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Improvement of farmers' livelihood through solar home system: Empirical evidences from four districts in Bangladesh

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ABSTRACT

The environment friendly renewable energy (i.e., solar energy) is expanding day by day to mitigate the demand of electricity in the remote areas. Considering the significance of the solar energy, the present study was conducted to explore the core economics of using solar household system and its impact on rural livelihoods and assessing the welfare aspects of such adoption. The survey was conducted in 240 households from February to April of 2018 in four upazilas, namely Madarganj, Roumari, Fulchori and Charvadrason of Jamalpur, Kurigram, Gaibandha and Faridpur districts, respectively. A combination of descriptive and statistical techniques was applied to analyze the data. The results revealed that the age groups of 30-45 years had the maximum frequency of 52.08%. About 70.42% of the household heads were below S.S.C level and 14.16% were S.S.C passed. Among the household heads, about 60.83% were farmers and 8.33% were in other agriculture related occupation. The cash inflow of existing solar panel was Tk. 3520.00 and average salvage value was Tk. 4119.58. Assuming 12% discount rate, NPV was Tk. 18064.17 and BCR was 2.01 as well as IRR 32.39% which was greater than opportunity cost of invested capital. Average 2.07 working hour per day extended after installation of solar home system. Overall socio-economic benefit was increased. About 48.23% households' quality of life switched to good condition, 32.50% household's agricultural production increased and 45% households' social security is in good condition. The adoption of solar panel was economically viable and overall welfare increased in the study areas.

Introduction

Lack of access to electricity is a major constraint on growth and development in rural areas of developing countries (Laufer and Schafer, 2011). A large number of rural settlements are still without access to electricity, especially in sub-Saharan Africa and developing Asian countries (World Bank 2017). Electricity generation in Bangladesh mainly depends on fossil fuel that depleting rapidly (Halder *et al*., 2014). Due to high transmission and distribution costs in remote areas, many households are not connected to the national electricity network in Bangladesh (Mondal 2010). Natural gas reserves estimated to be exhausted very soon and Bangladesh's petroleum consumption is being totally import-based, increased use of renewable energy sources seems to be a reasonable step for the development of a sustainable long-term energy scenario (Islam, 2004). Even though Bangladesh's physical landscape is shaped by enormous amounts of water, the potential for hydroelectric power generation is quite limited. The use of solar energy (solar home system) is the most feasible option for rural electrification in Bangladesh (Harun 2015).

Bangladesh is suffering from acute shortage of electricity. To overcome the crisis, Government is mulling to develop atomic energy along with utilizing other possible sources. Under this crisis, an alternative source of energy is expanding in Bangladesh, especially in rural areas. The solar energy is one type of renewable energy, which has been used as an alternative source of energy in the inadequacy of continuous supply of electricity. It must be linked to development strategies for education, health, agriculture, access to information and infrastructure for socio-economic improvements. Solar home systems are the more reliable technology for uninterrupted electrification in rural areas of Bangladesh (Halder and Parvez, 2015). In 1996, Grameen Shakti successfully started expanding the renewable energy technology in rural Bangladesh. International donor agencies and development partners such as World Bank, USAID, GIZ, ADB, IDB, DFID, UK Aid and JICA involved themselves to finance the SHS program (Sharif and Mithila 2013). Up to 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 (IDCOL 2018). The solar home systems provide direct and indirect socio-

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economic benefits. But still it is very difficult to convince rural people about the positive long-term benefits of using solar energy. This study will help to explore the core economics of using solar energy and its impact on farmers' income, livelihood and future prospect of solar panel use in Bangladesh.

Materials and Methods

The study was conducted in the Charvadrason upazila of Faridpur district, Fulchori upazila of Gaibandha district, Madarganj upazila of Jamalpur district and Roumari upazila of Kurigram district. A total of 240 households (i.e., 60 from each upazila) were selected through multi-stage cluster sampling technique and conducted direct face to face interview by using a semi-structure questionnaire. Data were collected by the researchers in the month of February to April 2018. To examine the impact of solar panel on livelihood of the households, DFID (2000) Sustainable Livelihoods Framework was used. Some other analytical techniques were used for the study to achieve the objective which are as follows.

