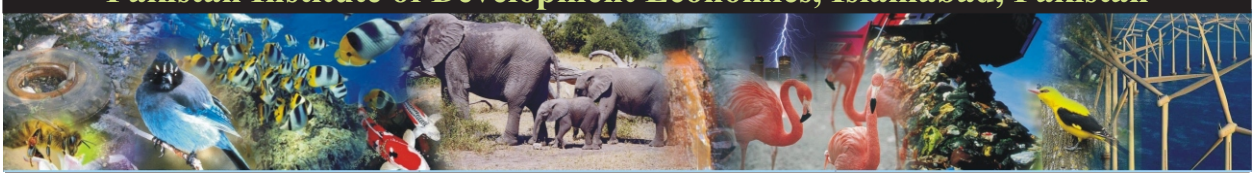
Department of Environmental Economics
Working Paper No. 12

Role of Solar Energy In Improving the Livelihood of Rural Households: A Case Study of Bajaur Agency

Saif-ur-Rahman
Muhammad Imran Khan
Usman Mustafa
Anayat Ullah

Department of Environmental Economics
Pakistan Institute of Development Economics, Islamabad, Pakistan



Department of Environmental Economics
Working Papers No. 12

Role of Solar Energy in Improving the Livelihood of Rural Household: A Case Study of Bajaur Agency

Saif-ur-Rahman
Pakistan Institute of Development Economics, Islamabad

Muhammad Imran Khan
Pakistan Institute of Development Economics, Islamabad

Usman Mustafa
Pakistan Institute of Development Economics, Islamabad

and

Anayat Ullah
Pakistan Institute of Development Economics, Islamabad

PAKISTAN INSTITUTE OF DEVELOPMENT ECONOMICS
ISLAMABAD
2017

Note: This working paper is published in continuation of the Working Paper Series published earlier by Centre for Environmental Economics and Climate Change (CEECC), Pakistan Institute of Development Economics (PIDE), Islamabad.

Pakistan Institute of Development Economics
Islamabad, Pakistan

E-mail: publications@pide.org.pk
Website: http://www.pide.org.pk
Fax: +92-51-9248065

Designed, composed, and finished at the Publications Division, PIDE.

C O N T E N T S

List of Tables

List of Figures

ABSTRACT

This Study was conducted in a far-flung village of Bajaur agency, where no electricity was available and about two years back a non-government organization provided solar system to each household. The paper intended to examine the socioeconomic and environmental changes occurred after the installation of the solar home system. Using a recall method, household survey was conducted for collecting the primary data through questionnaire and focus group discussions. The data was analysed through Regression model as well as through descriptive statistics. The results discovered that solar system has provided direct and indirect benefits to the plotted households. The study hours of the students were getting improved after the lightning source availability. The consumption of kerosene oil and LPG, which were used for lighting have been subtracted from their consumption baskets. This resulted less indoor pollution and more saving due to cut off of expenditure on these resources. The impact on business activities was negligible, however it added a little bit to the income because of the extended working hours at evening. Information and communication appliances along with other electrical equipment were found which were not available before the installation. There was significant improvement in social activities which were earlier limited to day time. Thus solar system has improved the livelihood capitals of the rural households and it is a viable system and should be extended to such other remote communities.

Keywords: Solar System, Socio Economic and Environmental Changes, Focus Group Discussions

1. INTRODUCTION

"Energy is one of the most important levers in human development, and, as such, it acts as a key factor in determining the economic development of all countries."

1.1. Importance of Energy

Energy is a source of all biological processes and life on this planet. Thousands of years ago, when the people learned how to control and use fire, the creation of new energy sources and systems started. In order to conduct a comfortable and technologically advanced life the need for new energy system was strongly felt [Gadonniex (2010)]. The energy supply is challenging because of high demand and limited availability of fossil fuels. The unsustainable use of energy in the past has strongly affected the Global Environment. One of the solutions to the problems lies under the umbrella of renewable energy, which is now becoming very important because of the increasing prices of fuels and the threats to the Global Environment [Jedemann (2011)]. Not only use of energy but also lack of access to clean energy sources may have drastic effects on environment. About 2 billion people in the world use traditional sources of energy while about 1.5 billion people have no access to energy [UN-Energy (2005)]. So, that is why the insufficient modern energy is considered as one of the key fence in the way of development. The renewable, environment friendly and decentralised sources of energy such as solar, wind and hydro are useful to provide electricity to remote areas, where people live without electricity. Usually in rural and remote areas the common grid electricity is not economically viable. Access to electricity is regarded as important channel for the development of human life. [Jedemann (2011)]. It has many times proven empirically and there is strong association between per capita energy consumption and the human development index [IEA (2009)].

Various studies revealed that, rural electrification is more helpful for development indicators of any economy. A study of the World Bank for 11 countries indicated that rural electrification is useful in number of ways; it works

Acknowledgements: We owe special thanks toFatima Athar, Research Assistant, Environmental Economics department, PIDE, for her help. All the errors and omissions are the responsibility of the authors.

for better health, because the people will not use those energy sources for cooking, lighting and heating, which emit CO_2 and create indoor pollution [Zilles (2007)]. Karekeziand Sihag (2004) argued that, without sufficient energy supplies the education and health condition cannot be desirably improved because in many rural areas kerosene oil and candles are used for lighting. According, to Kaplin (2007) burning of candles in a closed room create a lot of pollution and may cause mental problem or fetal damages to the kids and adults. In rural areas students do their study and homework at day time only because they do not have light to study at night. If there is little electricity available at night, it may improve students' performance by investing more time in their studies. So, that's why rural electrification plays a key role to improve the socioeconomic condition of the people in rural areas.

1.2. Energy Crises in Pakistan

According to Rafi Amir-U-Din (2014) Pakistan is facing worst energy crisis in recent years. Loss of R.s 100 billion is caused by electricity thieves in Pakistan every year, which is a serious issue to the management of enternal system. Pakistan was ranked, 36th lowest energy consuming country of the world in 2012 with use of only 43 Watts per person annually. In Pakistan almost 30 million people are living without electricity and if electricity is available then 16 to 18 hours' load shedding in rural areas is common and practical. In case of FATA (Federally Administered Tribal Areas) majority of the people were living in under developed and rural localities. That means, even in the 21st century, these individuals did not have access to T.V, phones and other modern technologies, which is a barrier to development of these under developed localities. Pakistan needs to improve the alternative options of electricity. Pakistan has almost the highest sun shine in the world. Pakistan needs to take serious steps for the production of energy through renewable sources to improve people livings, in rural areas. This will help in both reducing the import of fossil fuels and as well as decrease the deforestation in Pakistan [Merza, *et al*. (2003)].

Overtime there is increase in demand for energy in Pakistan and it is anticipated that it may further increases in the forthcoming years. Solar Energy is one of the low cost and environmentally friendly renewable sources of energy available in Pakistan. This renewable energy technology can be appropriately utilised in remote areas of FATA. In these distant and difficult terrain localities, supply and maintenance of electricity from national grid system is very much costly. Subsequently, the dispersed and remote villages of FATA are either deprived of electric energy or the power supply available is unreliable with inconsistency and low voltage. The alternative energy resources carry primary importance in FATA as compare to other settle parts of country. The Governor of Khyber Pakhtunkhwa (KP) has shown powerful interest in solar energy system and directed towards initiatives of different alternate energy resources

