Khan S.-A., Azad A. K. M. A. M. (2014), *Social Impact of Solar Home System in Rural Bangladesh [...]*, IAFOR Journal of Sustainability, Energy and the Environment **1(1)**:5-22.

SOCIAL IMPACT OF SOLAR HOME SYSTEM IN RURAL BANGLADESH: A CASE STUDY OF RURAL ZONE

Sabbir Ahmed Khan[1], A K M Abdul Malek Azad[2]

Abstract. The Initial research on the Solar Home System (SHS) was related to an evaluation of its present circumstances in Bangladesh. Afterwards, considering its increasing demand, a significant research study was conducted to find standardized qualification testing procedures for SHS components. Sequentially, the following research deals with the socio-economic impact and sustainable development in rural areas of Bangladesh using SHS. A combination of qualitative and quantitative methodological tactics, were used to provide descriptive evidence concerning electricity's impact on the assessable socio-economic data. Qualitative consultations with the specialists involved in the SHS propagation method, delivered overall information related to SHS packages and exposed the professional's individual opinion regarding socio-economic impacts of solar electricity in a rural part of Bangladesh. To finalize this information with field-level data, a pervasive household survey and individual short interviews with shop-keepers were performed in a rural area near Dhaka city. SHS's contribute to sustainable development mainly through the improvement of social aspects in rural life. The implementation of SHS's in rural Bangladesh, causes optimistic impacts, particularly in the areas of education, health, information, communication, social security and household works. Moreover, the plummeting of CO_2 emissions through the substitution of traditional lighting fuels has to be mentioned as a positive environmental impact. The economic impacts of the SHS's are limited to an increase in income of shops. Previously SHS's were mostly used by households who possessed high incomes however by now focusing on the poorer households has extended the opportunity of developing both socio-economic groups. During the last few decades, the implementation rate of SHSs are much notable than any other renewable energy system. This is especially so in rural areas. Showing the impact on rural development, this research will amplify the opportunity of SHS's in the long run having adequate government subsidy.

Keywords: Solar Home System (SHS), Social-economic impact, Rural development, Battery management, Level of satisfaction

1. Introduction

According to recent data, the Bangladeshi economy is quickly growing and poverty rates are tumbling (Khan et al 2012, Khan et al 2012, Hossain et al 2011). Numerical data reveals that the economy has grown at around 6% per annum & that poverty had dropped substantially from 45% in 2005 to around 30% by 2010 (Khan et al 2012). But at present the country is suffering from acute problems regarding its power supply (Islam & Islam 2005). The general lack of access to electricity imposes limits on the

[1] Research Assistant, Control & Applications Research Group (CARG), Department of Electrical and Electronic Engineering (EEE), BRAC University, Dhaka, Bangladesh, khan.sabbirahmed@yahoo.com
[2] Professor & Head, Control & Applications Research Group (CARG), Department of Electrical and Electronic Engineering (EEE), BRAC University, Dhaka, Bangladesh, a.azad@ieee.org

prospects of growth and increased welfare. The overall incidence of electrification for households is only 42%. About 81.4% of the total electricity generation depends on natural gas. The rate of increase in electricity consumption is 10% annually. At this rate, the proven reserve of natural gas may not last more than 10 years (Hasan et al 2012). In order to meet the target set by the REB (Rural Electrification Board), fossil fuel based power stations, presently generating electricity, cannot be just the only weapon. We need to find alternative electricity sources to satisfy demand (Islam & Mondal 2009). Under these circumstances, the Solar Home System (SHS) could potentially be a positive alternative in providing affordable electricity. Sunlight combines with two types of energy: light and heat. Both may be utilized directly or indirectly by converting them into electricity. Being a tropical region, Bangladesh is endowed with copious supply of solar energy. The annual amount of radiation varies from 1840-1575 KWh/m^2 which is 50%-100% higher than Europe. Consumption of only 0.07% of the radiation could meet the country's present requirement (Eusuf 1997). So, there are lots of possible benefits by properly using this energy source. Not just that, there are also ideas that the solar electricity may actually be supplied through the normal grid. However, to analyze the future prospects there is a need to evaluate the present scenarios of SHS. Certainly, based on the current social development impact of SHS, an efficient figure can be drawn upon to understand the upcoming energy crisis. That's why this research paper and analysis of its results is focused on the recent developments surrounding SHS and its social impact on rural life in Bangladesh.

2. Background

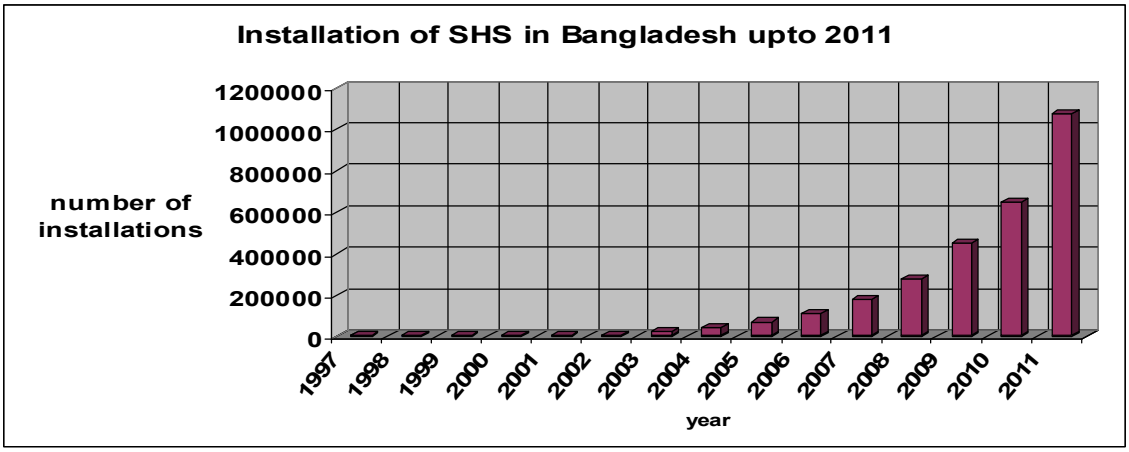

Figure 1. Exponential increment of SHS installation in Bangladesh.

