of all kinds. Following sections discuss about the contributions of SHS in generation and regenerations of livelihoods assets of the rural poor towards their sustainable livelihoods.

This study noted that if physical capitals are remaining the same as before, the financial capital will be increasing day by day. It is helping them to develop their ability through using solar home systems and transforming them as human capital. The human capital is generating social capital for the owners. Using solar home systems in natural capital they are well-endowing with financial capital of productive activities. Sustainable livelihood is a way of thinking about the objectives, scope and priorities for development, in order to enhance progress in poverty elimination. Sustainable livelihood aims to help poor people achieve lasting improvements against the indicators of poverty that they define.

Results from the household survey revealed that most of the families were using light, mobile chargers, fans and radios more than other electrical items. Radios are found particularly in the grocery stores where people usually spend their free time to gossip with neighbors. Nearly 50 percent of the families surveyed had at least one TV in their home. Refrigerators were yet not so common. However, there were still some families who possessed a refrigerator and the wider usage of them was increasing in line with the growing prosperity of families.

This study found that people are receiving better entertainment facilities with the help of SHS. That access to entertainment brings changes in lifestyle to rural people. Rather than gossiping with neighbors, ideally people now prefer to watch many of the TV shows now available and gain further knowledge. It assists people to keep in step with the modern world and also know about current world events. Due to have lighting facilities in the home, children can now have more time to study. Farmers can

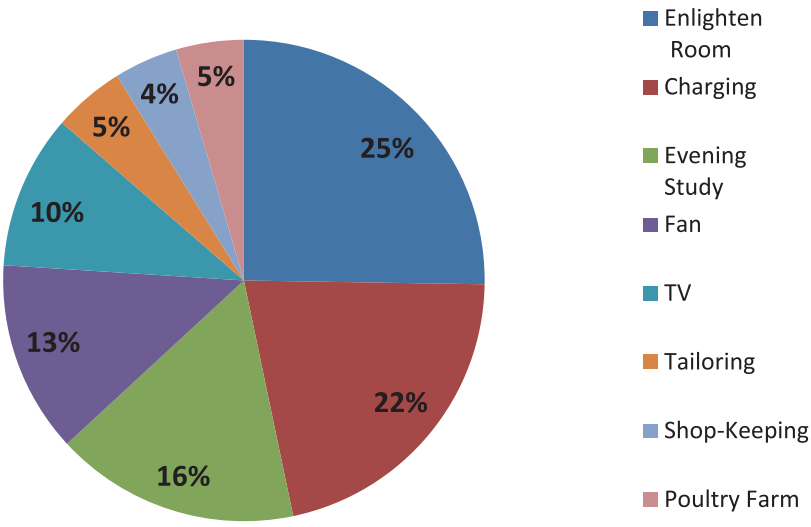

Fig. 1. Uses of SHS services

now work longer hours in the field. Better lighting facilities have also changed the daily routine of females in the household. These days they do not have to depend on just on sunlight to complete their household chores. Daily communication is also no longer a big deal for the rural areas people. With the help of mobile phones and better lighting facilities, they can move easily anywhere they need to, not only physically but also virtually. Actually, they feel their own lives offer more security. In summary, the standard of our rural areas people has increased with the positive impact of SHS.

This study revealed that better opportunities for information and entertainment were perceived as important changes by 64 percent of SHS households, followed by improved lighting conditions (80 percent) and thus easier movement in the house at night (48 percent). As another benefit of lighting, the improved conditions for studying by school children were quoted in 52 percent of SHS households. Other frequently mentioned changes include the possibility to charge mobile phones (72 percent), an overall increased living standard (56 percent), increased security due to household lighting (44 percent), and facilitated household work in the evening hours (36percent).

