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Solar electrification & education attainment: A case study of rural Bajaur agency, Pakistan

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A B S T R A C T

his paper intended to examine the impact of solar electrification on education attainment in rural areas of Bajaur Agency. The household survey was conducted by using a recall method for collecting the primary data through structured questionnaire. The data was analysed through regression model as well as through descriptive statistics. The solar energy has provided direct and indirect benefits to the plotted households in the study area of Bajaur Agency, Pakistan. The result reveals that, the study hours of students had increased after the installation of solar energy system. There was significant improvement in social activities which were earlier limited to day time. Moreover, a slight increase in income activities was also noticed due to increase in working hours. Thus, solar energy has improved the study hours and had a direct impact on human capital of the rural households. So, it is viable system and should be extended to such other inaccessible communities.

1. Introduction

In the past few years, world has witnessed the fast progress in the field of renewable energy projects [1,2].Keeping in mind this fact also that majority of renewable energy projects are installed in rural areas and resulted in having a very positive impact on the development of rural settlements[3,4]. It is also obvious that renewable energy projects have a positive impact in terms of demographics, agricultural development and on different levels of social and human capital [5, 6, 7].Furthermore, as the society begins to consider the substitutions to fossil fuels and the growth of ‘green’ industry more seriously, understanding of the science and technology in terms of energy becomes more important and evident [8]. The health and safety consequences of using other energy sources for instance, kerosene and candles are substantial [9].

In developing countries, improved modern education delivers the promise of meaningful employment for graduates, also progress towards a knowledge-based economy and rapid national economic growth [10]. It is also supported by the research that the access to electricity plays a significant role in improving learning outcomes and prolonged study hours [11]. Lack of adequate lighting critically undermines children’s ability to study in the evening and as a result it constrains their performance in the classrooms. Also, the high marginal cost of burning kerosene is a contributing factor that makes the parents unable to provide enough kerosene to continue their studies in evening [9].

The subsequent studies show the significant relationship between solar electrification and educational attainments, resulting in positive outcomes. According to a study conducted in

Nepal, interviews with local schoolteachers and students revealed that educational attainment is greater due to solar electrification because it allows the students with more time for reading and home assignments [12]. Another study in Kenya discovered that lighting has enabled existing teachers to provide extra teaching classes early in the day and late at night. It enabled them to make up for the material that was not effectively covered during normal class hours, due to shortfall of staff [13]. It is obvious that access to modern lighting technologies can yield substantial benefits. For example, a study conducted for the Millennium Villages Project in Malawi indicated that when households (hospitals or schools) switched from kerosene lamps to solar lamps, their annual expenditures on lighting dropped by almost $50 per building, excluding the cost of the lantern about $30 [14]. In short, it can be said that electricity facilitates both improved quantity and quality of studying; making it available in more parts of the day. This may clarify why provision of electricity seems to have a positive impact on the literacy rate of the youth [15]. In case of Sudan and Tanzania, the introduction of solar electricity at schools allowed success in completion rates at primary and secondary schools from less than 50 percent to close to 100 percent [16]. In Kenya, recently electrified schools showed a considerable jump on student scores for national examinations which was highly impressive [13].

Multiple studies have confirmed the positive connection between household access to electricity and various improved educational outcomes. In Zimbabwe, it was concluded that children with the access to solar energy in a household spend more time doing homework compared to those without having access [17]. In Bangladesh, duration of school attendance by children is also linked with the duration of household access to electricity [18]. In Philippines, homes with access to electricity on average have children that attend school for two years longer than those from homes lacking it which eventually affects the education rate of the country [19]. In Vietnam, another report concluded that children from grid connected households tend to stay in school more than those without grid electricity [20].In India, students whose households are electrified are more likely to complete grade appropriate tests successfully as compared to their counterparts whose households are not electrified. It cannot be incorrect to say that electrified households have higher literacy rates [21,22]. Another study of India concluded that an increase in school enrolment by about 6 percent for boys and 7.4 percent for girls is due to household electrification; as noted by the author, household electricity access, in conjunction with service reliability is what matters in improving household welfare in rural India [23].In Uganda, evidence from a pilot survey found that increase in usage of solar lamps has reported increase in the study time by approximately 30 minutes [9].