The SHS industry in Bangladesh has since its inception in 2004 undergone strong growth. The number of partner organizations involved, have expanded from only a handful originally to current 30 organizations at present. During this time there has also been the advent of supporting companies who manufacture and supply batteries, charge controllers, lamp circuit etc. (Aziz & Chowdhury 2012). Figure 1 shows the number of SHS's installed over the last 15 years in Bangladesh. Moreover the SHS project in Bangladesh is managed by a financial institution established by the Government of Bangladesh the Infrastructure Development Company Limited (IDCOL). Currently every month around 60 thousand SHS units are being installed by IDCOL. According to recent data, (31August 2011 data) IDCOL has installed 1,073,872 SHS's. Their target is

to finance 1 million SHS's by the end of 2012 (Khan et al 2012, www.idcol.org). So now it is high time to measure the social impact of this budding market.

3. Methodology of Research

In the past several research projects have evaluated the solar home system operating in Bangladesh (Blunck 2007). However, the main focus of this research is to ascertain the proper social impact that has resulted from the use of SHS in rural areas. To do this the survey questionnaires submitted to households. They were patterned contrarily so they could imitate the meticulous impact of SHS. Figure 2 shows the tentative locations of studied area. The survey was conducted in the Gazipur (Kapasia, Lohadi) rural area, which is located near the city of Dhaka. It was envisioned that under examination the collected data would definitively define socio-economic conditions and provide an emblematic example of rural Bangladesh. The Kapasia area chosen for the research contains a huge number of villages, many of which do not have a grid connection. Following a provisional assessment it was clear that most of the population within the Kapasia area under consideration could afford a SHS as they are economically better off than other areas. Furthermore, their was the realization that solar home systems installed within the Kapasia area may play an imperative role in increasing the literacy rate amongst local people. The interviews conducted involved 25 household owners and 5 small grocery store owners. All the selected households were dominated the male member of the family.

Figure 2. Tentative Locations of the Study Village

3.1. Key Statistics of the Study Area

Kapasia has an area of 354.98 square kilometers. Kapasia has 11 unions and 231 villages, of which only two villages are urban with remaining 229 classified as rural.

The total population of Kapasia is around 385,580 and the literacy rate is 56%. Furthermore 70% of the people of Kapasia are residing abroad. For this reason Kapasia is economically stronger when compared to most other rural areas in Bangladesh. Additionally 20% of the people employed within Kapasia are either service holders, small businessmen, teachers, grocery shop owners, or work on poultry firms etc. 10% of the resident population live on farms and were ascertained as not being able to afford the Solar Home System. Key statistics of Kapasia Thana are given in the following Table 1.

Table 1. Kapasia Thana at a Glance for the Year 2009. (Source: BRAC, Kapasia Unit, Gazipur)

SL. No.	ITEM	STATISTICS
01	NO. OF UNION	11
02	NO. OF VILLAGE	231
03	TOTAL NO. OF POPULATION	385,580
04	NO. FO PRIMARY SCHOOL	225
05	LITERACY RATE	56%
06	NO. OF HOSPITAL	02
07	NO. OF BANK	09
08	NO OF BAZAR	55
09	ROAD IN KM (PACCA)	90
10	ROAD IN KM (KACHA)	238
11	NO. OF NGO WORKING	08
12	VGD CARD HOLDER	550
13	TOTAL AGRICULTURE LAND	64,960
14	NO. OF POND	2,260
15	TOTAL WATER BODY	825
16	NO. OF CHILDREN (0-15 YEARS)	75,821

BRAC has some criteria to select a location, which are:

- Grid connection will not reach by the next 5 years.
- High population density.
- Economically more or less sound.
- Number of markets and Bazar.

Kapasia fulfills all the criteria mentioned above thus it was selected as a project area in 1998.

3.2. Collection of Information

Information for the research was mainly collected by way of survey questionnaires conducted within households and at rural markets. To explore a more realistic portrayal or considered view of technical, social and economic aspects within the study area, the survey was carried out in those households that possessed solar home systems. The names of the property owner and the installation year of SHS were solely collected from selected village register books. To discover tangible views of SHS usage the survey was carried out from the village Lohadi under Barishabo union in Gazipur district servicing the SHS by BRAC. Figure 3 shows the Jamiratchor BRAC office.]

After collecting all the current data a mammoth study on the previous research work was then undertaken to also verify the deviation between the impact of present and

past results. This helped to provide an effective summary of the research work. The next section will concisely discuss the results and analysis.

Figure 3. Jamiratchor BRAC office Kapasia Gazipur

3.3. Types of Solar Home System

Table 2. Description of Solar PV Systems Provided by BRAC at Kapasia

Solar PV Module	Appliances	Components	Operating Time	Price (TK)
20 Wp	Two lamps of 8 watt	One module of 20 watt. One deep discharge battery of 47 Ah. Two charge controller. Two lamps of 8 watt. One structure, other accessories & installation.	4 hour per day.	10,500
40 Wp	Three lamps of 8 watt & one Black and White TV	One module of 40 watt. One deep discharge battery of 70 Ah. One charge controller. Three lamps of 8 watt. One socket for TV or mobile charger. One structure, other accessories and installation.	4 hour per day.	18,200
50 Wp	Four lamps of 8 watt & one Black and White TV	One module of 50 watt. One deep discharge battery of 80 Ah. One charge controller. Four lamps of 8 watt. One socket for TV or mobile charger. One structure, other accessories and installation.	4 hour per day.	22,500
60/65 Wp	Five lamps of 8 watt & one Black and White TV	One module of 60/65 watt. One deep discharge battery of 80 Ah. One charge controller. Five lamps of 8 watt. One socket for TV or mobile charger. One structure, other accessories and installation.	4 hour per day.	28,600
75 Wp	Six lamps of 8 watt & one Black and White TV	One module of 75 watt. One deep discharge battery of 98 Ah or 100 Ah. One charge controller. Six lamps of 8 watt. One socket for TV or mobile charger. One structure, other accessories and installation.	4 hour per day.	31,400

Four types of solar home systems are provided by BRAC. They mainly vary in size, capacity and price but their operating time remains constant. Table 2 gives a clear view about the available range of appliances and components for solar home system.