The study reveals that on average, primary school boys read 1.7 and girls 1.9 hours per day with electric light, and boys/girls at secondary school age read 3 and 2.5 hours respectively with electric light. While electric light does enhance the reading comfort and the conditions for pupils to do their homework, it is difficult to judge the role this plays in achieving more highly aggregated impacts, e.g. an improvement in the educational status. It noted that 55 percent of respondents in the household sample found no change and 44 percent asserted an improvement of the family's health condition since the acquisition of the SHS. This study also found that 62 percent of the households found that their access to relevant information has improved due to the SHS.

This study found that the average number of times people watch the news per week rose slightly from four times before the installation of the SHS to five times afterwards. While radios are hardly ever used in combination with SHS, some interviewees indicated that they use news services via their mobile phones. Others appreciated that they could now read the newspaper in the evenings under electric light. While only few users name mobile charging as an important benefit of the SHS, more than 60 percent of the interviewees indicate that their possibilities of communicating have improved due to the SHS. Around 40 percent of the respondents that commented on their perception of safety find their safety improved since the acquisition of the SHS, while 60 percent do not. Only 5 percent of respondents said that their workload had decreased due to the use of the SHS, while 10 percent explained that it had increased.

More than half of the interviewed shop-owners – typically in teashops, grocery stores and small restaurants explained that their profits rose through the SHS. Besides lighting, TV is an important factor in attracting customers in over half of the cases. Furthermore, over three quarters of the commercial users of SHS stated that they have extended their daily working hours in their business since using the SHS, by an average of two hours. The SHS considered in this study generally do not have enough capacity to be used for electrical appliances that could be used in production, such as heating lamps in poultry farms, irrigation pumps for agriculture, or mobile phone charging on a larger scale. Around 10 percent of the MSE in the sample were also connected to the grid, but considered the SHS to be very important as backup, since power-cuts usually occur precisely in the evening hours when they need lighting for their business activities.

Human Capital

Human capital is a key to livelihoods processes of rural poor. It found that the villagers of the study areas have to work hard to earn income using scope and

opportunities of different kinds. These are fishing in the river, collecting honey from the forest, catching crabs from the river and canals, running boats as transports, and growing crops. The women work hard to raise chicken, duck, goat, cows and to grow vegetables. They are to manage storage of food grain, firewoods, fodder, feed, etc. Women take the pains of collecting fresh drinking water from far away from their home as human capital represents the skills, knowledge, ability to labor and good health that together enable people to pursue different livelihoods strategies and achieve their livelihood objectives. In the study areas, at a household level human capital is a factor of the amount and quality of labor available; this varies according to household size, skill levels, leadership potential, health status, etc. This study found that children of 73 percent households are getting the benefits of evening study through using the solar home systems. From 6 pm to 10 pm everyday total four hours are adding in their study time. Most of the teachers and highly educated persons in the study areas are starting to give the private tuition in their home. For this benefit, students are getting the advantage of better study and some of the students are staying in the teacher's home at the time of their final exam. The interest, opportunity and competition of the study are growing among the students and the result of their school is better than the before of solar installation. After completing the college they are continuing their study and starting their higher study. According to the study, 20 percent students are continuing their study for graduation. The students get the information about higher education using television through solar home system. Interest is growing through television among them. The study facility is providing the security of their future and making them as human capital of the country. At the time of using kerosene, the students were read almost one and half hour to two hours on daily base. But most of the students were suffering of eye burning in that time.

The study noted that using television is a popular entertainment facility of solar home systems in rural areas. Not only entertainment but also television has a strong impact on the knowledge sector of health. It noted that 18 percent households have growing awareness about health and different disease through using television. They are informing about the diseases of children, water, air, virus, eye, heart, animal, diabetic, presser, AIDS, cancer etc. They are highly informing about better nutrition and trying to maintain in their life. Health is the directly linked up with the human capital. If they can maintain a good health and proper diet, then it will be easier fulfilling the requirements of human capital.

