Impact of solar panel on livelihoods in a selected area of Bangladesh

Mohammad Ataur Rahman[*,1] and Md. Ibrahim Kholilullah[2]

[1]Associate Professor, Department of Agricultural Finance, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh, E-mail**:** marahman@bau**.**edu**.**bd
[2]Department of Agricultural Finance, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh, E-mail**:** kholil204@gmail**.**com
[*]**Corresponding author:** marahman@bau**.**edu**.**bd

Abstract

Demand-supply gap of electricity is one of the largest bottlenecks for economic growth in Bangladesh**.** Solar panels may be a reliable and good source for supplying electricity throughout the country**.** The study was undertaken to determine the impact of solar panel on livelihoods, Internal Rate of Return (IRR) and Payback period (PBP) of the solar panel and the problems and constrains of the solar panel faced by the households. For sustainable solar panel use, financial analysis is essential to increase the sustainability of poor people's livelihoods through promoting improved access to different types of capital. With these views multi-stage cluster sampling technique was used to collect data from 60 respondents who were using solar panels in some areas of Sherpur upazila under Bogra district in Bangladesh. Survey method was followed to collect data from the respondents. Data were collected by the researcher through personal interview and focus group discussion. Tabular technique was applied for the analysis of data and sustainable livelihood framework was used for the analysis of household assets. Most of the respondents reported that both their income, expenditure level as well as their livelihoods had increased after using the solar panels. After getting the solar panel purchased most of the livelihood assets were improved. Financial analyses were done on the basis of investment decision making tools revealed that NPV, BCR, IRR and PBP were Tk 8242**.**97, 1**.**03, 17**.**46**%** and 5**.**21 years, respectively**.** But 75% of the respondents said that the land was unchanged. 96.67% of the respondents reported shortage of sunlight in rainy day as problem, 90% of the respondents marked choosing of proper place and angel to place the solar panel as problem, and 91.67% of the respondents showed low power storage capacity as problem. It may be conclude that Bangladesh has a great potentiality to adopt more solar panels especially in household level since it has positive impact on livelihoods.

Keywords*: Solar panel, livelihood, bangladesh*

1. Introduction

Electricity is the prime hauler for the expansion of all economic and industrial activities**.** The power generations in Bangladesh mostly depend on use of natural gas, diesel and coal**.** But the reserve of natural gas is being lessening at an disquieting rate, with the current consumption rate, the natural gas will last a few decades and diesel and coal are very expensive [1]**.** Total installed electricity generation capacity in Bangladesh was 15,351 MW as of January 2017 [2]**.** Bangladesh has plan to increase power generation capacity keeping on mind an untouched market of up to 60 million people which will be potentially connected to the countrywide grid and projected demand will be 39000 MW by 2030 [3].

In Bangladesh, demand-supply gap of electricity is one of the largest drawbacks for economic growth**.** With declining supply of gas, coal is high environmental risk and diesel and furnace oil is quite expensive and hydro resources are very scare**.** Nuclear energy seems to be a substitute energy option, but densely populated country like Bangladesh, makes the nuclear power plants too controversial and risky project**.** As a result, new kinds of energy sources are gaining more attention**.** Presently, various kinds of energy sources play important role in the life of human**.** But the natural energy resources had been exhausted**.** This is due to speedily mounting population growth rate and utilization of energy**.** Fortunately, new sources of energy have been discovered**.** The production of electrical energy can be done using various types of technology and using natural resources like natural gas, and hydro energy**.**

Some of these root of high exertion of energy resources and also effect the environment**.** As a result, new kinds of energy sources are gaining more attention**.**

Solar energy is the one that gets most consideration, because energy conversion procedure from solar energy to electricity is dirt free and it does not cause any harmful to the natural environment**.** It is simple to put this energy system into use in remote rural areas, islands, educational structure and homestead where electrical power transmission lines are not available or inefficient**.** We can stock up the electric current that is produced from solar energy systems in batteries and get it to use in the night**.** Electrical energy production from solar panel has more advantages over other energy systems such as natural gas power, nuclear power, hydropower and diesel engine power, if they are compared in terms of investment, transmission, land and environmental cost**.** A total of 300000 solar panels had been installed in more than forty thousand villages of 456 upazilas of all districts of Bangladesh**.** Daily on average 44 MW electrical energy is being produced by these solar panels [4]**.** So, solar panel is more efficient way to cover the electricity shortage of the country**.**