3.4. Sample Survey

The case study of three households and two grocery shops are included below:

Household 1:
Name of the Respondent: Md. Ainuddin.
Address: Village- Lohadi, Post Office- Gazipur, Union-Barishabo, District- Gazipur
Age: 50 Years
Education: Class 5
Occupation: Tailor
Monthly income: 5000 Taka
Family Members: 5 Number of person.
Previous kerosene consumption per month: 6 Liters
Mr. Ainuddin replaced four kerosene lamps and one car battery with solar home system. He is using the 75 Watt solar home system he is the most recent user and he did not have any complain with the system.
Average cost for lighting and entertainment of this family:
Initial cost:
Car battery: 2500 taka
Three kerosene lamp: 50*3 = 450 taka
Monthly expense:
Charging the car battery: 60 taka
Transportation cost for charging the battery: 20 taka
Kerosene cost: 6*46=276 taka
[Per litter kerosene cost=46 taka]
Mr. Ainuddin had to replace the kerosene lamp (Hurricane) every 4 years and he had to replace the Chimney every 6 months. The life- time of the car battery was approximately 3 years.
From the above analysis and from his personal opinion we can say that solar home system is a best solution and he is also being benefited financially as he can work extra one or two hours. Now his grandchildren get more time to study.

Household 2:
Name of the Respondent: Md. Shahidul Islam.
Address: Village- Lohadi, Post Office- Gazipur,Union-Barishabo, District- Gazipur
Age: 45 Years
Family Members: 5 Number of person.
Capacity of the SHS: 75 Watt
Previous kerosene consumption per month: 5/6 Liters
Md. Shahidul Islam has also replaced three hurricane lamp and one car battery with 75 Wp solar home system through, which he can run 6 light 10 Watt each and 1 black and white TV. He was using the system for about 2 years and left with few monthly installment of the cost. During these two years he had to change one lamp only and on the

components on the SHS was working fine. He was also satisfied with the service of the BRAC employee.

Household 3:
Name of the Respondent: Md. Shoriuddin.
Address: C/O Md. Shamer Ali Village- Lohadi, Post Office- Gazipur, Union-Barishabo, District- Gazipur
Age: 50 Years
Family Members: 6 Nos.
Capacity of the SHS: 50 Watt.
Previous kerosene consumption per month: 5 Liters
In this household they replaced two Kerosene lamp and one car battery by solar home systems. This family bought the Solar Home System on 22 December 2002. The system capacity is 50 watt. In these 7 years they only had to change the charge controller once. This is the only household we found who were using a DC fan. They were very satisfied with the overall performance of the system and they were also planning to buy another SHS.

Grocery shop 1:
Name: Md. Idrish Ali.
Address: Jolpai Tola Bazar, Village- Lohadi, Union- Barishabo, District- Gazipur
Age: 48
Occupation: Business
Monthly more income: 450 Taka
Monthly bill from another lamp: 150 Taka
Md. Idrish Ali installed the solar home system to run his business. He was using a 75 Wp SHS for one and half years. He said that he earns an additional 15 to 20 Taka more per day after the installation of SHS, because working time was extended two hours more. He was having some problem with the battery.

Grocery shop 2:
Name: Tara Mia Kholifa.
Address: Jolpai Tola Bazar**,** Village- Lohadi, Union- Barishabo, District- Gazipur
Age: 45
Education: Class 6.
Occupation: Business
Monthly more income: 400 Taka
Monthly bill from another lamp: 150 Taka
Tara Mia Kholifa was the oldest solar some user in the study area. He installed a 30 Wp solar home system in the year 1998. Except the solar panel he had replaced all the components once.

4. Results and Analysis

4.1. Average Income Condition and Ability to Afford SHS

Analyzing the surveyed data from Figure 4, it appears that the mean income of those families were not so high. More than 50 percent families' incomes were lower

than 7 thousands taka per month and only a few households are having more than 10 thousands taka per month.

According to this data, 48% of the households were regarded as low-income families. Most of them bought their SHS components with the help of an installation program offered by Partner Organizations (PO's). But due to the low household income it was difficult for them to pay the total amount installation cost. Therefore the feasibility of the monthly installment scheme with low interest. Good numbers of people like to go for the monthly installment rather than bearing total installment cost. According to the collected data, about 80% household installed SHS by monthly installment pattern.

Usually a range of solar panel types are available and offered for sale by the PO's. However, the most popular is the 50Wp solar panel. These 50 Wp solar home systems were also common in the studied area, which produced enough energy to run three lamps and one black & white TV system. The larger capacity systems (75Wp), were used by comparatively larger families (a higher income group per household) Although, 75Wp was also a popular options, greater numbers of households preferred to use the 50 Wp panel because of its lower cost and installation program. Table 3 shows the top two PO's 50 Wp scheme and Figure 5 shows the most used SHS.

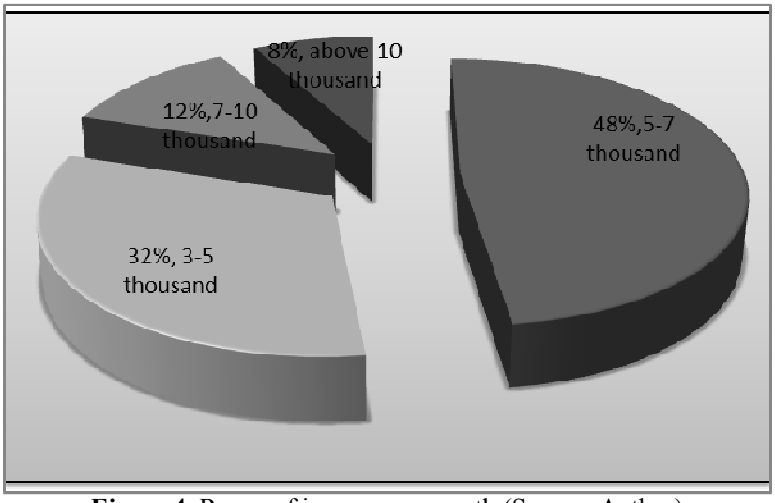

Figure 4. Range of income per month (Source: Author)