Furthermore, lack of access to modern energy services at the home can negatively impact schooling and education system at large. Numerous medical studies have documented a strong connection between the effects of indoor air pollution at home (from cook stoves) and acute respiratory infections in children, which is the major cause of school absenteeism in many countries which is alarming. For instance, in Uganda, one-third of school absenteeism comes from such infections, which commonly last for 7 to 9 days each, resulting in negative impact on study [24]. Moreover, many children, typically girls, are withdrawn from school to complete their home chores, including cooking and fuel wood collection mostly in rural areas. One study in Malawi noted that literacy rate was lower in fuel wood stressed regions of the country, and it also found a strong correlation between the time children spend in collecting fuel and reduced school attendance [24].

Some studies also paid keen attention to the financial barriers in installation of solar panels on both micro and macro level. In India, the unavailability of sufficient credit facilities and the difficulties in obtaining required finances for energy saving projects are the strong restraints to investments in energy efficiency [25]. In Malaysia, financing for energy efficiency remained a challenge due to limited successful cases and costs of renewable energy technologies are still "considered high" and risky by financiers [26]. In Nepal, the United Nations Development Programme surveyed key lenders in the sector and noted that commercial banks and financial institutions are "generally not interested" in investing in energy [27]. In the Solomon Islands, the government has defaulted on previous loan interest payments, actions that make it difficult, even today, to secure financing for energy projects, given the fact that investors see the Solomon Islands as high risk [28].As one assessment cautioned, it is most of the times evident that commercial finance is difficult to obtain on affordable terms [29].

2. Methodology

In this study, the quantitative research technique is used to quantify the impact of solar energy on education attainment. For this purpose, primary data is collected through structured questionnaire. The questionnaire comprised of the demographic information that is age, gender, and marital status, number of family members and structure of the household. Also, information about the household members, their children's level of education and the time allocation for study at home was included in the questionnaire. Furthermore, the subsequent section explains the methods and techniques used in this study.

2.1 Sample Size

The study area for this study is rural Bajaur Agency, located on western boarder of Pakistan and has about 52 km long border with Afghanistan. Due to lack of proper governance, infrastructures and schools, the literacy rate is 19 percent. The local people are deprived of basic needs of life for instance; education, hospitals, electricity and transportation. The village Lakiyanu of Bajaur Agency is selected for this study because there was no electricity before the installation of solar plant in this village. As the village Lakiyanu consists of 120 households, it was decided to cover 50 percent of the households which would be a good representative sample of the area. Therefore, 60 households were selected randomly because all the households were provided with the solar system. The sample size was selected in sequence that it covers 60 households before solar installation and 60 households after provision of solar energy.

2.2 Impact Assessment

The impact assessment is used for evaluating the impact of the program or interventions. In this study, the impact of solar energy on education attainment is evaluated. The impact covers different variables that are the changes in household income, education and access to information. The aim of the impact assessment is to measure the average changes occurred after the implementation of a program at individual, household and community level [30]. For the assessment of such program intervention, two groups are required, one is the treated and the other is the untreated one or the data of interest variable before and after the intervention of a program is required [30]. For this purpose, before and after comparison method was used. In this method, the impact of program on the outcome indicators is measured by calculating the difference between before and after the intervention by using statistical models. For the comparison of outcome on interest variables, one might use the data of the base line survey before the intervention and the end line survey after the intervention. And if the data before the program/project is not available then it is generated retrospectively by using a recall method. The beneficiaries are asked about the interest variables with respect to the situation at the present day. By using this recall method, the difference between t1 (before the intervention) and t2 (after the intervention) can be measured [31]. The rationale of using this method in the study is that a good comparison group is not available and there is also the lack of a base line survey before the intervention, therefore we cannot use the other methods discussed above and hence we are using the recall method for the comparison of before and after situation. Regression analysis is used with the following specification.

$$Y = \beta_0 + \beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 + e_i \qquad (1)$$