Therefore, researcher focused on impact of solar panel of the users and to see whether the program could have positive impact on the respondents particularly in reducing poverty**.** This research was mainly aimed to investigate the impact of solar panel on livelihoods with financial analysis for the sustainability of the project and the problems and constrains of the solar panel faced by the households**.**

2. Materials and methods

Sherpur upazila of Bogra district in Bangladesh was selected purposively because of the intensity of solar panel users and familiarity of the area. A total 60 households was selected through multi-stage cluster sampling technique and conducted direct face to face interview by using semi-structure questionnaire. Survey method was followed to collect data from the respondents. The period covered in this study was January to December/2015. Data were collected during the month of January to March, 2016. Repeated visits were made for collecting primary data. To determine the NPV, BCR, IRR financial techniques were applied. To examine the impact of solar panel on livelihood of the households, DFID **(**2000**)** Sustainable Livelihoods Guidance Sheets framework was used for the analysis of households throughout several features using the household approach of identifying household assets within the vast social and economic transforming processes of community institutions and obligations, lawful framework and market structures [5] .

2.1 Analytical Tools

The following models were used for the study.

Net Present Value (NPV)

NPV is the difference between the present value of cash inflow and present value of cash outflow. NPV study is sensitive to future cash inflow that an investment will yield [6].

$$\text{NPV}\ (r, \text{N}) = \sum_{t=0}^{N} \frac{R_t}{(1+r)^t} \qquad (1)$$

Where

t = the time of the cash flow

r = the (the that could be earned on an investment in the financial markets with similar risk); the opportunity cost of capital.

R_t= the net cash flow i.e. cash inflow – cash outflow, at time *t*. For educational purposes, R_o is commonly placed to the left of the sum to emphasize its role as (minus) the investment.

N= The total number of periods

If NPV>0, that means positive, the project supposed to be accepted. However, if NPV<0 that is negative, the project should be rejected as cash flow will also be negative.

Benefit Cost Ratio **(**BCR**)**

The BCR is a relative measure, which is used to compare benefit per unit of cost. The BCR was estimated as a ratio of total cash inflow and total cash outflow **[**7**]**. The formula of Calculating BCR (undiscounted) is:

$$\text{BCR}= \frac{\sum_{t=1}^{r}\frac{B_t}{(1+r)^t}}{\sum_{t=1}^{r}\frac{C_t}{(1+r)^t}} \quad (2)$$

Where, B_t is the benefit in time t and
C_t is the cost in time t.
If BCR>1, the project is accepted and beneficial.
If BCR=1, we interpret it as indifferent
If BCR<1, the project is rejected.

Internal Rate of Return (IRR)

Internal Rate of Return is a discount rate that makes the NPV of all cash flows from a particular project equal to zero. The IRR is the annual percentage rate of return that an investment real returns over the whole life of the investment. It is expressed in percentage(%) terms [8].

$$IRR = r_a + \frac{NPV_a(r_b + r_a)}{(NPV_a - NPV_b)} \quad (3)$$

If IRR is greater than cost of capital, then the project is accepted, Other than rejected.

Payback Period (PBP)

In simple terms, payback period is the length of time required to recover initial cash outlay on the project. If cash inflows are constant, then the payback period is calculated by dividing the initial outlay by the annual cash inflow [9].

$$PBP = \frac{TI}{NR} \quad (4)$$

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

When we consider the payback period, the shorter payback period is more attractive for the project. Farms using this principle to find out the tolerable payback period.