and provided solar energy units in FATA [FDA (2015)]. The solar energy is economically viable, environment friendly, and, technically suitable and sustainable solution for FATA. These energy units were given to a village in Bajaur agency named Lakiyanu. The village is located in remote areas about 50 kilometers from the head quarter of Bajaur agency. There is a single metallic road to the village. No Health center was available in this village. Primary school is available in the nearby village at a distance of about 1 kilometer and the high school and a small hospital is available at a distance of about 10 kilometers. Most of the adults of the village are uneducated and about 70 percent of kids were currently enrolled in schools. Female education ratio is very low as there is no female middle or high school available near the village. Due to the cultural restrictions and barriers these tribal people do not send their female children to outstation schools. Farming is the main occupation of the villagers. Female are also involved in the agriculture activities. Some of the villagers have small home base shops in which basic food items and other necessary items were available. No centralise electricity was available to the village and the people were using conventional sources of energy like kerosene oil, Liquefied petroleum gas (LPG) and wood for lighting, heating water and rooms and for cooking (Information from key informants).The Lakiyanu village has now been provided solar system under the project RLCIP (Rural Livelihood and Community Infrastructure Project) in December 2013. RLCIP is one of the projects of Multi-Donor Trust Fund (MDTF), administered by Planning and Development (P&D) department of FATA secretariat and supported by World Bank. Its aim was to improve the livelihood of marginalise and poor people. The solar system provided to the households consist of one 200 watts' solar panel along with 12 volt two energy savers, one 200 volt dry battery, one electric fan and a controller. Solar system was given to each household on the basis of rooms in their homes, one system per two rooms [RLCIP (2013)]. Due to the implementation of these systems, the quality of access to electricity was expected to be improved in all households in Lakiyanu village which was again expected to lead to a measurable change in their livelihood asset. Looking to the project implementation at very deserving place it plausible to think on Following questions related to solar energy system installations in FATA. The worthy looking thing is, if after this project, does the installation of solar energy system improve the health and education condition of the household members? Does the installation of solar energy system boost the access to information? Is the solar energy helpful in increasing the income of the users? Does the solar energy help in reducing deforestation and greenhouse gases? In order to determine the effects of a renewable energy on the livelihoods of those villagers we took two concepts into account. The sustainable livelihood approach (SLA) is considered as the suitable approach to analyse the above research questions as it gives comprehensive and suitable framework to assess the impact of improved access to electricity. The concept of energy service is used to operationalise the

link between access to electricity and livelihood assets. The study of Yaw, *et al*. (2014) measure effects of solar system on watching TV and listing radio in off-grid rural area, including demographic, socio economic, technology and environmental influences as variables. The solar electrified families were more benefited as compare to other non-solar electrified households by gaining more hours to enjoy TV and spending less money. Also the cost of per hour radio listening and TV watching was not as much in the solar electrified family then the ones not electrified household. The current paper aimed to investigate the impact of solar system on the livelihood capitals of the people. Specifically, the study has subsequent objectives: To investigate the impact of solar system on household's health, education, and income. To measure reduction in CO_2 emission and impact on deforestation and to investigate the role of solar energy on access to information. This study provides a great help in the future projects regarding decentralised electrification with renewable energy through its findings as this is the only study in Pakistan and especially in FATA.

1.3. Study Area: Bajaur Agency

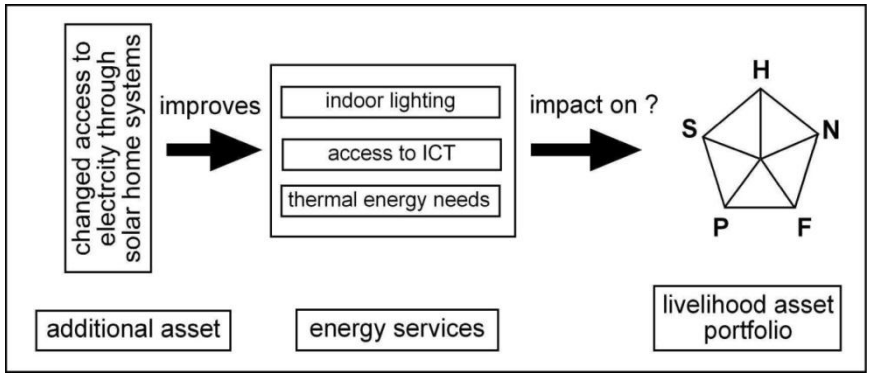
Bajaur Agency was declared federally administered tribal area in 1973. Before 1960 it was semi-independent area of Malakand. In 1960 Bajaur was given the status of a sub division in Malakand agency. The poplation of Bajaur agency is estimated to be 850, 0000 to 900, 0000. Bajaur has a 52 km long border with Afghanistan. Geographically, Bajaur share areas with Malakand agency on the South-East, with dir district on the North-West, on the South West with Mohmand agency and with Afghanistan on North-West. Bajaur is famous for its delicious and amazing food, lavish greenery unique culture and life style as well as its unique history. Bajaur has simple administrative set up. It is divided in to two sub division namely Khar sub division and Nawagai sub division under the supervision of one assistant political agent. The Khar sub division is further divided into three tehsils, Khar, Salarzai and Uthmankhel. On the other hand, Nawagai division is divided into four tehsils namely, Chamarkand, Nawagai, Mohmand and Bararng. So, all the tehsils of the agency are controlled by three political tehsildars and Naib tehsildars. The agency is governed by political agent with two assistant political agents. Agriculture is the widely ranged profession of local people of Bajaur agency. Various crops, fruits and vegetable are cultivated. 75350 hectares' area is under cultivations while 53685 hectares' area is uncultivated. While, 14061 hectares' land is under irrigation while 54006 hectares' land is non-irrigated. Forest comprises 87, 169 acres of the total area of the agency [FATA Development Statistics (2012)].

Due to lack of proper governance and infrastructures the literacy rate of education is 19 percent in Bajaur [CGPA (2015)]. The People do not have access to media and other important institutions. Regarding health, for every 2179 persons there is only one bed in hospital and on average one doctor for

7670 persons. The major source of energy is WAPDA. Out of the 1815 units surveyed, 1028 (59.49 percent) are being run with the electricity provided by the WAPDA alone and 679 (39.29 percent) units with power acquired from both WAPDA and through self-operated generators. The villagers in Bajaur agency are deprived of basic needs of life starting from education, hospitals, electricity and to the end of roads for transport across the area.

2. METHODOLOGY

2.1. Conceptual Framework



Source: Maximilian study.

2.2. Livelihoods

Livelihoods are termed as those methods and ways through which the people get access to the resources or assets which are essential for the survival [Ellies (2000)]. The survival strategy may be short term or long term which depends upon the goals and needs of the people. Five important types of capitals are known regarding livelihoods such as natural, physical, social, human and financial capitals [Carney, *et al*. (1999)]. The purpose of this research is to know the impacts of solar system on all these five assets of livelihood and in conceptual framework the linkages between these five capitals and solar home system are developed.

2.3. Livelihood Assets

At the core of livelihood framework is the idea that a wide range of assets are needed by people in order to have a suitable livelihood outcomes and it can be categorised by five capitals. “Drawing on economic metaphor, such livelihood resources may be seen as the capital base from which various out growing streams are achieved and from which livelihoods are constructed” [Scoones (1998)]. Actually poor people do not have a wide access to livelihood

assets. That is why these assets have to be innovatively combined. As these assets are interdependent, therefore improvement in one asset can affect the other in positive direction.

(i) *Physical Capital*

Basic infrastructures and production goods are regarded as the essential physical capital to support livelihood. Physical capital is basic infrastructures such as transport, proper housing and buildings, provision of water and sanitation etc [Dyner, *et al*. (2005)]. Lake of basic infrastructures gives birth to serious social problems such as poverty, illiteracy, unemployment, poor health and education [Carney, *et el*. (1999)]. So, that is why introduction of solar system may contribute to physical capital itself. As all the assets are inter linked. Access to the electricity will have productive effects on the other assets as well [Dyner, *et al*. (2005)].

(ii) Human Capital

Skills, knowledge, the ability to work and good health are termed as human capital. These are as important as the physical capital for a viable livelihood income [Carney, *et al*. (1999)]. If there is access to clean energy, the hours of production will get increase, and hence will have good impacts on health, education and wellbeing. Buragohain (2012) identify the impact of solar energy on ruler development in India. Reduction in expenditure of kerosene oil has seen due to solar system in the targeted community in all income groups. Solar system mostly benefiting women, who utilise it while working. Result showed reduction in crime rate due to accessibility of light in the community. Performance of school going children were improved due to the solar home lighting system and parents have reported significant improvement in their children's education.