Table 3. 50 W panel system with load and price (www.gshakti.org, www.brac.net)

PO Name	System in Watt	Load Provided	Price
Grameen Shakti	50 Wp	4 Nos.7 watt lamp and 1 No 17" B/W TV point	26,800 taka
BRAC Solar	50 Wp	Four lamps of 8 watt & one Black and White TV	22,500 taka

Production of solar panels requires capital-intensive manufacturing facilities that are highly automated. At present Bangladesh is unable to manufacture the required PV modules and these are thus imported from outside countries (Islam & Mondal 2009). This is also true for high tech devices like LED's. Nevertheless, these high tech components are imported and assembled in Bangladesh by the Partner Organizations (POs) to produce the final device. For that reason the cost of components and installation is presents a high cost for those on minimum incomes. But a monthly payment program initiative from PO's has made it easier for some households to afford them. Still this is not

a common scenario, and the monthly payment and installment program together is still not sufficient enough to reach the poorest families. The high cost of acquiring a SHS's means that there is still a long way to go until electrification using SHS's will be available in every household within the Kapasia region.

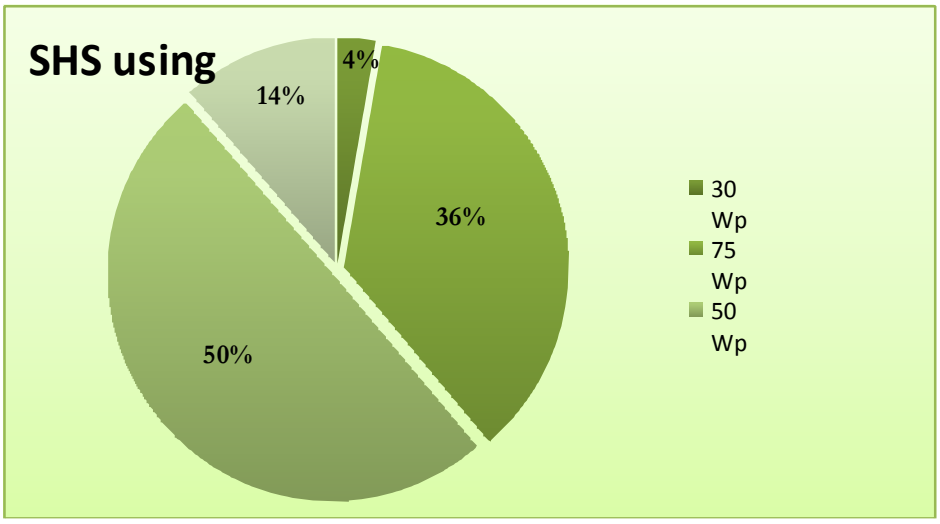

Figure 5. Most used SHS system (Source: Author)

4.2. Present Load Using Scenario and Increasing Obligation of SHS

Nowadays different electronic devices and equipment are very much familiar to people living regular lives even in rural areas. Table 4 shows the augmentation of electronic loads from last five years in the surveyed area. Figure 6 denotes the overall status of electronic load usage within the 25 families surveyed from products such as electric lights, mobile chargers, fans, radios, TV's (Black and White), Refrigerators etc. In addition, Table 5 shows the Period of Daily Energy Consumption for Lighting and Entertainment with respect to hourly usage.

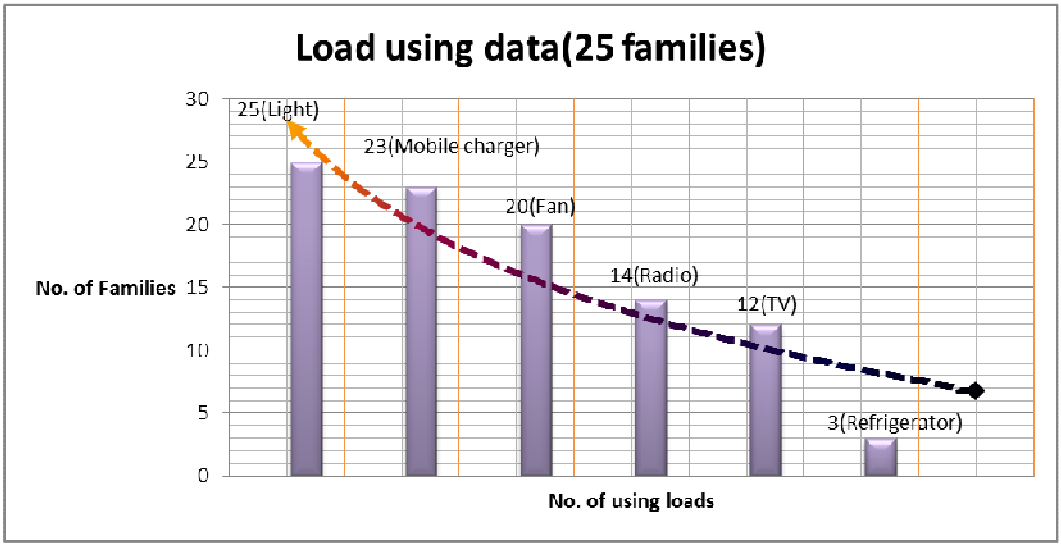

Figure 6. Load using data of 25 families (Source: Author)

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% of the families surveyed had at least one B/W 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. While investigating household incomes, it was found that refrigerator ownership was more likely to be affordable amongst households that had an income greater than 7000 Taka.

As discussed earlier government reports have found that poverty levels have been decaying over the last 15 years. The increasing usage of electronic goods in daily life also reflects the validity of this government report. This therefore indicates that in spite of having low supply of electricity from the national grid such a newly developed life style is really only possible due to the growing us of SHS's.