3. Results and discussion

3.1 Determination of the NPV, BCR and IRR of the Solar Panel

For determining 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 was estimated. By analyzing the data we found that an average initial investment or cash outflow for the use of solar panel was Tk. 26555. Annual operation and maintenance (O&M) costs of solar panels were related to repairing and maintenance [10]. We also found that an average operation and maintenance cost were Tk.102 and it was increased on the basis of 8% inflation rate for the solar panel life time which was an average 12 years. Quantification of the benefits of a solar panel is a decisive step in the economic

feasibility assessment of solar panel activities. 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 is vital to find an indirect technique to appraise the benefits, and the most realistic method is to place market values in term of substitute electricity for a given final use [11]. It was estimated for the data that an average cash inflow was Tk. 5195 and average salvage value was Tk. 1280. The NPV, BCR and IRR was calculated on discount rate 15% and 20%. We used the discount rates 15% and 20% because of getting positive NPV and negative NPV value. At discount rate 15%, NPV was Tk. 1070.73 and BCR was 1.03 and at discount rate 20%, NPV was Tk. -3959.59. Using the both discounting rates (Lower discounting rate 15% and upper discounting rate 20%) we found the IRR 16.06% which was greater than opportunity cost of capital (15%, lending rate of interest) [12], the project was economically viable. We also calculated the payback period for the project which was 5.21 years and it was less than average life time of solar panel. So, the project was economically viable and acceptable (see appendix-1 and appendix-2).

3.2 Impact of Solar Panel on Livelihoods

We analyzed the impact of solar panel on livelihoods on the basis of five assets like human, social, natural, physical and financial assets [5]. To think of human capital as a store of capability, which can contribute to yield a flow of services. Being able to work with contemporary equipment is individual productive capabilities. But these capabilities not only depend on knowledge but also comprise useful behavioral way of life as well as level of liveliness and physical and mental health. Social capital means the stock of belief, common thoughtful, common ethics, and communally held information that facilitates the social harmonization of economic activity [13]. Natural resources including their land (purchased), land (lease/mortgage) etc. Physical capital has two dimension one is natural another one is produced. Produced capital is that kind of physical assets that are generated by applying human fruitful activities to natural capital, and that are used to make available of goods or services. Financial capital is what allows all these useful activities to get going, in a financial system, in progress of the returns that will stream from them. Above all five kinds of assets were given in the table 1.

Table 1 Change of different type of assets

Assets	Items	Degree of change		
		Increased	Unchanged	Decreased
Human assets	Education	46(76.67)	13(21.67)	1(1.67)
	Nutrition	42(70)	15(25)	3(5)
	Health status	43(71.67)	15(25)	2(3.33)
	Capacity to work	36(60)	18(30)	6(10)
Social assets	Women empowerment	40(66.67)	8(13.33)	12(20)
	Leadership	40(66.67)	13(21.67)	7(11.67)
Natural assets	Land (purchased)	23 (38.33)	20 (33.33)	17 (28.33)
	Land (lease/mortgage)	13(21.67)	45 (75)	2 (3.33)
	Trees and forests	20 (33.33)	14 (23.33)	26 (43.33)
Physical assets	Bed	38(63.33)	20(33.33)	2(3.33)
	Chair	35(58.33)	19(31.66)	6(10)
	Table	31(51.67)	27(45)	2(3.33)
	Cupboard	40(66.67)	14(23.33)	6(10)
	Showcase	30(50)	23(38.33)	7(11.67)
	Television	24(40)	26(43.33)	10(16.67)
	Bicycle	23(38.33)	24(40)	13(21.67)
Financial assets	Cash in hand	42(70)	13(21.67)	5(8.33)
	Deposit in the bank	46(76.67)	10(16.67)	4(6.67)
	Goats	42(70)	14(23.33)	4(6.67)
	Duck	40(66.67)	13(21.67)	7(11.67)

(Figures in parentheses indicate percentages)
Source**:** Field Survey, 2016

Table 1 shows that most of the assets were positively changed after using solar panel except land (lease/mortgage) which was unchanged by 75% respondents. Beside this, 43.33% respondents replied that their trees and forests were decreased after using solar panel**.**

3.3 Problems faced by the Solar Panel User

The problem reported in this section was based on the opinions of the respondents. The most common and serious problems is summarized below and presented in following figure 1.