Net Present Value (NPV) were calculated by the following formula (Berk *et al*., 2015).

$$NPV\ (r, N) = \left| \sum_{t=0}^{N} \frac{R^t}{(1+r)^t} \right|$$

Where, t = the time of the cash flow; r = the opportunity cost of capital (that could be earned on an investment in the financial markets with similar risk); R^t= the net cash flow i.e. cash inflow – cash outflow at time t; and N= the total number of periods.

Benefit Cost Ratio (BCR) were calculated by the following formula (Fred and Mark, 1998).

$$BCR = \left| \frac{\sum_t \frac{B^t}{(1+r)^t}}{\sum_t \frac{C^t}{(1+r)^t}} \right|$$

Where, B^t= benefit in time t; C^t= cost in time t; and
r= rate of interest.

Internal Rate of Return (IRR) were calculated by the following formula (Gupta, 1990).

$$IRR = r_a + \left| \frac{NPV_a(r_b - r_a)}{(NPV_a - NPV_b)} \right|$$

Where, r_a= Lower discount rate; r_b= Higher discount rate;
NPV_a = NPV using the lower discount rate, and NPV_b = NPV using the higher discount rate.

Payback Period (PBP) were calculated by the following formula (Jim, 2002).

PBP =TI/NR

Where, TI = Amount of total investment; and NR= Annual profit, which is annual gross income less annual operational cost.

Likert scale was used to determine the perception about solar house system on livelihood of the rural households. Perception score for each respondent was calculated by using Perception Index (Roy, 2009) and it was calculated by using the following formula:

Perception Index (PI) = 5×SA + 4×A + 3×U + 2× DA + 1×SDA

Where, SA = Total number of respondents expressing their perception 'strongly agree' for the statement; A = Total number of respondents expressing their perception 'agree' for the statement; U = Total number of respondents expressing their perception 'undecided' for the statement; DA = Total number of respondents expressing their perception 'disagree' for the statement; and SDA = Total number of respondents expressing their perception 'strongly disagree' for the statement.

A constraint facing index (CFI) was computed by using the following formula:

CFI = (Ch × 3) + (Cm × 2) + (Cl ×1) + (Cn ×0)

Where, Ch = Number of responses indicating high constraint; Cm =Number of responses indicating medium constraint; Cl = Number of responses indicating low constraint; and Cn = Number of responses indicating no constraint.

Results and Discussion

Socioeconomic characteristics

The study results revealed that among the 240 respondents, the age group of 30-45 years had the maximum frequency of 125, which was almost 52.08% of the total population surveyed. Educational status exposed that about 70.42% were below SSC while 14.16% were SSC passed. About 60.83 percent household heads were farmers and 8.33 percent were laborers. A small part of household's occupation is in service. About 61% peoples were engaged with agriculture directly (Fig. 1).

Land holding of respondent

After solar home systems adoption, total land holding of the respondent increased. Before the adoption of SHS the amount of land holding was 336 decimal and after that it is 365 decimal (Fig. 2). The findings also show that the change in their expenditure positively related to installation of solar panel.