3. Discussion

Solar lights play an important role in supporting the education in term of improving the study hours of the children in remote areas. It is also supported by the research that the access to electricity plays a significant role in improving learning outcomes and prolonged study hours [11]. Because, most of the households in remote areas using kerosene and LPG as energy resources for lighting. The results shown in Table.1 provide the strong evidence of a significant and positive association between solar electrification and educational attainment. In short, it can be said that electricity facilitates both improved quantity and quality of studying; making it available in more parts of the day. This may clarify why provision of electricity seems to have a positive impact on the literacy rate of the youth [15]. The table.1 also illustrates that after solar installation, study hours of the children have increased. Solar electrification has helped households to support their children’s studies and education facilities at remote areas of Bajaur Agency. The result also exhibits a positive and significant relationship between increasing number of rooms in a household and student’s study hours in the area. So, high number of rooms in a household can also help students to spend some more time on studies. The family size is negatively associated with student’s study hours. It is observed that the students who are living in large families cannot study and focus for long time due to lack of peaceful environment. It might be possible that due to limited facilities in rural areas, they are unable to meet the needs of all family members. So sometimes there are also some management issues which are satisfying the need for accommodation and space for their children to study at night. However, income is an important variable which can have direct or indirect effects in children’s education but in terms of this study income is statistically not significant. Availability of computer is also positively associated but not significant factor in increasing the student’s study hours in rural Bajaur agency.

The figure.1 shows that the number of study hours has been improved after solar panel installation in the study area. Also, it is observed that there is a clear difference between the two means, trimmed means, and medians shown in Table 2. So, in rural households the solar energy has improved children’s study hours. Furthermore, as this variable has been taken as an indicator of human capital, so we can say that the provision of solar energy is the best economical option in

Table 1. Impact of solar energy on children study hours				
Dependent Variable: Ave_ Study Hours of Children, Least Squares Method Used, Sample (Adjusted): 1 120, Included Observations: 120 After Adjustments				
Variable	**Coefficient**	**Std. Error**	**T-Statistic**	**Probability**
Constant	0.45370	0.44330	1.02360	0.3082
Computer_Available	0.19460	0.31600	0.61590	0.5392
Faimly_Income	1.71e-05	1.52e-05	1.12580	0.2627
Family_Size	-0.00300	0.04300	-0.06704	0.9447
No_Rooms	0.18460	0.08780	2.10250	0.0378
Solar_Home	0.60090	0.16090	3.75675	0.0003
R-Squared	0.18530	Mean Dependent Var		1.01840
Adjusted R-Squared	0.14960	S.D. Dependent Var		0.89132
S.E. of Regression	0.82200	Akaike Info Criterion		2.49554
Sum Squared Residuals	77.0280	Schwarz Criterion		2.63402
F-Statistic	5.18360	Durbin-Watson Stat		2.00810
Prob(F-Statistic)	0.00026			