Most of the solar panel users reported that, when it is rainy days, they face the shortage of power. Again, if more power was used at day period they face shortage because it gets charged only at sunlight. So it was also a major problem. Some users indicated that the power productivity of the panel should be longer than it contained at present. Due to the lower productivity they faced shortage of power for using electric tools. Some users said that, the power storage capacity was relatively lower. Many users complained that the initial cost of solar panel was higher. It was not under the nose of all people especially for poor people. That's why People thought that Government should give solar panels to the poor at free of cost, although government had already started this project. It was not possible to repair the panel by the users when get problems, having no training or knowledge on solar panel they cannot maintain it properly. Only a little numbers of NGOs were providing credit on solar panel. For this most of the areas kept out of solar panel credit as well as solar electricity facilities. The credit programs were not available to almost all the areas. The users who buy panels on credit complain that interest rate was very high. Even the people who buy the panels on cash indicated that they rejected credit due to having high interest rate. The users did not have any training to operate solar panel. For this reason many people did not buy solar panel in fear to operate properly. Even, the people working as installer or technician were not well trained or higher degree owners. Some people marked battery capacity as lower. Battery can receive less charge from the sun. For this they get less

power to use. So, they hope that the battery capacity should be enriched. Some users faced the problems of choosing of proper place and angel to place the solar panel. Because, village area is mostly covered with trees or bamboo bushes. So they found hardly a proper place to settle the panel. Many users' commented that unsealed battery contains toxic metal and metal salts, and release gas while charging. Some users said that they changed battery water for toxic problems. It was very common that users faced the problem of strong wind and sand storms. Many users told me that they have to change the switch and regulator several times**.** That means the quality of switch and regulator was very poor.