Table 4. Increased number of electronic materials in our rural area in last 10 years

House Hold No.	2002- 2005						2006-2012					
	Light	Fan	Mobile charger	Radio	TV		Light	Fan	Mobile Charger	Radio	TV	
1.	Yes	No	No	No	No		Yes	Yes	Yes	No	No	
2.	Yes	No	No	No	No		Yes	Yes	No	No	No	
3.	No	No	No	No	No		Yes	Yes	Yes	No	No	
4.	Yes	No	No	No	No		Yes	Yes	Yes	No	No	
5.	Yes	Yes	Yes	No	No		Yes	Yes	Yes	Yes	Yes	
6.	Yes	Yes	Yes	No	No		Yes	Yes	Yes	Yes	Yes	
7.	Yes	Yes	No	No	No		Yes	Yes	Yes	Yes	Yes	
8.	No	No	No	No	No		Yes	No	No	No	No	
9.	No	No	No	No	No		Yes	No	Yes	No	No	
10.	Yes	Yes	No	No	No		Yes	Yes	Yes	Yes	Yes	
11.	Yes	No	No	No	No		Yes	Yes	Yes	Yes	Yes	
12.	Yes	No	No	No	No		Yes	Yes	Yes	Yes	Yes	
13.	Yes	Yes	No	No	No		Yes	Yes	Yes	No	No	
14.	Yes	Yes	No	No	No		Yes	Yes	Yes	Yes	Yes	
15.	Yes	Yes	No	No	No		Yes	Yes	Yes	Yes	No	
16.	Yes	Yes	Yes	No	No		Yes	Yes	Yes	Yes	Yes	
17.	Yes	Yes	Yes	Yes	No		Yes	Yes	Yes	Yes	Yes	
18.	Yes	Yes	Yes	No	No		Yes	Yes	Yes	Yes	No	
19.	Yes	No	No	No	No		Yes	Yes	No	No	No	
20.	Yes	Yes	No	No	No		Yes	Yes	Yes	Yes	Yes	
21.	Yes	Yes	Yes	No	No		Yes	Yes	Yes	Yes	Yes	
22.	Yes	Yes	Yes	No	No		Yes	Yes	Yes	Yes	No	
23.	No	No	No	No	No		Yes	No	Yes	No	No	
24.	No	No	No	No	No		Yes	No	Yes	No	No	
25.	Yes	No	No	No	No		Yes	Yes	Yes	No	Yes	

Table 5. The Period of Daily Energy Consumption for Lighting and Entertainment.

Consumption	Morning	Afternoon	Evening	Night
Lighting	-	-	6pm-7pm	7pm-10pm
TV			3:30pm-7pm	7pm-9pm
Radio	7am-8am			

Conventional Energy Sources in the Study Area other than SHS:

Candles: Some of the people in this area were using candles for lighting. Mainly business people were using candles for emergency lighting and students were using candles before examination, at least 2 hours in the night. The average price of a candle in this area was 2 Taka.

Hurricane (Kerosene Lamps with Chimney): For domestic lighting this type of lamp was the most widely used form. This type of lamp was more preferable than candles and wick lamp because it produces more light. One kerosene lamp with glass chimney costs around 120 to 200 Taka.

Torches: This type of flash-light was widely used for communication to the out-doors or for intermittent indoor use, usually powered by 2 or 3 dry cell batteries, which was not in any way rechargeable.

Car battery: For entertainment purpose some people used to use car battery. To watch a black and white TV for about one hour they had to recharge a car battery twice a month and to do that they had to spend approximately, 200 taka per month.

Nowadays those conventional energy sources are not as popular as before. One of main reasons is increasing demand of SHS's.

Table 6 includes the rural electric load usage data of Bangladesh. Actually within rural areas, all these loads are not used constantly. There are some particular times of the day when loads vary. This research has also focused on timing of usage loads.

Studying Table 6, it can be summarized that the average daily electricity requirement for one household is 156 Wh.

Table 6. Daily Typical Energy Requirement for Lighting and Entertainment.

Appliance	Power (W)	Duration (Hour)	Energy (Wh)
Lamp 1 (reading and bed room)	6	5	30
Lamp 2 (bed room)	6	4	24
Lamp 3 (bed room)	6	2	12
Radio	10	1	10
TV(Black and white)	20	4	80

4.3. Problems of Households and Contribution of SHS on Social Life Changing

Having undertaken an overview of total electrical system in the designated rural area, now it's time to have an appropriate comprehension on the regular problems that the residents are facing and how SHS can contribute to solve these problems. Though poverty conditions in Bangladesh are reducing day by day the overall living standard and per capita income of the country is still low. People living in rural areas still face difficult conditions in their daily lives having to find basic items such as food and clothes as well as not being connected to the electricity grid. The financial difficulties facing people in Bangladesh is the countries foremost problem. The lack of access to electricity is also a crucial problem particularly in respect to people living in rural areas. For this reason the identification of these problems during the survey stage took a vital place in this research.

Figure 7 entails the actual phenomena of our rural area's problems. About 28% of problems occur due to the lack of proper electricity, particularly where there is no grid electricity. It also looks improbable to expect grid electricity throughout the whole country knowing our limitations of resources. Hence, Solar Home System (SHS) can play an obvious role where there is no grid electricity connection. SHS can provide access to electricity at a low cost and without distorting the environment. Therefore SHS can dramatically improve the lifestyles of rural people in Bangladesh. Figure 8 designates some of the regular activities that are frequently undertaken by people with the help of a SHS unit in their household, thus demonstrating that this technology has made the lives of these rural people far more active and easier than before.