(iii) Natural Capital

All the natural resources such as land, forest, water and clean atmosphere to which household have access is natural capital [Carney, *et al*. (1999)]. All the renewable resources like solar radiation; wind and many other are parts of natural capital [Dyner, *et al*. (2005)]. Suitable and proper access to electricity improves the livelihood of people and also decrease the negative impacts on the global environment [Carney, *et al.* (1999)].

(iv) Social Capital

All form of social interactions comes under the heading of social capital. Access to such form of capital will have a meaningful impact on the livelihood and it will make people work together [Carney, *et al*. (1999)]. The utilisation of

such a source to have access to specific type of livelihood outcome is social capital. Similarly, access to electricity will improve social capital by providing new options, hence will improve the livelihood of people.

(v) Financial Capital

The available cash or its equivalent which enable people to plan various ways for livelihood refers to financial capital. Available stock is separated from inflow of money. Available stock is cash, bank deposit or liquid assets and it can be in the form of credits. On the other hand earned income, state transfers and remittances are known as regular inflow of money where reliability is important among all the five types of assets [Dyner, *et al.* (2005)]. Like other capitals this capital can also be made useful and helpful through the access to electricity by using useful and efficient technologies. As access to electricity will create new opportunities, useful for a proper and comfortable livelihood, so it will lead to additional income which is directly related to financial capital [Carney, *et al*. (1999)].

2.4. Impact Assessment

The impacts of a program or intervention are evaluated in impact assessment. For example in this study it is solar energy which affects the various socioeconomic variables of the household. These effects are the changes in income, health, education and access to information along with others livelihood capitals. 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 [Conning and Deb (2007)]. For the assessment of such program intervention, two groups are required, one is the treated and the other is the untreated group or the data of interest variable before and after the intervention of a program is required. [Conning and Deb (2007)]. There are different methods used for the assessment of the impacts of a program. Some of the commonly used methods are difference in difference technique propensity score matching and instrumental variable technique.

2.4.1. *Difference in Difference (DID)*

The outcome indicators of the treatment and control group are compared two times in Difference in Difference (DID) method. For example in case of solar electrification, the difference in outcome indicators before the installation is calculated and then the difference in outcome indicators after the installation is calculated and finally the difference in the two differences is calculated. The main requirement for this method is the base line survey before the intervention and the end line survey after the intervention [Khandker, *et al*. (2010)]. The choice of DID for this study is not justified because of the background of poor and insufficient information regarding the variables and the lack of a good counter factual. The following table explains difference in difference method.

	Before	After	Difference
Treatment	A	B	B-A
Controlled	C	D	D-C
Difference	A-C	B-D	DD=(B-A)-(D-C)

2.4.2. *Instrumental Variable (IV)*

The Instrumental Variable (IV) method depends on a natural experiment, under which nature creates the treatment and control groups. The instrumental variables are those variables that affect the intervention, not the outcomes. In case of solar electrification, the instrumental variables could have been those variables which affects the installation of solar system but has no impact on the interest variables. Though the instrumental variables method decreases the selection biases, but it is difficult to find such variables. Clear theoretical intuition, good quality secondary data and a solid grasp is requires for using this method [Khandker, *et al*. (2010)].

2.4.3. *Propensity Score Matching (PSM)*

The propensity score matching method is most widely used method for the comparison of treatment and control groups which have the same characteristics by using statistical modeling [Pattanayak (2009)]. Under this method, a user household is compared with a non-user household having the same characteristics and the difference in outcomes is evaluated. Again this is not an appropriate method because of the lack of a comparison group. It is actually based on Probit model and predicted the probabilities which is based on probit model.

$$P(y|x_1, x_2, \dots x_k) = \phi(\beta_0 + \beta_1 X_1 + \cdots + B_k X_k)$$

2.4.4. *Before and After Comparison*

In this method the impact of program on the outcome indicators are measured by calculating the difference in outcome indicators before and after the intervention 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 in retrospect about the interest variables with respect to the situation at the present day. By using this recall method the difference between t_1 (before the intervention) and t_2 (after the intervention) can be measured [Greene (2012)]. The rationale of this method for using in this study is that a good comparison group is not available and the lack of a base line survey before the intervention therefore we cannot use the other methods discussed above and hence using this recall method for the comparison

of before and after situation. Regression anaylisis is used with the following specification.

$$Y_i = \beta_1 + B_2 + B_3 + +B_4 + B_5 + \epsilon_i$$

2.5. Data

This study is based on primary data by using both quantitative and qualitative data collection tecniques. The quantitative data was collected through structured and semi structured questionnaire. While for qualitative data Focus Group Discussions (FGDs) were arranged among the elders of the community. The following questions were put in the questionnaire,

- Demographic information's of the household like number of family members, age, sex, marital status and structure of the household.
- Information about the household member's health conditions like different diseases cause by indoor pollution and information on their children education like the time which they spend for reading and writing their school work.
- Information about different electrical equipment's used for information and communication like TV, Radio, computer, mobile etc. and the time spend for using these devices.
- Information about different resources used for cooking and lighting.
- Information about economic activities of the household members and their income
- Beside this we have also collected information on the perceptions and satisfaction level of the households heads about the solar system.

2.6. Sample Size and Selection of the Household

As the village Lakiyanu consist of 120 households, it was decided to cover 50 percent of the households which could be a good representative sample of the population.Within the area of Bajaur agency a village, where all the households were given the solar panel it was more reasonable to select any respondent randomly. Accordingly, 60 households were selected randomly because all the households were provided solar system. This sample size was organised in sequence that it looks like before solar installation data of first 60 respondents followed by the data of after solar installation period of 60 respondents.

3. ESTIMATES OF THE IMPACT

3.1. Impact on Education

Solar lights can play an important role in supporting the education in term of improving the study hours of the children in remote areas. Because

the solar light provides better light than kerosene and LPG as most of the household in remote areas use these two energy resources for lighting. Results, at Table 3.1 provide the strong evidences of a significant and positive association between solar electrification of a house and study hours of children living in that house. This shows that after solar installation study hours of the kids have increased. Solar electrification has helped housholds to support their kid's studies and education facilities at remote areas of Bajaur agency. High number of rooms can help students to study some-more minutes, where the result also indicates positive and significant relationship between increasing number of rooms in a household and students study hours in Bajaur agency. The study shows that family size is negatively associated with student's study hours. It possibility seen as, the students can not study without peace and focus for long time in larger families and its also possible that facilities are limited in rural areas to support the need of all family members, so larger families have, sometimes management issues of resources for satisfiying the need of accommodation and space for kids for studying at night. However, family income can support students to facilitate and incinticise for more and better study but this is statistically not significant in our case. Availability of computer is associated positive but not significant factor for increasing the students study in Bajaur agency, See (Table 1).