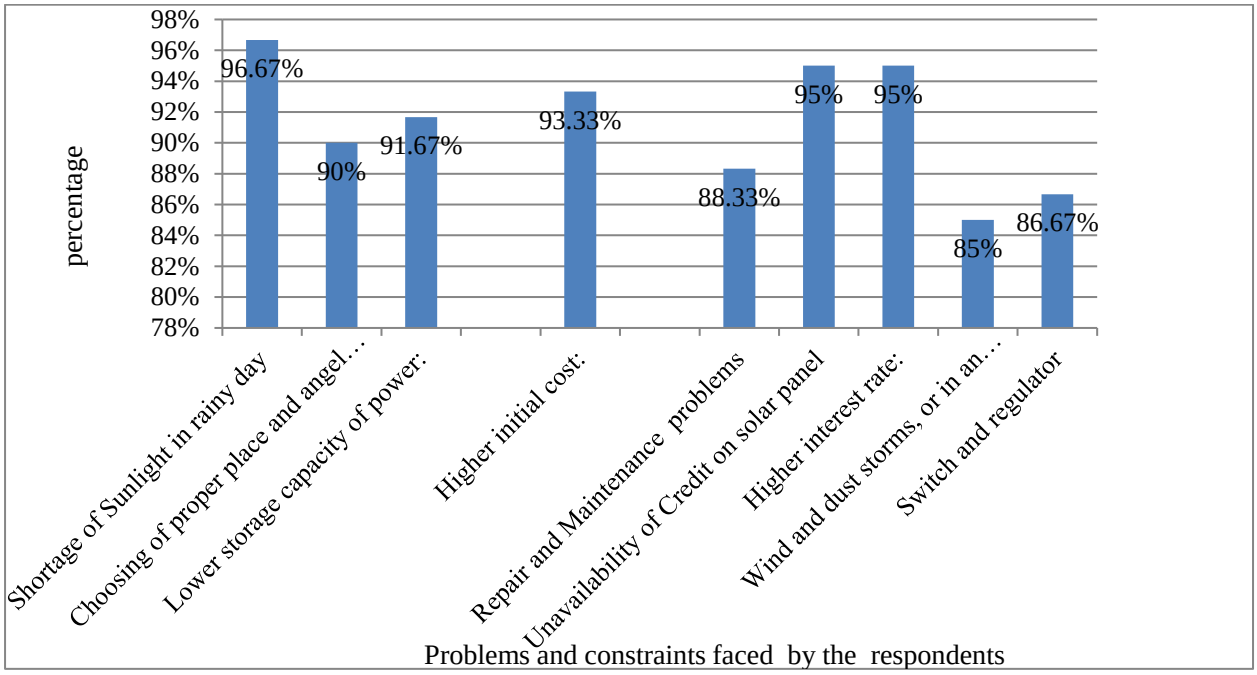

Figure 1 Problems and constraints faced by the respondents

4. Conclusion

Bangladesh is village based country but the villages are very scatter. It is known as a 'river endowment' country and the rivers are crisscross the country which make the grid electrification in many rural areas difficult and very expensive. As an alternative and very convenience, solar panel is very popular with both the consumers and suppliers and the use of solar panel is increasing day-by-day rapidly all over the country. But appropriate financial provision, including payment of installments, service fee, subsidy, technical and permissible support for organizations dealing to set up in the solar sector is important [14]. Technician guidance is essential for mounting local technical support, which can contribute to make the project sustainable. Participation of women should be encourage for training, as they are the most important actor of the systems and can able to do some of the safeguarding. For improvement of rural livelihoods and poverty alleviation, solar panel is an effective tool. "Bangladesh is really goes in front in solar home systems. The program is making a difference in the lives and livelihoods of rural people by alleviating poverty. It has fabulous potential for scaling-up and also replication in other countries under comparable conditions or necessary adaptations" [15]. The findings of the present study indicate that if the solar panel technology can be spread to the people, it must be financially viable and help to develop living standards of the people. It improved the socio-economic status of the respondents. The study observed some problems which must be solved for better use of solar panel.

References

[1] Ishrat, M., Malek, M., Hossain,M. and Sarkar, MAR, "Production and Utilization of Natural Gas in Bangladesh," (2015), *(*PDF Download Available*)*. Available from: https// www. researchgate.net/publication/ 289374730/ [accessed May 20, 2017].

[2] Bangladesh Power Development Board. Retrieved 3 November 2014. http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=5&Itemid=6. (Accessed on April 30, 2017).

[3] Bangladesh Country Commercial Guide 2016. Bangladesh-Power and Energy. Available at https://www.export.gov/article?id=Bangladesh-Power-and-energy (Accessed on May 2017).

[4] Momotaz, SN and Karim, AM, "Customer Satisfaction of the Solar Home System Service in Bangladesh," World Journal of Social Sciences, 2*(7) (*2012*)* 193 – 210.

[5] DFID 2000. Sustainable Livelihoods Guidance Sheets. Department for International Development.Http://www.Livelihoods.Org/Info/Info_Guidanceshessts.Html. (Accessed on January 30, 2016).

[6] Berk, J., DeMarzo, P. and Stangeland, D., Corporate Finance (3rd Canadian ed.). Toronto: Pearson Canada. (2015) 64.

[7] Fred, T. and Mark TG., "Handbook of Public Finance (Public Administration and Public Policy)," Routledge publication. (1998) 251.

[8] Gupta, GS, "Managerial Economics," Tata McGraw-Hill Publishing Company Limited, India. (1990) 215.

[9] Jim M., "Financial Management: An Introduction, Routledge Publishing," New York. (2002) 358.

[10] Kandpal, C. Bharati, J. and Sinha,CS., "Economics of Family Sized Biogas Plants in India," Energy Conversation Management, 32 (1991) 101-13.

[11] Singh, KJ. and Sooch, S., "Comparative Study of Economics of Different Models of Family Size Biogas Plants for State of Punjab," India. Energy Conversion and Management, 45 (2004) 1329–41.

[12] Dhaka Tribune Beta,2016. available at http://www.dhakatribune.com/business/ 2016/10/03/lending/2016/10/03/lending-rates- move-closer-single-digit/.(Accessed on January 30, 2017).

[13] Neva, RG 2003. Five Kinds of Capital: Useful Concepts for Sustainable Development. Global Development and Environment Institute Working Paper No. 03-07. Tufts University Medford MA 02155, USA http://ase.tufts.edu/gdae.

[14] Harun, MA. 2015. The role of solar home system in socio-economic development of rural Bangladesh, A PhD Dissertation, Department of Economics, Jahangirnagar University, Bangladesh.

[15] Islamic Development Bank 2012. Solar power is turning on the lights in Bangladesh. Is DB SUCCESS STORY SERIES: NO.4 (MARCH 2012). available athttp://www.isdb.org/irj/go/km/docs/documents/IDBDevelopments/Attachments/Projects/4_IDB SuccessStory4_Bangladesh_Solar_power_is_turning_on_the_lights.pdf (accessed on May 05,2017).