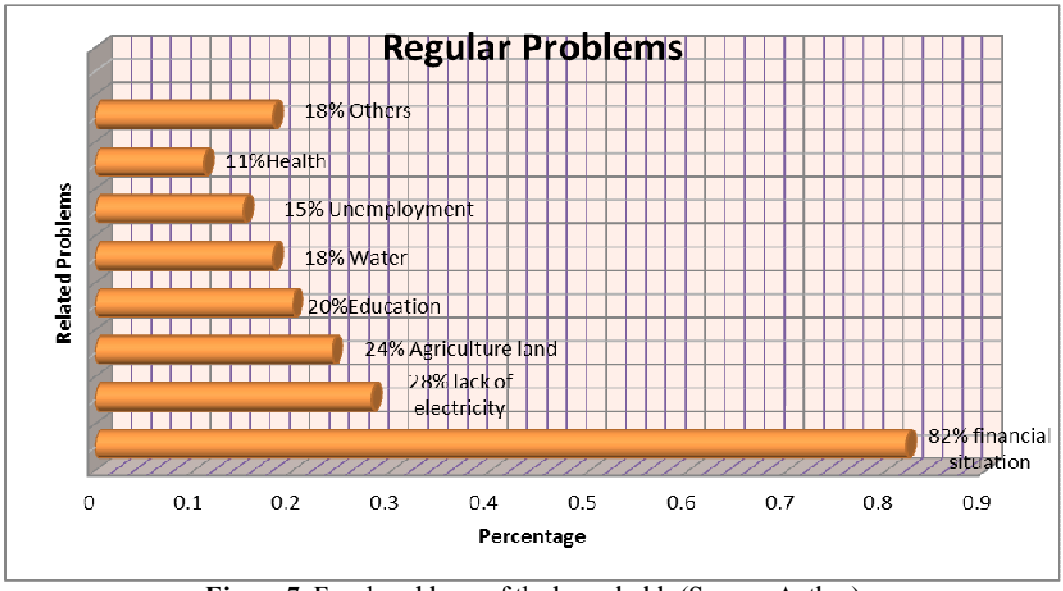

Figure 7. Focal problems of the households (Source: Author)

To reveal the subjective impressions of SHS users with respect to the socio-economic impacts of their systems, they were asked about changes in their daily lives following the installation of their system in their household. Figure 9 reveals the surveyed result, and gives a clear understanding of the positive social impacts that SHS has provided in rural Bangladesh. Now the target is to find the reasons why people are getting more interested with SHS. So the next conducted data is based on the reasons behind the public popularity towards SHS. In the investigation, the people were asked about the socio-economic impact of the SHS. Our motive was to identify the changes that SHS brought to them. The study detected many factors that bought changes in the daily lives of households. For example 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 neighbours, 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 now work longer hours in the field. Better lighting facilities have also changed the daily routine of females in the household. These days they don't 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.

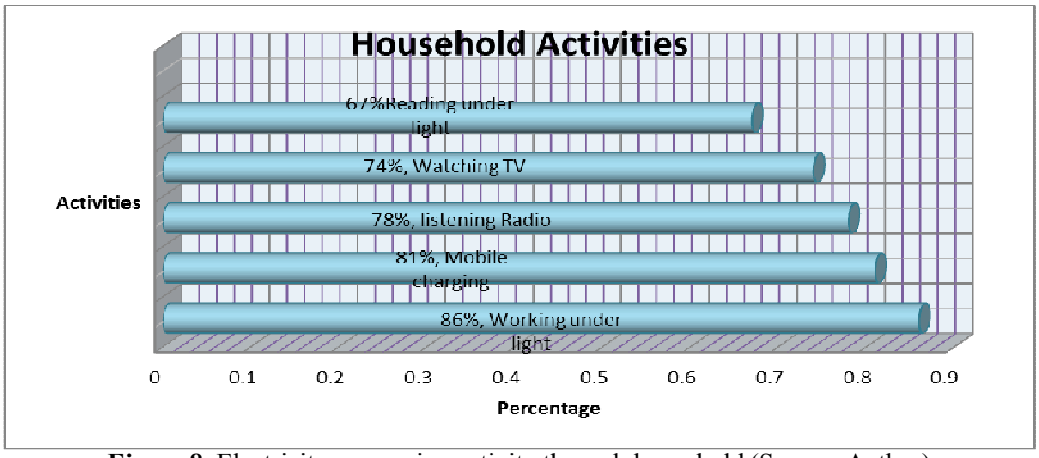

Figure 8. Electricity consuming activity through household (Source: Author)

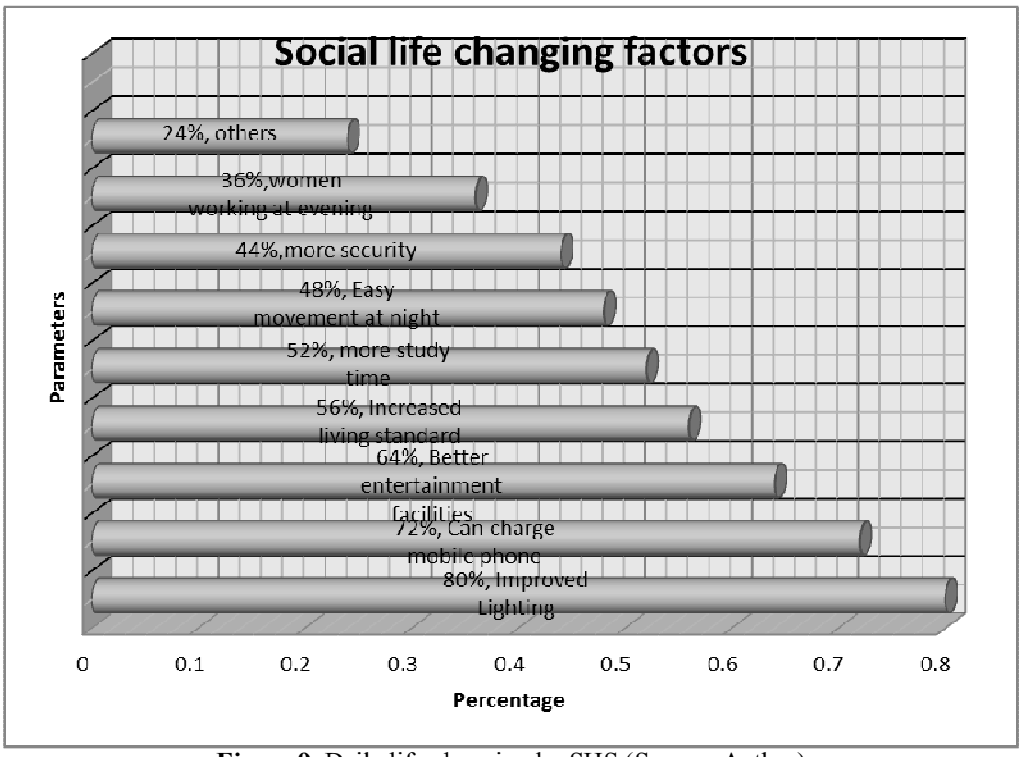

Figure 9. Daily life changing by SHS (Source: Author)

Better opportunities for information and entertainment were perceived as important changes by 64% of SHS households, followed by improved lighting conditions (80%) and thus easier movement in the house at night (48%). As another benefit of lighting, the improved conditions for studying by school children were quoted in 52% of SHS households. Other frequently mentioned changes include the possibility to charge mobile phones (72%), an overall increased living standard (56%), increased se-

curity due to household lighting (44%), and facilitated household work in the evening hours (36%).