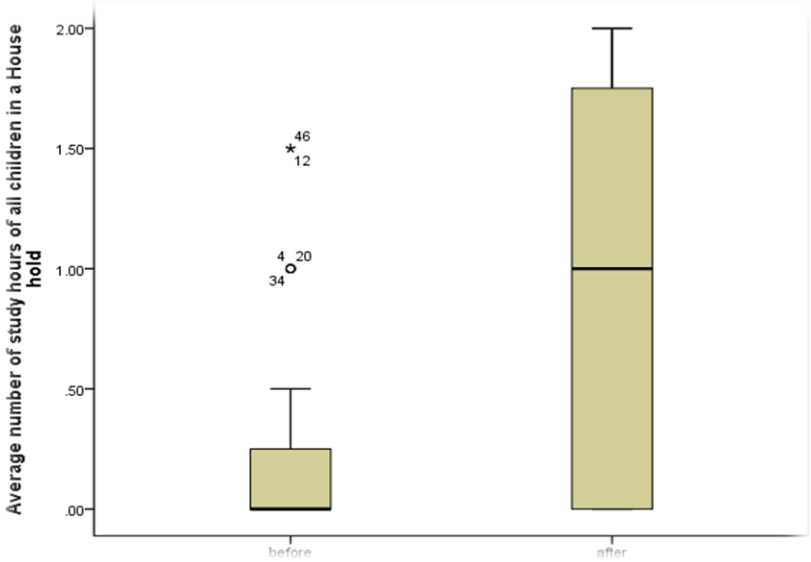
Table 1

Solar Electrification Effects on Children Average Study Hours in Bajaur Agency

Dependent Variable: Ave_ Study Hours of Childeren
Method: Least Squares
Sample (Adjusted): 1 120
Included Observations: 120 After Adjustments

Variable	Coefficient	Std. Error	T-Statistic	Prob.
C	0.453700	0.443270	1.023530	0.3082
Computer_Available	0.194591	0.315961	0.615870	0.5392
Faimly_Income	1.71e-05	1.52e-05	1.125795	0.2626
Family_Size	-0.002987	0.043003	-0.069464	0.9447
No_Rooms	0.184615	0.087810	2.102440	0.0377
Solar_Home	0.600980	0.159973	3.756756	0.0003
R-Squared	0.185235	Mean Dependent Var		1.018333
Adjusted R-Squared	0.149500	S.D. Dependent Var		0.891320
S.E. Of Regression	0.821998	Akaike Info Criterion		2.494549
Sum Squared Resid	77.02759	Schwarz Criterion		2.633924
Log Likelihood	-143.6729	Hannan-Quinn Criter.		2.551150
F-Statistic	5.183537	Durbin-Watson Stat		2.008142
Prob(F-Statistic)	0.000253			

Fig. 1. Box-Plot of Study Hours Before and After Solar Panel Installation



Number of study hours has been improved as shown in figure 1 and we can also observe a clear difference between the two means, trimmed means, medians in Table 2. We can also see the difference between the maximum values of before and after situations. So it can be stated that the solar energy has improved the children's education condition of rural households. Furthermore, as this variable has been taken as an indicator of the human capital, so we can say that the provision of solar energy is the best economical option in remote areas and its possible that the human capital of the rural households can be some how improved in longrun with such kind of projects.

Table 2

Before and After Statistics of Study Time (Minutes)

Variable	Statistics	Before	After
Study Minutes	Mean	16.6667	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

3.2. Solar Electrification Effects on Access to Information

Solar electrification has positive and statistically significant relationship with time spent, using the IC applinces in remote areas. Housholds are able to spend more time after electrification as it helps to provide enough energy for charging electric applainces, like mobile, games, radio and handlights. The 27 percent of variation in dependent variable is explained by solar electrification of a house. Family income of houshold is positively associated with using IC appliances, but it is not statistically significant in this paper. Increasing income can make households able to buy more IC applainces but it doesn't imply that, the person will have spent more of its time around IC items, with income growth. Result indicates that, large families spent more time in gatherings around TV, Radio, and another IC applainces. Radio and TV are two most frequently used IC appliances. The avaliblity of TV and Radio have positive relationship with time spent around IC appliances at household level. We can also say that the households, having their own TV and Radio, spend more time around this kind of IC appliances. Other than avalibility of IC applainces, gatherings in a family can have positive relationship with time spending around avalible IC applainces.The model is good fit with the R squared value of 64 and adjusted R squared of 61.

Table 3

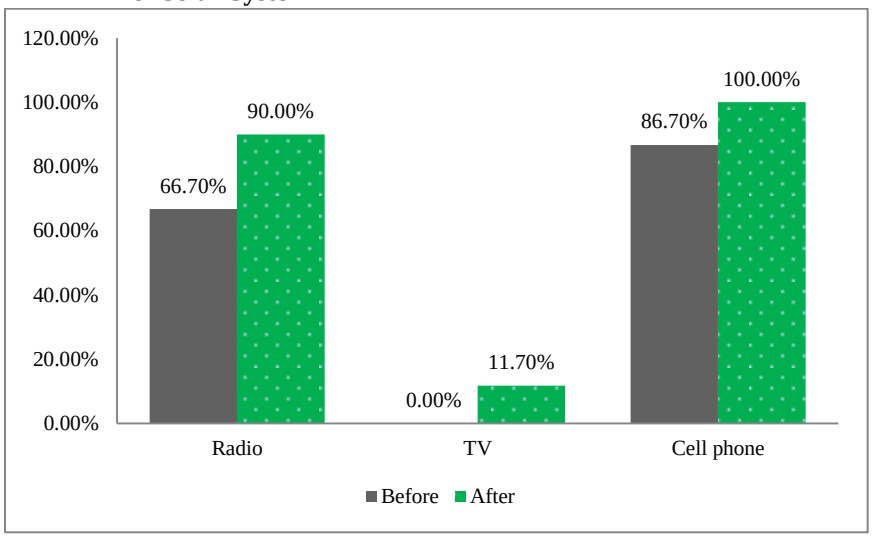
Estimation Solar Electrification Effects on Average Time Spent Using IC Appliances

Dependent Variable: TIMESPEND_ICTAPPLIANCES
Method: Least Square Sample (adjusted): 1 120
Included observations: 120 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.484983	0.464063	-1.045082	0.2983
Solar_Home	0.274066	0.118082	1.474114	0.0433
Faimly_Income	4.84E-06	1.21E-05	0.399225	0.6905
Family_Size	0.054720	0.032632	1.676851	0.0964
No_Rooms	0.067886	0.066334	1.023392	0.3083
Radio_Available	1.480211	0.163005	9.080780	0.0000
Gathering	0.428048	0.115718	3.699077	0.0003
Gender	-0.541994	0.319334	-1.697267	0.0924
TV_Available	0.592686	0.209369	2.830824	0.0055
R-squared	0.640979	Mean dependent var		1.358333
Adjusted R-squared	0.615104	S.D. dependent var		0.994065
S.E. of regression	0.616718	Akaike info criterion		1.943228
Sum squared resid	42.21785	Schwarz criterion		2.152290
Log likelihood	-107.5937	Hannan-Quinn criter.		2.028129
F-statistic	24.77179	Durbin-Watson stat		1.718136
Prob(F-statistic)	0.000000			

Figure 2 shows that before the electrification no TV was available and after the electrification just 11 percent of the household bought TV. The reason is that since no electricity was available before the electrification and we know that TV is operated by electricity. So if there is no electricity then how could one operate TV? That's why no TV was available before electrification. After electrification very few households bought TV. The second reason is that since the solar systems provided to them has limited power of 12 volts which can operate those appliances which are 12 volts, while TV is operated by 220 volt. So for the conversion of 12 volts power to 220 volt power we need a Uninterruptible Power Supply (UPS). And as we know that most of the people are poor that's why they cannot afford to buy a UPS. On the other hand if we see the ownership of radio, most of the people i.e. 66 percent were having and using radio before the electrification as it does not need much electric power to operate. It is operated through batteries that may be chargeable or disposable. Almost 24 percent increase occurred after the electrification that may be because of the chargeable batteries. Regarding the availability of cell phones, about 13 percent of the households have no cell phone available before the electrification. In most of the households just one elder member has cell phone with him. While after the electrification 100 percent of the households have cell phone available and most of the household all the elder members have cell phone with them. The reason is that before electrification they used to charge their cell phones in bazar (market) situated at a distance of about 6 kilometer by 10 rupees. So that's why some people do not have cell phones and in most of the families just a single member used cell phone.

Fig. 2. Ownership of IC Appliances Before and After the Installation of Solar System



After the provision of solar system 100 percent of the households used mobile phones, and in most of the families almost all the elder members started using mobile phones. So the findings show that the solar energy has much impact on the mobile usage, while its impact on TV and radio usage is not that much. So if we see its overall impact, the solar energy has improved the access to information and as access to information has been taken as an indicator of social capital. So we can say that the solar energy has up to some extent improved the social capital of the rural households.