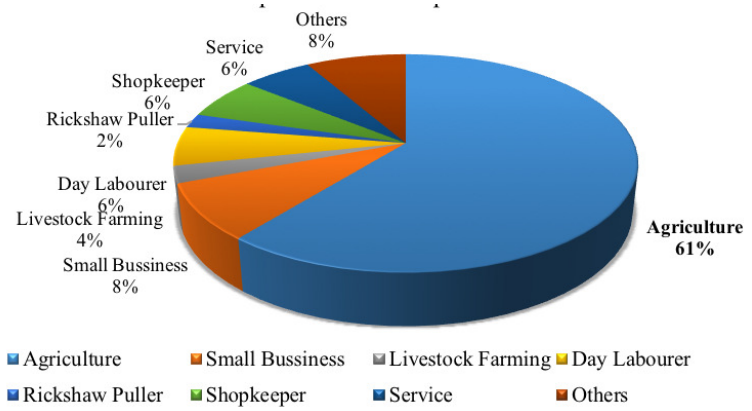

Fig. 1. Occupation of the respondents

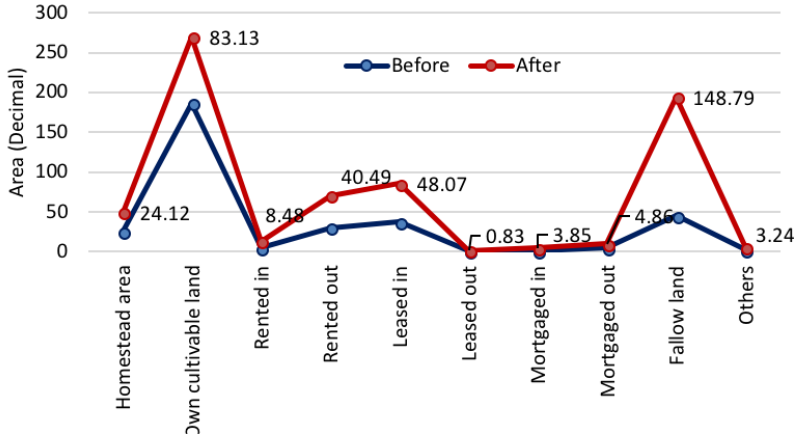

Fig. 2. Household land holding before and after installing SHS

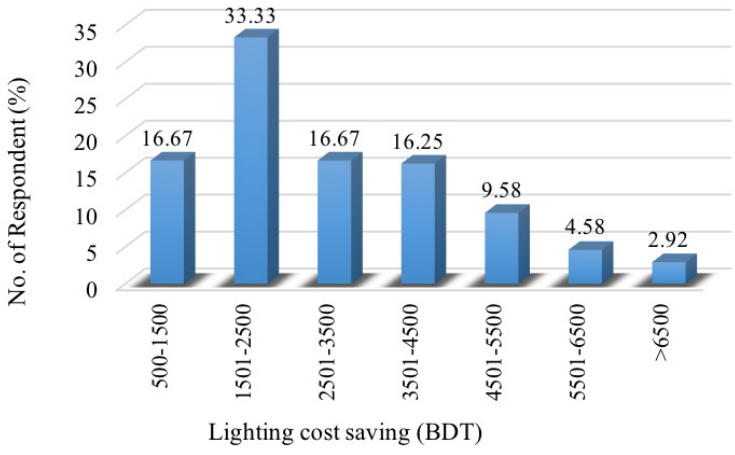

Fig. 3. Yearly lighting cost saving from the SHS

Livelihood framework

Livelihood pattern can be measured by presenting the assets in a framework which is known as asset pentagon. Asset pentagon is composed of five types of capitals namely human capital, social capital, natural capital, physical capital and financial capital (DFID, 2000). A sustainable livelihood is the outcome of inter and intra relationship between the components of these capitals. Changes in the asset position during one year were discussed as the transformation and improvement of the livelihoods of the respondents. Results show that the access to human capital for farmers who were using SHS was increased by 54.17% due to the adoption. Training increased by 34.17% and knowledge or efficiency increased by 74.17%. In case of social capital self-managerial capability of project farmers was 75.42% which was constant after the adoption. But the social access or network was increased by 85% for the solar panel user farmers. Overall natural capital resource access by the project farmers was constant which 67.91% was. The total access of physical capital was increased by 58.06%. The access of using mobile phone was increased by 94.17% for the project farmers. Finally, the access on financial capital for project farmers was increased. The capital, cash in hand was increased by 73.33% which covered majority of the project farmers. Fig. 4 shows that the significant improvement took place in farmers' livelihood by the installation of solar panel in the study areas.

Payment system and investments of SHS

There were two types of purchasing mode i.e., paying the whole amount, installment offered by different NGOs and both of the method. About 32% households purchased paying the whole amount of money by cash managed from household income. A large number i.e., 68% households purchased using installment options offered by NGOs. Duration of installment varies from 24-36 months. In case of cash payment maximum number of respondents' payment were in the range of Tk. 12001 to Tk. 22000. In installation payment the maximum respondents' were in the installment range of taka 24001 to taka 32000.