Another motive of this exploration was to find the most benefited household members following the introduction of SHS into the household. According to Figure 10, the results assess that the most benefited members are women. Actually they are assisted in many activities by the availability of SHS. They are provided with entertainment in the evening through watching TV. Through this they are also educating themselves and advancing their personal knowledge of the world outside their home or village. Many of them are also listening to radio. Children are also very much benefiting as their activities increases. They are having chance to grow up like town kids. Most of all, women and children have noticed the improved security conditions following the introduction of SHS into the household.

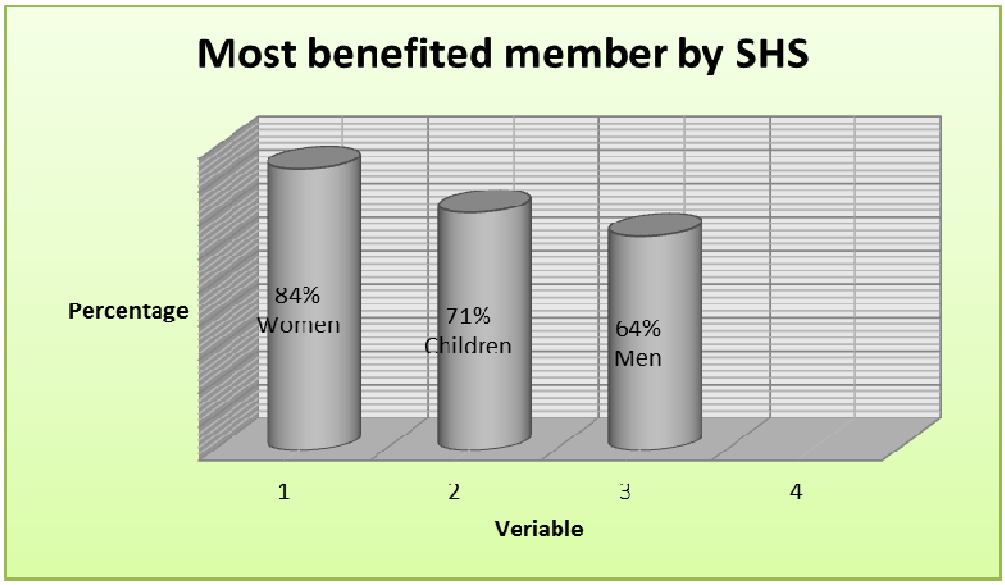

Figure 10. Most benefited member. (Source: Author)

4.4. Level of Satisfaction

Gradually, SHS is becoming a priority for the rural people. But due to the high installation price many people are still not that much interested to purchasing a SHS for their home. In addition, some people report that they are not enough satisfied with the service of the SHS organization. Still the results generally reveal that overall users of SHS are satisfied with the service they are getting. Figure 11 compares the satisfaction levels of SHS users taken from the conducted survey report. Also comparing the Michael Blunck Report of 2006 (Blunck 2007) it seems quite clear that SHS is gradually becoming a both a popular item and has name recognition amongst rural people in Bangladesh. Figure 11 outlines the positive improvement stemming from SHS usage over the last 6 years. This improvement has gone from 35 % (2006) to 52% (2012) according to results reported in our survey.

4.5. Damaged Battery Management

Towards the end of the survey, battery and charge regulator related questionnaires were asked of each household. This was due to their short warranty periods and that people need to change these items after certain period of time. Each PO's have their own program to teach people what to do with those damaged or worn out components. The survey was conducted from the 25 families along with the 5 grocery shops to find out what they actually did with those damage components. Most of them returned the items to the NGO after using them, but not all. Some of them throw the items out, which might possibly be very harmful to the environment. According to Figure 12, the 32% of people who indicated that they threw out worn or broken components is a matter of concern. This is because this percentage will be likely to increase further in the years ahead with the growing numbers of families using SHS and may result in a more threatening and hazardous environment in the near future.

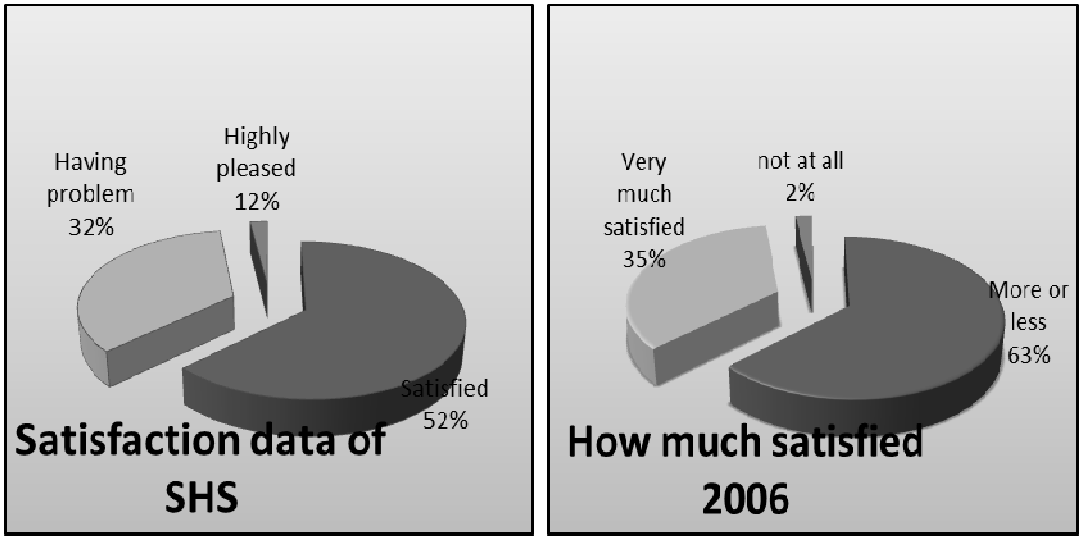

Figure 11. Comparison of satisfaction data 2006 and 2012 (Source: Author)