3.3. Impact on Total Household Income

The income of household in Bajaur agency is positively associated with family size, which means large families need large income to support their consumption. This relationship can also be seen, as likewise larger families can provide, more labour force to work in the market, which might be the reason of high family income. However, this relationship in our estimation is not statistically significant. Inside the family male workers generate more revenue/income for family, but it's not necessary that male workers are earning alone. The relationship is positive but not significant. Increasing household age is declining the income of family.

Table 4

Estimation Results of Before and After Effect Model of Total Family Income

Dependent Variable: INCOME
Method: Least Squares
Included observations: 120 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-3142.323	781.2590	-4.022127	0.0002
Family_Size	23.81975	34.73493	0.685758	0.4954
Gender	803.0631	504.1669	1.592852	0.1163
HHH_Age	-7.045620	9.055525	-0.778047	0.4395
Solar_Home	40.89679	118.8207	0.344189	0.7319
Working_Hours	257.8886	32.12028	8.028842	0.0000
Expenditure_Replacement	1.046573	0.296701	3.527369	0.0008
Timespend_Ict Appliances	291.1364	61.77798	4.712624	0.0000
R-squared	0.687388	Mean dependent var		400.4225
Adjusted R-squared	0.647050	S.D. dependent var		792.3935
S.E. of regression	470.7575	Akaike info criterion		15.26454
Sum squared resid	13739981	Schwarz criterion		15.55136
Log likelihood	-532.8911	Hannan-Quinn criter.		15.37860
F-statistic	17.04108	Durbin-Watson stat		1.871754
Prob(F-statistic)	0.000000			

3.4. Impact on the consumption of Energy Resources Used for Cooking

As there is no availability of the centralised gas in FATA therefore the people of FATA use wood, dung cakes, crops residuals and LPG for cooking and heating. Most of the people living in remote hilly areas of FATA and they collect wood by themselves while those who live in plain areas buy wood from nearby markets. Regarding the impact of solar energy on the consumption of wood, dung cakes and crops residuals first we convert dung cakes into kilogram as we have measured dung cakes in number and then we sum up the quantity of wood, crops residuals and dung cakes befor and after. After finding the difference, we have regressed the average difference of the quantity of these three energy resources on the dummy variable which takes value one if the intervention was made otherwise zero.

The result of the regression analysis given in the Table 5, it shows that the coefficient of the dummy variable is insignificant. Means that there is no impact of solar energy on the consumption of energy resources used for cooking. Considering the fact that more or less there is no change occure in energy consumption so, it would be better if various solar kitchen appliances were also provided to beneficiary households in Bajaur agency.

Table 5

Estimation Result of Before and After Effect Model of the Consumption of Conventional Resources Used for Cooking

Dependent Variable: CROPSRESEDUAL_CNSMPTION
Method: Least Squares
Included observations: 119 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	48.30166	22.66343	2.131260	0.0353
Family_Size	3.435854	1.242330	2.765653	0.0066
Gender	-17.52737	13.59424	-1.289323	0.1999
HHH_Age	0.145795	0.344055	0.423754	0.6726
Solar_Home	-3.002687	4.855617	-0.618395	0.5376
Income_Increase	0.009909	0.003486	2.842417	0.0053
Struct_Hous	-9.918303	5.458331	-1.817094	0.0719
R-squared	0.171835	Mean dependent var		64.28571
Adjusted R-squared	0.127469	S.D. dependent var		27.52723
S.E. of regression	25.71301	Akaike info criterion		9.388893
Sum squared resid	74049.78	Schwarz criterion		9.552371
Log likelihood	-551.6392	Hannan-Quinn criter.		9.455277
F-statistic	3.873127	Durbin-Watson stat		0.908964
Prob(F-statistic)	0.001500			

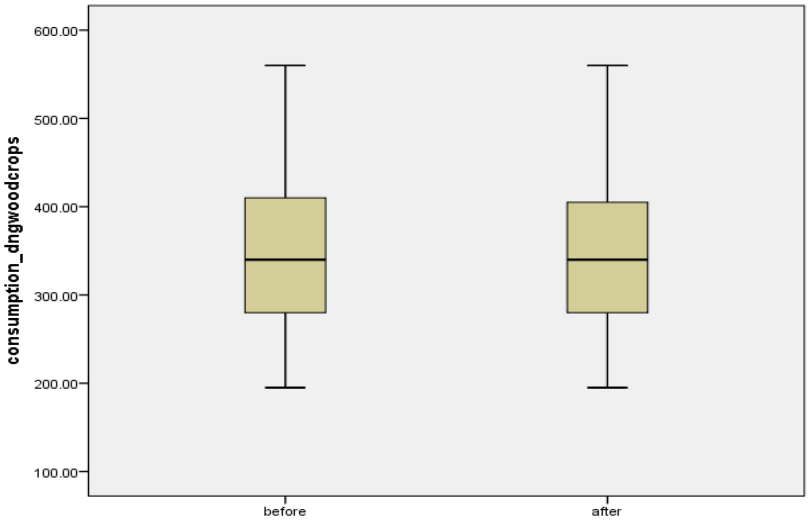
Table 6 which show the descriptive statistics confirms the result of the regression analysis. Approximately there is no difference in energy consumption even before and after installation of solar panel in rural areas of Bajaur agency. The data shows negligible amount of change for the reason that household were not provided solar kitchen appliances. The local people of Bajaur agency were still dependent on the use of dung cakes, wood and LPG for their day to day life.

Table 6

Before and After Consumption of Conventional Energy Resources (Dungcakes, Wood, Crops)

Variable	Statistics		Before	After
consumption_dngwood crops (kg/month)	Mean		341.833	341.333
	95% CI	Lower	318.522	318.115
		Upper	365.145	364.552
	5% Trimmed Mean		339.63	339.074
	Median		340	340
	Variance		8143.19	8078.7
	Std. Deviation		90.2396	89.8816
	Minimum		195	195
	Maximum		560	560
	Range		365	365
	Interquartile Range		130	127.5

Fig. 3. Box-Plot of Before and After Consumption of Conventional Energy Resources



Furthermore, Table 6 shows that, there is negligible difference between the two means; trimmed means while no difference between the two median values and the minimum and maximum values. This Figure 3 also come up with the same result, by showing almost no variation in before and after installation of solar system in rural households n Bajaur agency. The rural people used the same energy resources for cooking as they were using before the installation of the solar system. The reason is that the solar system provided to them generate a limited power of just 12 volt through which they cannot operate cooking stoves either the cooking stoves provided to them, so rural people relying on the same traditional energy resources for cooking.

3.5. Impact on the Consumption of Energy Resources Used for Lighting

There are 20 to 22 hours load shedding in FATA while there are some areas in which still there is no electricity available. The people use kerosene oil and LPG for lighting. Most of the people used LPG for cooking as well. The solar system provided to the people must have impact on the consumption of kerosene oil and LPG. To assess the impact of solar system on the consumption of kerosene oil and LPG, we regressed the before and after difference in quantity of LPG and kerosene oil separately on the dummy variable which takes the value one if the intervention is made otherwise zero.