Natural Capital

Natural capital is the term used for the natural resource stocks from which resource flows and services (e.g. nutrient cycling, erosion protection) useful for livelihoods are derived. There is a wide variation in the resources that make up natural capital, from intangible public goods such as the atmosphere and biodiversity to divisible assets used directly for production (trees, lands etc.) (Akimova 2018; Boyle 2012). The people of study areas are depending on natural capital to maintain their livelihoods. This study found that solar home systems have a very important in their livelihoods activities like fishing from the river, collecting honey from Sundarbans, aquaculture and agricultural activities. Using the light of solar home systems the fishermen are fishing from both river and Sundarban after daylight. Probably, they are using 10 watt solar home systems in their boat. They use solar for various fishing purpose as like shrimp fry collection, making net and cage in the night. The farmers use solar light in their crop field so that the rats and other animals don't waste their field. Some of them are using light at the time of rice husking at the night. These activities are enriching their natural capital which has a scope of increasing financial capital.

Financial Capital

Financial capital denotes the financial resources that people use to achieve their livelihood objectives. The definition used here is not economically robust in that it includes flows as well as stocks and it can contribute to consumption as well as production (Brent and Rogers 2010). Livelihoods of the people of the study areas depend on solar home systems in economically. It noted that livelihoods of 36 percent households are depending on solar home systems and they are starting income generating activities at their households. The popular income generating activities are poultry farming, tailoring, grocery and tea shop keeping, computer shop, private tuition, electrician etc. The main condition of poultry farming is having solar home systems because there requires light in the whole night. In summer season there is also requiring fan in both poultry and cock farm. Farming is a profitable business in coastal region of Bangladesh. In tailoring shop the tailors are getting the benefit of more work hours in daily base and outcomes of their work are generating more moneys. The selling of grocery and tea shop keepers are increasing by using solar light. Some of the keepers are using television in their shop so that people are gathering in the shop and the selling is increasing in their shop. Some grocery and tea keepers create the scope of playing carom in their shop by using solar light and it is also increasing their financial capital. The new scope of income generating activity of solar home system is computer shop. This business depends on totally solar home systems. From the serials video to internet activities are available in this computer shop and many young entrepreneurs is taking as profession through computer training. The educated people of coastal region are starting to give tuition in local students by using evening solar light. Local electrical shops start the repairing the controller, battery and charging the battery of solar home systems. This is creating scope of more income for the local electrician. People are also opening charger shops, computer learning center, TV and Radio center in the market with the help of solar home systems. These activities also are enriching the financial capital of them by using solar home systems.

The study found that solar home systems have a huge economic benefit rather than kerosene and at the flow of time economically solar is more benefiter than kerosene. This study noted that the monthly cost of five members of family was BDT 150 taka in five years ago. They were using 20 watt solar home system and the price of that package was BDT 12,000 taka. Already they used solar home systems in five years. If they used continuously kerosene in these years, they need one more year to balance this money. But every year the price of kerosene is increasing highly. So, at this point there need some less time to balance the money.

Physical Capital

Physical capital comprises the basic infrastructure and producer goods needed to support livelihoods (Brew-Hammond and Kemausuor 2009). Solar home system is helping the people of study areas to maintain their physical capitals save. At the time of using kerosene lamp inside of home is being dirty and oil based smoky. But using solar the home becomes enlightening and clean. The fishermen are repairing their net, boat and troller most of the time evening by solar light. The carpenters are making and repairing furniture by using solar light after sunset. Because of using solar light the shopkeepers feel more safety than before and there are low chances to fire in their shop. The computers, laptops, printers, scan machines of the computer shop are running because of using solar home system. Television, mobile phone, fan are using through the electricity of solar home systems. The easy bike and motor van are charging by solar home systems. Using solar light the pond of coastal region are becoming safety from the stealing. The dairy farm and poultry farm are running well by using solar light and fan.