Lighting cost saving from SHS

After installation of SHS respondents are getting more lights to illuminate their home rather than lamp, lantern, etc. In an average 4 lights were used in each household. The highest number of respondent percentage are 33.33% in the category lighting cost savings of Tk. 1500 to Tk. 2500 (Fig. 3). They used this savings in different purposes like their child education or health purpose, etc.

Use of Electronic devices

After installation of SHS the use of electronics devices (specially fan) and mobile phones for communication has enhanced remarkably. On an average, each household used 1 fan and 2 mobile phones at a time. They were also using mobile as a media of audio and video player and internet connecting device.

NPV, BCR and IRR of the Solar Panel

The NPV, BCR and IRR of the solar panel, cost of solar panels, benefits of solar panels and then economic viability of solar electricity production from solar panel were estimated in this study. By analyzing the data, it was found that an average initial investment or cash outflow for the use of solar panel was Tk. 16485.60. Annual operation and maintenance (O&M) costs of solar panels were related to repairing and maintenance. The study also found that an average operation and maintenance cost was Tk. 317.88 and it was increased on the basis of 8% inflation rate for the solar panel life time which was an average 14 years. The benefits accruing from establishing and operating a solar panel fall into two essential categories: monetary and environmental. The monetary benefits are the saved costs on energy substituted by electrical energy produced. It was estimated that an average cash inflow was Tk.3520.00 and average salvage value was Tk. 4119.58 in the study areas assuming 12% discount rate. BCR, NPV, IRR and PBP were used to evaluate the investment on solar home system and in all respect this investment was feasible. Users were benefited from this investment (Table 1).

Table 1. Financial status of solar home system under different methods

Analysis	Result	Comment
Benefit cost ratio (BCR)	2.01	BCR>1, the project is accepted and beneficial.
Net Present Value (NPV)	18064.17	NPV>0, means positive, the project supposed to be accepted
Internal Rate of Return (IRR)	32.39%	IRR 32.39% is greater than opportunity cost of capital (12%).
Discounted Payback Period (PBP)	4.68	Payback period for the project is 4.68 years which is less than average life time of solar panel.

Source: Authors' calculation, 2018

Socio-economic impacts of solar home system

Before installation of SHS average working hour of household members was 5.85 hours/day. After installation of SHS households, working hour increased to 7.92 hours/day. So, average working hour extends 2.07 hours/day after installation of SHS. Table 2 shows that for agricultural/business production in the study area, 32.50% households were moderate and 39.17% households were in good condition. Only 10.82% households stated that status of agricultural benefit was low. About 50% respondents thought that, opportunity for creation of entrepreneurship were moderate and employment was increasing where 49.58% thought that it was moderate. Solar panel added the new era for the rural people. Without the electricity supply, most people of the study areas had been suffering from theft and immoral activities. About 45% respondent thought social security is in good condition. After adaptation on solar home system 48.75% in good, 32.03% in very good and 2.92% in excellent condition of the study areas.

Table 2. Before and after situations of socioeconomic aspect of the SHS users (Percentage of households)

Scale of indicator		Low	Moderate	Good	Very good	Excellent
Quality of life	Before	90.83	9.17	0.00	0.00	0.00
	After	3.33	39.58	48.33	8.33	0.42
Lifestyle status	Before	93.33	6.67	0.00	0.00	0.00
	After	10.0	35.4	42.9	10.4	1.3
Access to information	Before	93.33	6.67	0.00	0.00	0.00
	After	0.83	32.50	39.17	25.42	2.08
Agricultural/ Business production	Before	94.17	5.83	0.00	0.00	0.00
	After	10.83	51.25	32.92	4.17	0.83
Entrepreneurship	Before	97.5	2.5	0	0	0
	After	21.25	50.00	25.42	2.50	0.83
Employment	Before	97.08	2.92	0.00	0.00	0.00
	After	24.58	49.58	21.67	3.33	0.83
Security	Before	72.92	27.08	0.00	0.00	0.00
	After	0.00	35.83	45.00	18.33	0.83
Adaption on SHS	Before	4.58	95.42	0.00	0.00	0.00
	After	2.08	14.17	48.75	32.08	2.92

Source: Authors' calculation based on survey, 2018.