Appendix-1

Calculation of NPV at discount rate 15%

Year	Cash outflow (Investment) (Tk.)	Cash outflow (O&M) (Tk.)	Discount at 15%	Present cash outflow (investment) (Tk.)	Present outflow (O&M) (Tk.)	Total Present outflow (Tk.)	Total cash inflow (Tk.)	Present inflow (Tk.)	NPV (Tk.)
0	26555	0	1	26555	0		0	0	
1		102	0.8695		88.689		5195	4517.053	
2		110.16	0.7561		83.292		5195	3927.94	
3		118.972	0.6575		78.224		5195	3415.713	
4		128.489	0.5717		73.457		5195	2969.982	
5		138.768	0.4971		68.982		5195	2582.435	
6		149.869	0.4323		64.788	27086.99	5195	2245.799	1070.73
7		161.858	0.3759		60.842		5195	1952.801	
8		174.806	0.3269		57.144		5195	1698.246	
9		188.790	0.2842		53.654		5195	1476.419	
10		203.893	0.2471		50.382		5195	1283.685	
11		220.204	0.2149		47.322		5195	1116.406	
12	(1280)	237.820	0.1869	239.23	44.449		5195	970.9455	
	Total			26315.77	771.225			28157.42	

Source: Field Survey, 2016

Discounted NPV =Total Present inflow –Total present out

=28157.42-27086.99

=1070.73 Tk

Since, NPV was positive (NPV>0) and the value was Tk 1070.73, the project was economically viable.

$$\text{Discounted BCR} = \frac{\text{Total Present inflow}}{\text{Total present outflow}}$$

=28157.42/27086.99

=1.03

Since the BCR>1, the project was economically viable.

Appendix-2

Calculation of NPV at discount rate 20%

Year	Cash outflow (Investment) (Tk.)	Cash outflow (O&M) (Tk.)	Discount at 20%	Present cash outflow (investment) (Tk.)	Present outflow (O&M) (Tk.)	Total Present outflow (Tk.)	Total cash inflow (Tk.)	Present inflow (Tk.)	NPV (Tk.)
0	26555	0	1	26555	0		0	0	
1		102	0.8333		85		5195	4329.1667	
2		110.16	0.6944		76.5		5195	3607.6389	
3		118.972	0.5787		68.850		5195	3006.3657	
4		128.489	0.4823		61.964		5195	2505.3048	
5		138.768	0.4019		55.768		5195	2087.7539	
6		149.869	0.3349		50.191	27021.31	5195	1739.7950	-3959.58
7		161.858	0.2791		45.172		5195	1449.8292	
8		174.806	0.2326		40.654		5195	1208.1909	
9		188.790	0.1938		36.589		5195	1006.8259	
10		203.893	0.1615		32.930		5195	839.0215	
11		220.204	0.1346		29.637		5195	699.1845	
12	(1280)	237.820	0.1122	143.62	26.673		5195	582.6539	
			Total	26411.38	609.93			23061.7308	

Source: Field Survey, 2016

NPV =Total Present inflow –Total present out

= 23061.7308-27021.31

= -3959.58

Since, NPV was negative (NPV<0) and the value was Tk. -3959.5802, the project was economically not viable.

$$\text{IRR} = \text{LDR} + \frac{\text{NPV at lower Discount Rate}}{\text{Difference between two discount}} \times (\text{HDR-LDR})$$
$$= 15 + \frac{1070.73}{5030.31} \times (20\text{-}15)$$
$$= 15 + (0.21285) \times 5$$
$$= 16.064\%$$

Since the IRR for twelve years was 16.064%, which was greater than interest rate on lending (15%) so, the project was economically viable and acceptable.

$$\text{Discounted Payback Period} = \frac{\text{Cost of Project}}{\text{Annual Saving}}$$
$$= \frac{26555}{5093}$$
$$= 5.21 \text{ years}$$

Payback period for the project is 5.21 years which is less than average life time of solar panel. So the project is economically viable and acceptable.