This study noted that one of the main economic activities of the study areas based on rural markets called Haat. The trading continues until evening. Generally Kerosene lamps called Kupi, Harricane and mantle lamps called Hazzak were the major appliances used to illuminate the Haat shops. All of these alternatives are detrimental to the environment. Now client shops are connected to SHS and using lights to illuminate their shops which are safe and cheap. Feedback from users of the SHS in the study areas indicated that users were highly satisfied with this technology. Many business holders in the study areas noted his income had increased significantly, while a grocery shop owner observed that more customers had been visiting his shop. A continuous power supply that provided light for five hours every evening led to an increase in the shops' working hours.

Social Capital

There is much debate about what exactly is meant by the term 'social capital'. In the context of the sustainable livelihoods framework it is taken to mean the social resources upon which people draw in pursuit of their livelihood objectives (Chakrabarti and Chakrabarti 2002). This study explored that solar home systems are increasing the scope of better livelihoods, creating access of information through television and radio of coastal region peoples. The main benefit of solar is enlightening the room and it is increasing safety of the people. Children are getting more time for preparing their study well. Women and children are moving easily from house to other place and feeling more safety than before. The overall household working time of them are increasing after sunset. They are looking after their children study, cooking, sewing, maintaining poultry farm, working of households. They are gathering in one particular neighbor house at afternoon which has the facility of color television with different channels. The women empowerment is growing in the coastal region of Bangladesh. Beside their daily work, they are maintaining income generating activities in their home and earning money to fulfill their personal need. In evening people are gathering in the local grocery shop and sharing their knowledge and information from television and mobile phone. They have a chance of entertaining by television and communicating with friends and family by using mobile. Omitting kerosene is benefit for their health purpose and makes them healthier than before. These benefits from solar home system give a living standard of the coastal people and they can cope with the country. This radical change of social life is enhancing the quality life of rural people in coastal region of Bangladesh.

It noted that the people in the study areas use mobile with the help of SHS which producing several social benefits; it enhances entrepreneurship, reduce information asymmetries and market inefficiencies, and facilitate better transport. Access to such facilities brings about changes in the lifestyle of coastal people. Rather than spending time talking to each other (socializing), the participants of the study preferred to watch TV shows to be up-to-date on current national and global affairs. They gathered in tea stalls or shops in the market place to watch a special program, movie, or match together. Enjoying TV entertainment shows helped them to relax after a day's farming and other activities. Rechargeable lead-acid batteries usually used to power TV sets need to be transported over several kilometers for recharging in many cases. An SHS requires only sunlight and will last up to 20 years with minimal servicing.

Challenges of Implementing Solar Home Systems:

The solar home systems face the problems of governance. Probably, the companies are providing three years warranty and repair services of SHS. But most of the time after one year to two years the bulb, controller, battery, wire and switch-board of solar home systems are damaged and do not work well. Sometimes the panel is also damaging before the warranty period. Promises of warranty are not following over the period. That is why the user are converted the line direct to the panel by

themselves. The companies do not repair the controller but they repair the battery. If the companies repair the battery, the quality of services is very low. After ending warranty period, the respondents have no facilities of service center of solar home systems. This time they go to the local electrician and try to repair their battery and controller. Lacking of knowledge about solar most of the time they do not able to repair the battery and controller.

Furthermore, the growth of SHS is also thwarted due to insufficient demonstration of the technology and the shortage of awareness among the SHS non-adopters through media, lack of effective promotional campaign and advertisement regarding the benefits that are experienced by SHS users, industry and among policy-makers is considered as Informational barriers (Javadi et al. 2013). Moreover, the rapid and smooth dispersion of SHS installations in rural Bangladesh is also impeded because of insufficient number of technical human experts on system installation, maintenance and running proper operation of SHSs as well as providing insufficient training program to SHS users (Mainali 2014 a).