Table 3. Quantitative data for socio-economic development variables and their changes

Variable		Total (Tk.)	Difference	t-value	P-value
Income	Before installation	7756.35	4236.70	3.9467***	0.0043
	After installation	11993.06			
Expenditure	Before installation	5535.83	1536.94	1.8417	0.1628
	After installation	7072.78			

Source: Authors' calculation, 2018; *** indicates significant at 1% level;

Table 4. Rank wise constraints facing index of using SHS

Constraints	Constant Facing Index (CFI)	Rank
Shortage of sunlight in rainy day and heavy winter	562	1
Repair and maintenance problems	496	2
Unavailability of credit on solar panel	473	3
Higher interest rate	469	4
Lower life guarantee of solar panel	460	5
No technical knowledge/ training on the use of solar panel	445	6
Lower productivity of solar panel	414	7
Lower battery capacity used in solar panel	410	8
Higher initial cost	361	9
Choosing of proper place and angle to place the solar panel	355	10
Lower storage capacity of power	352	11
Unsealed battery contain toxic metal and metal salts and release gas while charging	330	12
Minimum installation support	325	13

Source: Authors' estimation, 2018

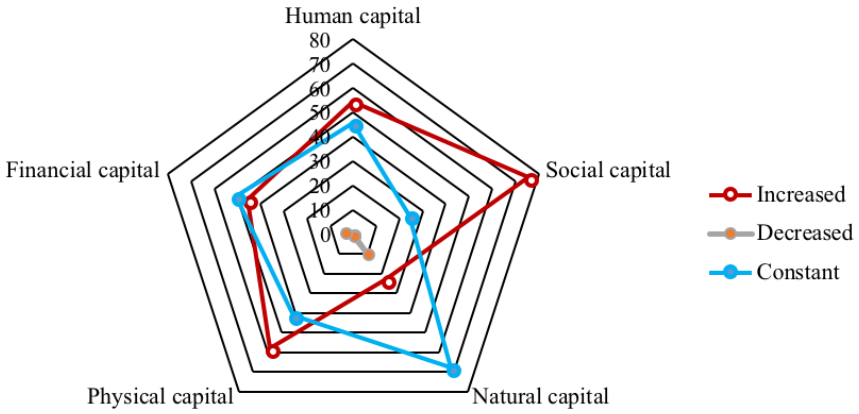

Fig. 4. Livelihood status of sample households

Quantitative measurement of socio-economic development by installing SHS

Table 3 shows that the monthly average income increased from Tk. 7756.35 to Tk. 11993.06 and positively affect their socioeconomic development which is statistically significant at 5% level and it was verified by the value of t-statistic.

Constrains of using SHS in Bangladesh

SHS users face different problem due to their lack of technical knowledge. Due to the poor maintenance, they don't get sufficient output from their connections. Moreover, different new companies were arising and to sustain and make profit in this competitive market, they often operate on such policies that reduce the acceptance of SHS to users. For this reason, the constraints of SHS were categorized basically in the following parts which are presented in Table 4.

Due to shortage of sunlight in the rainy days, the users did not get sufficient light from the SHS. Repair and maintenance, unavailability of credit, lower life span of SHS, low productivity and low battery capacity were the major constraints of using SHS. They suggested to reduce the issues so that they can get better service from SHS.

Conclusions and Policy Recommendations

The adoption of solar panel was economically viable and has positive impact on asset ownership and enhance the quality of life and productivity in the rural areas as well as it contributes to achieve the Sustainable Development Goals (SDGs) more rapidly. In this survey, it is found that micro financing system increases the affordability to purchase a solar system in the rural areas. The SHS roles on social development is more dramatic to facilitate economic development and overall welfare as well. Clear household lighting and fresh air improve education, health, facilitates in access to information, communication, entertainment which increase perception on safety. Solar panel needs to be subsidized and need to make available so that people in the remote areas all over the country can buy it easily. The proper policy guidelines and implementation will accelerate the use of renewable energy which will enhance the economy and the livelihoods of the rural people.

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