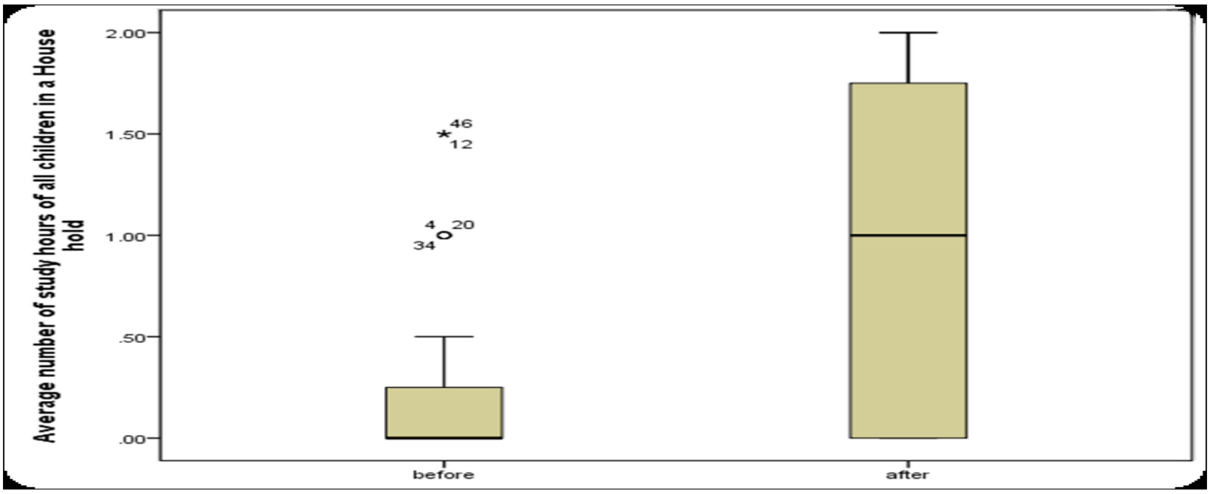

Fig. 1. Box-Plot of Study Hours before and after Solar Panel Installation

Table 2. Before and After Statistics of Study Time (Minutes)			
Variable Study Hours	**Statistics** **Mean**	**Before** 16.6667	**After** 55.3333
	5% Trimmed Mean	13.5185	54.8148
	Median	0	60
	Variance	923.077	2277.23
	Std. Deviation	30.3822	47.7203
	Minimum	0	0
	Maximum	90	120
	Range	90	120
	Interquartile Range	30	120

remote areas and it is also possible that the human capital of the rural households can be somehow improved in long run through the intervention of such kind of projects.Human capital includes education, skills, knowledge and good health. These are some important factors for achieving certain livelihood goals. Multiple studies have confirmed the positive connection between household access to electricity and various improved educational outcomes. In Zimbabwe, it was concluded that children with the access to solar energy in a household spend more time doing homework compared to those without having access [17]. The results of the regression and descriptive statistics showed a substantial increase in the study hours of the children after solar panel installation. Most respondents were of the view that it was difficult for their children to do their homework and other educational activities in the light of kerosene lamp because it does not provide them much light and is not long lasting while the solar energy bulb provides clean and bright light. So, it becomes very easy for the children to perform their learning activities in a best way till late night. The subsequent studies show the significant relationship between solar electrification and educational attainments, resulting in positive outcomes. According to a study conducted in Nepal, interviews with local school teachers and students revealed that educational attainment is greater due to solar electrification because it allows the students with more time for reading and home assignments [12]. Similarly, the people using kerosene oil and LPG for lighting, emits CO_2 and other dangerous gases inside the room, which can cause asthma, tuberculosis, eye infection and other dangerous diseases. This directly affects the human mental and physical capabilities. The study finding also showed that after the installation of solar system, consumption of kerosene oil and LPG has finished. Therefore, education and good health are the two important factors of the human capital which are positively affected after the installation of the solar panel and showed a significant improvement.

4. Conclusion

Based on the empirical findings, this paper concludes that the implementation of decentralised renewable energy technologies in rural areas had various impacts on livelihood assets of the natives. However, without claiming fully explored impact quantification on the livelihood capitals, the impact differs in form of intensity. The shift from kerosene oil and LPG to a renewable energy technology has a positive impact on local environment due to reduction in CO_2 emission. The impact on family income was not strongly significant and negligible impact on the income of the household was observed. But some respondents reported an increase in their income due to extended working hours for instance; keeping shops open till late night and sewing clothes by women at night time. A substantial increase was noticed in the study hours of the children after the installation of the solar system. The consumption of kerosene oil and LPG has completely gone out of consumption baskets and it is quite appealing that the chances and frequency of such diseases caused by indoor pollution might be declined up to reasonable notch. So, education and health are the two important factors of the human capital which are positively impacted after the installation of the solar system and have shown an apparent improvement. These findings give the impression of encouragement for future decisions, regarding solar system provision to other remote areas in Pakistan. Based on the light of the findings of the study, following recommendations are made;

- The solar energy projects should be extended to other rural areas of Pakistan because they have a positive impact on the education attainment of the remote communities.
- Government of Pakistan should subsidies solar technology so that poor people may also purchase it easily, considering their financial and purchasing power.
- Government should encourage and facilitate donor agencies while installing solar systems in rural areas.

The government should subsidies and develop the market for solar equipments to reduce indoor pollution and to achieve education attainment in rural communities.

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