Coastal households have experienced some technical problems while using the SHS. Poor quality components of the SHS such as PV panel, battery and charge controller in the market, lack of standard and quality control for SHS components, poor technical link in running the system and absence of technical expertise to support the development of SHS are involved as some technical barriers that are likely to hamper smooth running of SHSs in coastal Bangladesh (Mainali 2014b). Moreover, incorrect installation of a SHS unit, poorly designed SHS using inferior quality of SHS components and improper sizing of the system are responsible to demonstrate problems in the performance of the system. Partner Organizations (POs) have also experienced problems associated with poor technology and system components (battery and charge controller) as well as maintenance and management issues. Due to the rapid growth of the SHS usage, while POs have to supply components of SHS regularly to meet the demand, some of the POs appear to lack sufficient institutional capacity and technical skills to manage installations of SHSs. Hence, these issues are seemed to be responsible for problems that have recently accounted for by POs, involving inferior-quality components of SHS (Rahman et al. 2013).

Furthermore, there are also some challenges of the SHS that affect the smooth progress of SHS installation in the coastal Bangladesh. Although it is the responsibility of POs and other SHS service providers to do servicing, SHS users do not receive any proper and sufficient technical training on the maintenance of the SHS. Due to the lack of education-Cum awareness of SHS, they tend to misuse the components of the SHS during the operation of the system which causes premature problem of the system (Palit 2013).

Conclusion:

Energy demand in Bangladesh is rising swiftly every day because of the population growth and consequently to meet the requirement of higher consumption. The rate of ongoing rising demand for power exceeds the capacity to produce grid electricity, using only non-renewable resources such as fossil fuel and others (Khan et al. 2012). Absence of transmission and distribution of on-grid electricity in many rural areas are responsible for the continuous energy crunch in Bangladesh. This study noted that Solar Home System (SHS) is an alternative solution to fulfill the demand for the household lighting. Adoption of a SHS unit enables a convenient and sustainable way of accessing a high-quality, clean and environment-friendly energy service (Khan et al 2012). This study explained the socio-economic positive benefits for operating a SHS unit in coastal villages, including the high-quality household lighting, extended hours of education, and better health related awareness among women through watching TV and income generation opportunities. SHS has profound and far-reaching economic, socio-cultural, and demographic impacts on life and living

of the coastal people in Bangladesh. Most of the respondents are found satisfied with their SHS. However, some constrains have been noticed which are slowing the diffusion of SHSs in rural areas. In order to make sure of the substantial growth of SHS in every coastal place, it is essential to overcome the barriers and existing problems of the SHS. The service providers need to work with its technical standard committee to set required standards, and to push local Bangladeshi assemblers with the aim to improve the quality of their products of SHS so that they can develop good quality SHS in the local markets. Besides, producing better quality SHS components by focusing on designing components with better reliability can be an effective approach to minimize manufacture of low quality SHS components.

REFERENCES

Akimova V.V. (2018). Solar energy production: specifics of its territorial structure and modern geographical trends. Geography, Environment, Sustainability, 11(3):100-110. https://doi.org/10.24057/2071-9388-2018-11-3-100-110

Akpan U., Essien M., and Isihak S. (2013). The impact of rural electrification on rural micro-enterprises in Niger Delta, Nigeria. Energy for Sustainable Development, 17(5), 1–6.

Asaduzzaman M., Yunus M., Haque A.E., Azad A.A.M., Neelormi S., and Hossain M. A. (2013). Power from the sun: An evaluation of institutional effectiveness and impact of solar home systems in Bangladesh. Renewable Energy and Sustainable Development. 13(7), 3–5.

Akikur R., Saidur R., Ping H., and Ullah K. (2013). Comparative Study of stand-alone and hybrid solar energy systems suitable for off-grid rural electrification: A review. Renewable and Sustainable Energy Reviews, (27), 738-752.

Bangladesh Bureau of Statistics (2012). Population Statistics of Bangladesh. Table 01.14.

Bhattacharyya S. (2015). Mini-grid Based Electrification in Bangladesh: Technical Configuration and Business Analysis. Renewable Energy, (75), 745-761.

Bhattacharyya S. and Palit D. (2014). Mini-grids for Rural Electrification of Developing Countries: Analysis and Case Studies from South Asia. Switzerland: Springer.