Table 7

Estimation Results of Before and After Effect Model of the Use of LPG

Dependent Variable: CONSUMPTION_LPGKEROSENE
Method: Least Squares
Included observations: 119 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-173.2256	147.7217	-1.172648	0.2434
Family_Size	51.99982	10.98878	4.732082	0.0000
HHH_Age	2.205793	3.173807	0.694999	0.4885
Solar_Home	-91.35686	43.43355	-2.103371	0.0377
Income_Increase	-0.049492	0.031105	-1.591111	0.1144
No_Rooms	39.70213	26.20799	1.514886	0.1326
R-squared	0.217756	Mean dependent var		491.3445
Adjusted R-squared	0.183144	S.D. dependent var		251.8453
S.E. of regression	227.6180	Akaike info criterion		13.74232
Sum squared resid	5854526.	Schwarz criterion		13.88244
Log likelihood	-811.6680	Hannan-Quinn criter.		13.79922
F-statistic	6.291246	Durbin-Watson stat		2.356751
Prob(F-statistic)	0.000035			

Regression results show that the coefficient of the dummy variable is significant. With the provision of solar system the consumption of LPG has decreased substantially. This we can confirm from the descriptive statistics given below

Table 8

Before and After Statistics of the Consumption of LPG

Variable	Descriptive	Before	After
Total quantity of LPG	Mean	4.5333	3.2167
	95% Lower	4.0312	2.9008
	CI Upper	5.0355	3.5325
	5% Trimmed Mean	4.5556	3.2778
	Median	4	3
consumed per month in Kg	Variance	3.779	1.495
	Std. Deviation	1.94384	1.22255
	Minimum	0	0
	Maximum	8	5
	Range	8	5
	Interquartile Range	3	2

Fig. 4. Box-Plot of Before and After Consumption of LPG

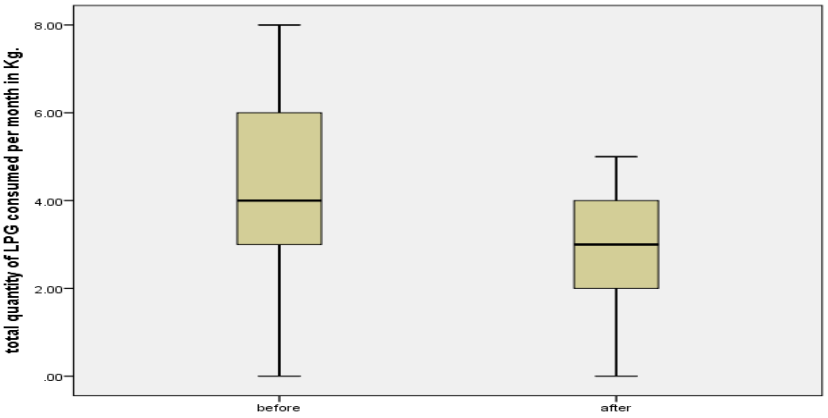


Figure 4 shows clear difference between the two means, trimmed means and medians. The mean value for before shows that the consumption of LPG was almost 4.5 kg per month per household. After the installation of the solar system the consumption of LPG decreased to 3.2 kg per month. Almost 1.5 kg decrease occurred in the consumption of LPG. According to the surveyed household, they used LPG only for cooking now. Similarly, the consumption of

kerosene oil has now been completely finished after the installation of the solar system. Because the kerosene oil was just used for lighting in these remote areas.

Table 9 shows that the average consumption of kerosene oil was almost 4 liters per month per household before the installation of solar system and the consumption of kerosene oil has declined to zero after the installation of the system. It means that the solar system has significant effects on the consumption of kerosene oil.

Table 9

Before and After Consumption of Kerosene Oil

Variable	Statistics		Before	After
Consumption Kerosene	Mean		3.75	0
(liter/month)	95% Confidence Interval for Mean	Lower Bound	3.4083	0
		Upper Bound	4.0917	0
	5% Trimmed Mean		3.7222	0
	Median		4	0
	Variance		1.75	0
	Std. Deviation		1.32288	0
	Minimum		2	0
	Maximum		6	0
	Range		4	0
	Interquartile Range		1	0

Figure 5 shows the kerosene oil consumption of household in rural Bajaur agency. There is dramatic decrease in kerosene oil consumption after the installation of solar energy panel. Before access to solar system the local people were using kerosene oil mainly for lighting purposes and that's why after installation of solar system they almost get rid of kerosene oil consumption.

Fig. 5. Box-Plot of Before and After Consumption of Kerosene Oil

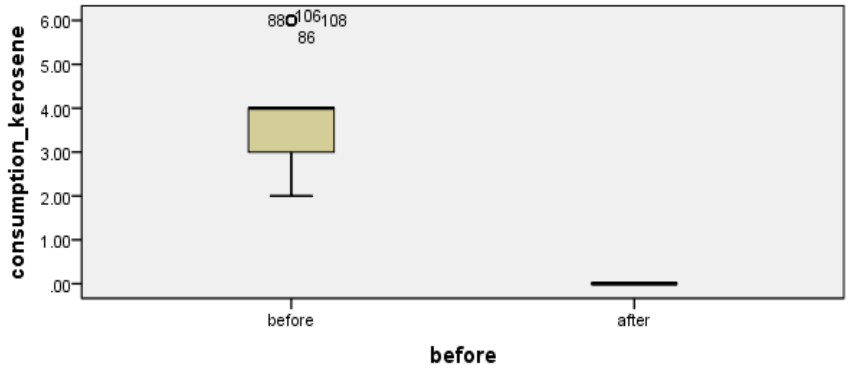


Table 10 shows that households, who have installed the solar panel in their houses, have smaller no of visits to hospital, as of reduction in use of kerosene oil, LPG, laltain and candles, which has reduced indoor air pollution in their houses. However, the effects are smaller only because of short time period to create difference in outcomes of before and after intervention. As its mentioned before that after only 3 to 4 months the data was collected on recall method. Most important variables are the availability of solar system at home and information imporoved with this energy syatem. These important variables are nigativly significant, which indicates that improvement in information can help for health-related knowledge to avaoide un healthy and inti health food and activities. All the families with higher Men, Women and Child diseases are visiting more frequently to hospitals. Only wom_dis are statistically significant. The crops reseduals burning is positively associated with hospital visits, which shows that family, which burns crops reseduals are more pron to deseasis and has many chances to visit hospital more frequently.

Table 10

Estimation Results of Before and After Effect Model of the Health Effects

Dependent Variable: VISITS_HOSPT
Method: Least Squares
Included observations: 120 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.962010	0.863077	2.273273	0.0249
HHH_Age	0.004040	0.019145	0.210996	0.8333
Solar_Home	-1.191320	0.303736	-3.922223	0.0002
Wom_Dis	0.238687	0.143035	1.668733	0.0980
Men_Disass	0.039837	0.368211	0.108189	0.9140
Cropsresedual_Cnsmption	0.000760	0.005099	0.149039	0.8818
Impro_Information	-0.004699	0.002860	-1.643251	0.1031
Child_Dises	0.019018	0.102965	0.184701	0.8538
R-Squared	0.206405	Mean dependent var		1.258333
Adjusted R-Squared	0.156805	S.D. dependent var		1.626957
S.E. Of Regression	1.493963	Akaike info criterion		3.705083
Sum Squared Resid	249.9758	Schwarz criterion		3.890915
Log Likelihood	-214.3050	Hannan-Quinn criter.		3.780550
F-Statistic	4.161421	Durbin-Watson stat		2.332319
Prob(F-Statistic)	0.000417			

4. DISCUSSION OF THE RESULTS

4.1. Natural Capital

Natural capital includes water, land, forest, biodiversity and the intangible good like the atmosphere which the people used to grow food and to structure any possible kind of livelihood. For assessing the impact of the solar energy on

natural capital, we have taken the intangible good like the atmosphere as an indicator of natural capital and for analysing the atmosphere we measure the consumption of different energy sources used for cooking and lighting. From the results we saw that the consumption of energy resources used for cooking like wood, dung cakes and crops residuals remain the same after the installation of the solar system as shown in the Table 3.6 and Figure 3.3, while the consumption of LPG decreased from 4.5 kg to 3.2 kg per month as shown in the Table 3.8. On the other energy resources used for lighting like kerosene oil have completely finished as shown in the Table 3.9 and Figure 3.5. If we see the overall impact on the natural capital we can say that the natural capital has been improved up to some extent because the people were using old form of lighting like candles, kerosene lamp and gas lamp which were creating a lot of indoor pollution and now the people are using smokeless technology for lighting which is definitely an improvement in the air quality after the installation of solar system. In general it can be stated that the shift from kerosene oil and LPG to a renewable energy technology has a positive impact on the global environment due to reduction in CO_2 emission.