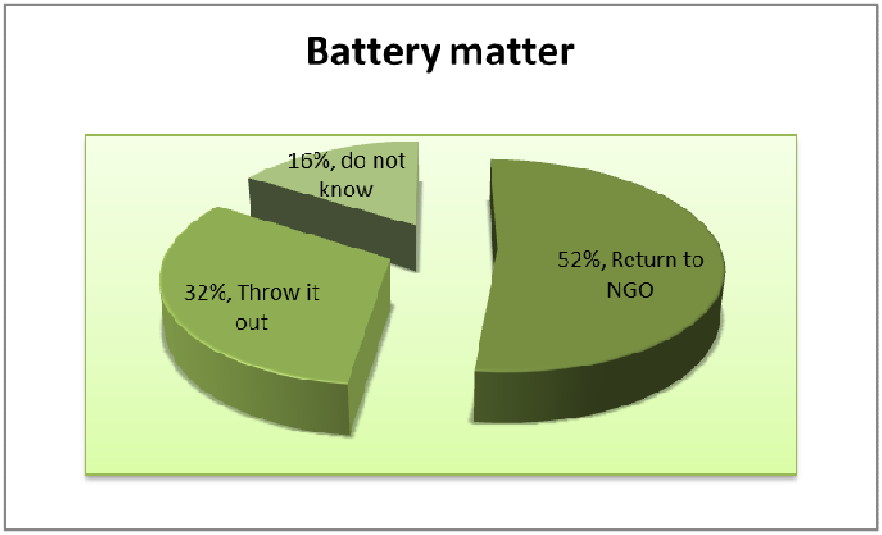

Figure 12. Management of damaging battery (Source: Author)

4.6. Need of Standard Qualification Testing

Standard component testing is badly needed nowadays. Due to the numerous manufacturers (local and foreign) the resulting device contains components that differ greatly in all parameters. As a result the overall quality varies from organization to organization. This unstable quality is increasing with the increase number of SHS installation and thus the system inefficiency. Maintenance of a standard quality will increase the life cycle of SHS and also make SHS more feasible for future. According to the synchronous research work reference paper (Khan et al 2012) is focused on standard qualification testing procedure and its impact on Bangladesh. Maintaining this qualification testing will result less discarding of components and tossing less e-wastage.

4.7. Need of Proper After-Sales-Services

In area surveyed the after-sales services are provided by BRAC solar and also by Grameen Shakti. However, 17 of the surveyed households were not satisfied with this service. According to SHS owners the main problem is related to the frequency of response; meaning technical services are not regular enough. Manpower is another notable obstacle for services. There are not enough technicians to support after-sales services. Again, there are further complaints regarding unskilled technicians. This reveals that skilled technicians need to be provided for and confirmed by the provider company. In fact, SHS is a totally interlocked system; if one of the devices components becomes damaged somehow, then the whole system becomes worthless. Unless the device is repaired by service center, owners are unable to get electricity from SHS. If the service issue is not improved then it may have an adverse effect on the SHS growing market. Furthermore, customer training should be included in the after sales service. About 50% of the SHS owners surveyed were not technically sound and they even don't know how to use it. For even the most minor technical problems the customer has to rely on the technical support services. This becomes annoying for both customer and seller. Many don't touch the system due to the fear of electric shocks. Moreover they are afraid of cleaning the panel on the SHS with dry cloths. As a result, basic training on SHS components and their operation should be included as part of the after sales service so to ensure safe usage.

5. Conclusion

The last 14 years of data shows that both rural and urban people prefer SHS as an effective alternative in providing energy for homes and businesses (Khan et al 2012). The effect on the rural population is more perceptible than on the urban as more people are aided by its capability. As mentioned before the poverty levels in Bangladesh have just started to fall. However this situation will remain uneven for sometime until both the rural and urban expansion in the economy are able to march on the same line. According to research results, SHS has started this revolution in the rural part of the Bangladesh economy and the satisfaction levels for it are quite high (Figure 11). But the main drawback is related to the income levels and the SHS price. According to the Figure 4, 48% of families have very low incomes, which means that they are unable to afford buying an SHS directly. Even paying by a monthly installment scheme is hard for them. Therefore, the government should give enough subsidies to keep the SHS price low. On

the other hand, the developing effect of SHS is not only beneficial on economic point of view but also with respect to its social impact such as improving living standards, and the new ways of thinking and gaining entertainment and so on. Nowadays, the work schedules of people in the surveyed area people increased by 86%. This is very positive sign for country's economy. Moreover, a 67% increase in the available reading times of students is a perfect example of increased development in living standards. Finally, this research indicates that woman are benefiting the most from having SHS's in their households as it improves their conventional life style, fives them the feeling of greater safety, allows them to have more entertainment choices, and take greater part in the economic activities near their home such as grocery shopping. Nevertheless, in spite of having so many advantages there are still some environmental menaces surrounding SHS usage such as the disposal of damaged batteries. The increasing numbers of SHS's used in Bangladesh will mean that an enormous number of damaged batteries will need to be disposed of thus consequently leading to a gigantic environmental hazard in the years ahead. Nonetheless, the environmental management of these batteries has become a very important topic to conduct future research. This has already started.

Acknowledgement

This research study is truly thankful to Prof. AKM Azad, who without his intellectual supervision this paper would not have been possible. I thank from the heart my departmental senior Mehrin whose data collection was very authentic and organized. In the end, thanks to all those whom were involved in the field-level data collection and also I thank the helpful households in Kapasia.

In addition, thanks are due to Michael Liam Kedzlie at IAFOR for the English editing of the manuscript.

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Received: 5 November 2012 • **Revised**: 18 March 2013 • **Accepted**: 8 May 2013