Bose M.L., Ahmad A., and Hossain M. (2009). The role of gender in economic activities with special reference to women's participation and empowerment in rural Bangladesh. Gender, Technology and Development, 13, 69–102. doi:10.1177/097185240901300104

Boyle G. (2012). Renewable Energy: Power for a Sustainable Future (3rd ed.).Milton Keynes: The Open University.

Brent A. and Rogers D. (2010). Renewable rural electrification: sustainability assessment of mini-hybrid off-grid technological systems in the African context. Renewable Energy, (35), 257-265.

Brew-Hammond A. and Kemausuor F. (2009). Energy for all in Africa—to be or not to be? Current Opinion in Environmental Sustainability.

Chakrabarti S. and Chakrabarti S. (2002). Rural electrification programme with solar energy in remote region – a case study in an island. Energy Policy, (30), 33-42.

IEA (2015). International Energy Association. World Energy Outlook 2015.

IEA (2014). Technology Roadmap: Solar Photovoltaic Energy.

Javadi F., Rismanchi B., Sarraf M., Afshar O., Saidur R., Ping H. and Rahim N. (2013). Global policy of rural electrification. Renewable and Sustainable Energy Reviews, (19), 402-416.

Khan S.A., Hasan M., Haque H.H., Jafar I.B., Raihana K., Rahman N.U., Farabi H.M., Audhuna N.K., Azad A.K.M. (2012). Solar home system evaluation in Bangladesh. Proceedings of the Second Asian Conference on Sustainability, Energy & the Environment, Osaka, Japan, pp. 199-209.

Khan S.A., Rahman R., Azad A.K.M. (2012). Solar home system components qualification testing procedure and its effect in Bangladesh perspective. Proceedings of the Global Humanitarian Technology Conference, Seattle, Washington, pp. 381-386.

Komatsu S., Kaneko S., and Ghosh P.P. (2011). Are micro-benefits negligible? The implications of the rapid expansion of Solar Home Systems (SHS) in rural Bangladesh for sustainable development. Energy Policy, 39, 4022–4031. doi:10.1016/j.enpol.2010.11.022

Mainali B. (2014a). Sustainability of rural energy access in developing countries. Doctoral Thesis. Stockholm: KTH Royal Institute of Technology.

Mainali B. (2014b). Sustainability of rural energy access in developing countries. Doctoral Thesis. Stockholm: KTH Royal Institute of Technology.

Mohideen R. (2013). Clean, renewable energy: Improving women's lives in South Asia. IEEE Technology and Society Magazine, 32, 48–55.

Palit D. (2013). Solar energy programs for rural electrification: Experiences and lessons from South Asia. Energy for Sustainable Development, (17), 270-279.

Rahman M., Paatero J., and Lahdelma R. (2013). Evaluation of choices for sustainable rural electrification in developing countries: A multi criteria approach. Energy Policy, (59), 589-599.

Received on August 21st, 2018 Accepted on November 15th, 2018

FIRST/CORRESPONDING AUTHOR

Hamidul Huq is a social scientist from Bangladesh. His specialization is in the areas of sustainable livelihoods, women empowerment, integrated coastal zone management, integrated water resources management, disaster management, ecosystem services and poverty alleviation, and interdisciplinary research and education. Hamidul Huq has been engaged in collaborative interdisciplinary education and research projects on Integrated Water Resources Management, Ecosystem Services and Poverty Alleviation, Disaster Prevention/Mitigation Measures against Floods and Storm Surges in Bangladesh with IWFM, BUET, Wageningen University, Southampton, Exeter, Oxford, Dundee and Kyoto universities. He worked as a postdoctoral researcher of UNESCO-IHE Institute for Water Education, Delft, the Netherlands. He obtained his PhD in Rural Development Sociology from Wageningen University. He is the author of the book *People's Practices: Exploring contestation, counter-development, and rural livelihoods (2001).*