4.2. Financial Capital

Savings, cash in hand, credit and any other economic assets constitute the financial capital. Financial capital is the most important capital among all the five capitals of the livelihood. Other capitals can be improved if we have strong financial capital. Regarding the impact of solar energy on capital, we have chosen the total family income as an indicator of financial capital. The impact on family income was not that much as shown in the Table 3.4 because the power of the solar system is not sufficient to operate any heavy machinery through which they can generate income for the reason that it provide just 12 volt power. But still some respondents reported a little bit growth in their income. They keep their shops open till late night after the installation of the solar system, which has positive effects on their sale and income. Some of the household reported that women are sewing cloths at night time, which was not possible before. People are now using better quality lights and they have alleviated the consumption of traditional energy resources like kerosene oil and LPG. It is expected that the people are now saving the money, which they were spending on kerosene oil and LPG. It is a positive effect on financial capital of households. Although the results show a negligible impact on the income of the household but we can say that the overall effect on the financial capital is positive and it is upgrading up to some extent.

4.3. Physical Capital

Physical capital includes basic infrastructure like building, roads, clean water supply and other physical goods essential for livelihood. Clean and

affordable energy itself is a physical capital. The provision of solar home system is a direct addition in the physical capital of the surveyed household. The solar home system consists of solar panel, batteries, bulbs, fans and inviter etc. These things were not existing with surveyed household before the project. The people purchased information and communication appliances as well as other electrical equipment's after the installation of the system. Very few people were using mobile phone before this project. The people used to charge their mobile phones in nearby markets for 10 rupees that's why only a single member of the family was hardly using mobile phone. After the installation of the system most of the family members started using mobile phones (Figure 3.2) for the reason that the people are now able to charge their cell phones in their homes. The usage of radio and TV was not that much effected. Because radio is operated through removable batteries, so most of the people were using it even before the installation of solar system. The TV cannot be operated directly through this 12 volt power. It required a device (UPS) to convert this 12 volt power to 220 volt and the people of the surveyed households were poor and could not afford it, that's why very few people reported that they have TV in their homes. The electric machines and irons which are operated through 12 volt power are found in most of the households, which were not available before the installation of the system. This shows that solar home system has positive and very good impact on the physical capital and living standards of the surveyed households.

4.4. Human Capital

Education, Skill, knowledge and Good health is Human capital. These are some important factors for achieving certain livelihood goals. The Solar home system are increasing study hours of the children. Studying and working hard is an investment in human capital, which will pay back in future. The results of the regression analysis in Table 3.1, descriptive statistics in Table 3.2 and Figure 3.1 showed a substantial increase in the study hours of the children. According to the parents of the children, 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 that much light, while the solar energy bulb provides clean and bright light. So, it become very easy for the children to perform their learning activities in a best way till late night. 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 affect the human mental and physical capabilities. So after the installation of solar system consumption of kerosene oil and LPG has completely finished. So education and good health are the two important factors of the human capital which are positively impacted after the installation of the solar home system and showed a significant improvement.

4.5. Social Capital

Social resources like Social interaction, association, affiliation and social claim which the people lie upon for pursuing their livelihood objectives constitute the social capital. Social interaction needs communication and information technologies through which the people could share their ideas and experiences with each other. As it is discussed in earlier sections that the usage of technologies has increased after the installation of the solar system. The people are now more connected with each other and rest of the world. One-way communication technology like TV and radio are quite effective as compared to two ways communication technology like mobile phones, which contact communities together. Beside this the people get together at night time has also been increased. Some of the household reported that their neighbor comes to their guesthouse (Hujra) at night for watching TV.

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

Based on the empirical findings this paper concludes that, the implementation of decentralised renewable Energy technologies in rural areas has various impacts on people's livelihood Assets. However, without claiming fully explored impact quantification on the livelihood capitals, the impact differs in form of intensity. The Natural Capital has been improved up to some extent because the people are using clean technology for lighting after the installation of solar system, which is definitely an improvement in the indoor air quality. The shift from kerosene oil and LPG to a renewable energy technology has a positive impact on local as well as on Global Environment due to reduction in CO_2 emission. The impact on family income was not strongly significant but still some respondents reported increase in their income due to extended working hours like keeping shops open till late night and sewing cloths by women at night time etc. Similarly saving of community has been increased due to their declining expenditure on kerosene oil and LPG, which is a positive impact on the financial capital of the plotted households. Although the results show a negligible impact on the income of the household but the overall impact is positive on the financial capital and it has improved up to some extent.

The provision of solar system is a direct addition in the physical capital of these households. This project encouraged people to purchase information and communication improving appliances like TV, Radio as well as some other electrical equipments. This shows that solar home system has positive impact on physical capital of the plotted households. 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 affected after the installation of the solar system and has shown an unconcealed improvement. The people are now more connected with rest of the world. Beside this people together at night and now use to set till late night in their homes. All this shows that the solar system has strengthen the social capital of plotted households. 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

- Such kinds of projects should be extended to other rural areas of FATA and Pakistan as such projects has great positive impacts on the livelihood of the remote community.
- Government should encourage and facilitate donor agencies while installing solar systems in rural areas.
- Government of Pakistan should subsidies solar technology so that the poor people may also purchase it easily considering their financial and purchasing ability.
- It is highly recommended that along with other electrical instruments operated by solar energy, the government should subsidies and develop the market for solar oven and solar stove, because as it is observed that the people of such remote areas use wood, dung cakes and crops residuals for cooking purpose, which cause a lot of indoor pollution and ultimately lead to CO_2 emissions and other dangerous gases to the atmosphere. With taking such steps we can be able to reduce CO_2 emissions to a great extent.

APPENDIX

Questionnaire

To be filled by Household Head:

Section I: Information regarding socioeconomic status of the Household

Q. Name of the Household Head: .....
Q. Age: …….. Sex: ……....
Q. Completed Years of Education: .....
Q. Total no. Family Member: …….....
Q. Availability of Solar System in your home: Yes……..No: ……...
Q. Household average monthly income……..

Section II: Health

Q. Did any of your family member suffered from such diseases (Last Month/ Year)

Diseases	Code	Diseases	Code
Asthma	1	Tuberculosis (TB)	5
Bronchitis	2	Malaria	6
Eye Infections	3	Other (specify)	7
ENT irritation	4		

Answer (use code for diseases):

Men: ……. Women: ……

Aged people: …… Children (5-15 age group): ……

Children (Less than 5 year of age): …….

Q. Do you think solar energy has any effect on your health? **(Only for Solar Electrified House hold)**

1	Positive	2	Negative	3	No Effect	4	Don't Know

If positive then,

Kerosene related accidents are less likely now

1	Yes	2	No

If "Yes" than, what kind of accident happened in past?

a. Burning of household member: Yes: ……. No: ……..

b. Fire: Yes: …… No: …….

c. Other (specify): ……..

Indoor air quality is better now

1	Yes	2	No

You are now more informed about health related issues

1	Yes	2	No

Section III: Education

Q. Total numbers of children enrolled in school in your house hold: …….

S. No.	**Sex** Male:1 Female: 2	**Age** (Years)	**Class**	**No. of study hours** (Average per day)	**No. of study hours** on average per day **before** access to solar energy **(only for solar electrified House Hold)**
1					
2					
3					
4					
5					
6					

Q. Has solar energy effects study hours of your children? **(Only for Solar Electrified House Hold)**

1	Increase	2	Decrease	3	No Effect/ Same	4	Don't Know

Section IV: Access to Information

Q. Access to such tools of information

Use code only **(1= Yes and 2= No)**

a) TV= …… If yes for how many hours per day (Mention time)……

b) Computer= ……..…… If yes for how many hours per day……

c) Radio= ……. If yes for how many hours per day……

d) Reading newspaper/books= ……. If yes for how many hours per day …..

e) Time spends by your household members for social gathering at night time…

f) Mobile=…… If yes, number of mobile users in your household ……

(Only for Solar Electrified House Hold)

f) Does the (S) SHS influence your mobile phone use?

1. Yes, I use it more often now 2. No, there is no influence
3. Yes, I use it less often now 4. I don't know

g) Where did you charge your mobile phone(s) before SHS?

1. In a nearby village 2. Within my village 3.Other [specify]

Q. Solar energy has improved access to information?

a) Much more …….. b) More…….. c) Same…….

Section V: Financial Capital

Q. No. of members who contributes to household income ……..

S. No	**Sex** Male=1 Female=2	**Age** (years)	**Activity Sector** (use code below)	**Job Position** (use code below)	**Domestic** worker=1 **Outside home** worker=2	**Monthly Average income**	No. of **working hours** per day	No. of **working hours** per day **(Before SHS)**
1								
2								
3								
4								

Activity sector: 1.Agriculture/livestock 2.Construction 3.Manufacturing 4.Transportation 5.Wholesale trade 6.Retail trade 7.Government job 8.sewing/ embroidery 9. Handicrafts 10. Home based shop 11. None /Unemployed.

Job Position: 1. Day wage worker 2. Salaried worker (private sector) 3. Salaried worker (public sector) 4. Self-employed. 5. None /Unemployed

Q. Solar energy improved your income generating activities? **(For solar electrified H.H)**

Yes…… No…….

If **yes** then please specify…….....**.....**

……

Section VI: Consumption on Energy Resources

Q. What type of energy do you use for lighting?

Energy sources	**Consumption** Yes=1 No=2	**Unit** Liter=1 Number=2 Kg=3	**Quantity** used/consumed per month	**Price per unit**	**Quantity** used/consumed per month **Before SHS**
Kerosene					
LPG					
Candles					
Emergency lights					
Other (specify)					

Q. What type of energy do you use for cooking?

Energy sources	**Consumption** Yes=1 No=2	**Unit**	**Quantity** used/consumed	**Price per unit**	**Quantity** used/consumed **Before SHS**
Kerosene					
LPG					
Dung Cakes					
Fire wood					
Crops residuals					
Other (specify)					

Q. Has solar energy effect the level of consumption on other energy resources? **(Only for solar electrified H.H)**

1	Increase	2	Decrease	3	No Effect/ Same	4	Don't Know

Q. Does anybody else benefit from the solar system?

a) Yes, my neighbor's b) Yes, my relatives c) Yes, others [specify]:

d) No, nobody else e) I don't know

If yes: How?

They charge their mobile phones here…….

They come here to watch TV……..

They come here to listen to the radio……

Other ……

REFERENCES

Ashley, C. and D. Carney (1999) *Sustainable Livelihoods: Lessons from Early Experience* (Vol. 7, No.1). London: Department for International Development.

Braden, C. (2012) Solar Energy and Rural Development—An Exploration into End-users' Impact Evaluation. A Field Study Conducted in the Solar Energy Village Rema, Ethiopia. Carl von Ossietzky University.

Brossmann, M. (2013) *Off-Grid Rural Electrification and Fighting Poverty* University of Tübingen. (Doctoral Dissertation, Master Thesis).

Buragohain, T. (2012) Impact of Solar Energy in Rural Development in India. International *Journal of Environmental Science and Development* 3:4, 334–338.

Carney, D. (1998) *Sustainable Rural Livelihoods: What Contribution Can We Make*. Advisers' Conference, July 1998. In Sustainable Rural Livelihoods: Department for International Development (DFID).

Cherni, J. A., I. Dyner, F. Henao, P. Jaramillo, R. Smith, and R. O. Font (2007) Energy Supply for Sustainable Rural Livelihoods. A Multi-criteria Decision-support System. *Energy Policy* 35:3, 1493–1504.

Conning, J. and P. Deb (2007) *Impact Evaluation for Land Property Rights Reforms*. World Bank: Poverty Reduction and Economic Management, Thematic Group on Poverty Analysis, Monitoring and Impact Evaluation.

Dyner, I., C. Alvarez, and J. Cherni (2005) Energy Contribution to Sustainable Rural Livelihoods in Developing Countries: A System Dynamics Approach. The 23rd International Conference of the System Dynamics Society, July 17-21, 2005, Boston USA.

Ellis, F. (2000) *Rural Livelihoods and Diversity in Development Countries.* New York: Oxford University Press.

Fata Development Statistics (2012) http://www.khyberpakhtunkhwa.gov.pk/Departments/BOS/main-menu-fata-dev-stats.php

FATA-Rural Livelihood and Community Infrastructure Project (RLCIP) (2013) Supporting the Recovery and Livelihood Needs of the Targeted Communities of FATA.

FDA (2015) Provision of Solar Energy to Villages in FATA (Phase-I).FATA Development Authority. Viewed in August, 2015 at http://fatada.gov.pk/

Gadonneix, P. (2010) Assessment of Energy Policy and Practices. World Energy Council. Viewed on January 2015.

Greene, William H. (n.d.) *Econometric Analysis*. 7th Edition.

Gustavsson, M. (2004) The Impact of Solar Electric Services on Lifestyles-experiences from Zambia. *J. Energy South. Afr.* 15:1, 10–15.

IEA [International Energy Agency] (2009) *World Energy Outlook 2009*. International Energy Agency (IEA) 9 rue de la Fédération, 75739 Paris

Cedex 15, France. Viewed on August, 2015. http://www.worldenergyoutlook.org/media/weowebsite/2009/WEO2009.pdf

Jedemann, M. (2011) The Impact of Decentralised Renewable Energy on Livelihoods: A Survey on Solar Home Systems for Villagers in the East Pamirs/Tajikistan Cologne, Germany: University of Cologne. (Master's Thesis).

Kamal, Pokhari and Samuhik (2011) Impact of Mini Grid Electrification: Final Report, June 2011. https://www.google.com.tr/webhp?hl=en#hl=en&q=IMPACT+OF+MINI+GRID+ELECTRIFICATION%2C+Kamalpokhari%2C+2011.

Kaplan, M. (2007) Chronic Neuro-Immune Diseases: Toxins in Burning Candles, Candle Wicks and Incense, in Melissa Kaplan's Chronic Neuroimmune Diseases Information on, [Online]. Available http://www. anapsid. org/cnd/mcs/candles.html.

Karekezi S. and A. R. Sihag (ed.) (2004) Energy Access Working Group. Synthesis/Compilation Report. Global Network on Energy for Sustainable Development(GNESD). Viewed at June http://webfea.fea.aub.edu.lb/fea/research/erg/web/Final%20Synthesis%20Re

Khandker, S. R., G. B. Koolwal, and H. A. Samad (2010) *Handbook on Impact Evaluation: Quantitative Methods and Practices*. World Bank Publications.

Mala, K., A. Schläpfer, and T. Pryor (2009) Better or Worse? The Role of Solar Photovoltaic (PV) Systems in Sustainable Development: Case Studies of Remote Atoll Communities in Kiribati. *Renewable Energy* 34:2, 358–361.

Mirza, U. K., M. M. Maroto-Valer, and N. Ahmad (2003) Status and Outlook of Solar Energy Use in Pakistan. *Renewable and Sustainable Energy Reviews* 7:6, 501–514.

Pattanayak, S. (2009) *Rough Guide to Impact Evaluation of Environmental and Development Programs*. South Asian Network for Development and Environmental Economics.

Scoones, I. (1998) *Sustainable Rural Livelihoods: A Framework for Analysis*. Institute of Development Studies, Brighton. (ID Working Papers 72).

Serpa, P. and R. Zilles (2007) The Diffusion of Photovoltaic Technology in Traditional Communities: The Contribution of Applied Anthropology. *Energy for Sustainable Development* 11:1, 78–87.

Sharif, I. and M. Mithila (2013) Rural Electrification Using PV: The Success Story of Bangladesh. *Energy Procedia* 33, 343–354.

United Nations—Energy (2005) The Energy Challenge for Achieving the Millennium Development Goals. Viewed on aAugust 2015 at http://www.un-energy.org/publications/50-the-energy-challenge-for-achieving-the-millennium-development-goals

Zahnd, A. and H. M. Kimber (2009) Benefits from a Renewable Energy Village Electrification System. *Renewable Energy* 34:2, 362–368.