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Rural Electrification and Its Impact on Households' Welfare

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Abstract
Electricity is the key input for urban and rural development which directly effects households' welfare in micro-level. Least developed countries policy focus on electrifying rural area through off-grid electricity because of high cost in connecting remote areas to national grid. This research estimates the welfare effects of Shorabak small hydropower in Fayzabad city of Badakhshan province, considering the wellbeing of residences in Taliqan city of Takhar provice that obtained from imported electricity from Tajikistan. The dependent variables of education, saving, health, employment, information and environment used as determinant of welfare in linear regression models. Residences of Fayzabad and Taliqan cities constituted the target population, who interviewed through 400 questionnaire using purposive samplings. For the purpose of analysis, regression models run in SPSS version 25. It was found that full access to electricity in Taliqan city positively changed study hours, saving via cheap per kW fee, decreased illness caused by utilizing wood, fuel for cooking and heating purposes. Furthermore, the level of information increased because of access to media particularly TV. A positive notion seen in keeping environment green by removing wood in households as result of using electricity instead. Generally the findings show, by Shorabak hydropower plant inauguration which is 90% completed the same welfare increase will be felt in Fayzabad city as well.

Keywords: Comparison Method, Rural Electrification, Welfare, Rural Electrification and Quantitative Data

Introduction

Afghanistan is a least developed country, located in central Asia. Most of its land is surrounded by mountains which made it water resource abundant country. From hydro-geographical point of view, Afghanistan water resources divided in to three ground water basins of great southern basin, central highland basin and Amu darya basin. These resources are located in south, central and north part of the country which at the same time, they are surveyed for electricity plants as well (Alim, 2006). Three decades of war left Afghanistan behind, therefore a weak political and unstable economics situation caused not to have regular updated information regarding the country's natural resources. A joint survey conducted by international partners and ministry of water shows, Afghanistan has 150000 million m3 snow and 30000 million m3 natural water resources (Aini, 2007). While only one-third of its resources manages and the remaining water drain off in to the neighboring countries, where it efficiently uses to irrigation, energy production and urban sanitation system. Meanwhile due to untreated water

resources, Afghanistan normally faces with draughts and makes the agriculture less productive (Habib, 2014). Despite of being natural water resource-abundant country that flows from its high mountains in central and northeastern part of the county, Afghanistan still imports its deficit electricity from neighboring countries (Wright, 2012). Afghanistan energy production capacity is approximately estimated 318 GW only from hydropower production and the remaining opportunities are in solar, wind and coal energy (Mir Danish, 2017). Afghan government is planning to mobilize its water resources through designing strategies to manage surface water in to agriculture and energy production sectors (M.Christensen, 2014). But there are some obstacles to avoid government to implement new hydropower project as one of them is weak financial status that push government back from its strategic hydropower development plans. Some of hydropower projects are financed by international communities that helps government expand its service to urban and suburbs (McKinna, 2018). Fortunately, some serious steps put forward to manage surface and groundwater toward agriculture development and mainly hydropower production. The energy sector emphasized on turning Afghanistan from an energy-dependent country to an energy-exporting country (Danish, 2017). Recently some hydropower plants and water dams inaugurated or newly contracted with national and international organizations. For instance, Salma dam is one of the crucial development both in agriculture and hydropower sector that eventually inaugurated by president Ghani and India Prime Minister, Mr. Modi after many security treats. Beside agriculture irrigation, the dam totally produces 40 MW electricity that use for Herat province electrification (Roy-Chaudhury, 2016). Furthermore, many construction program are going on in different part of the country that includes, rehabilitation, establishment and energy transmission programs from neighboring countries. Among many national projects, Badakhshan province electrification is recently signed between Afghan government and Pamir Energy Company a branch of Agha Khan Foundation, serving in central Asia to electrify mountainous and remote part of countries. Although prior to the mentioned contract, Shorabak hydropower plant was under construction that funded by Germany, but it is only electrifies Fayzabad city capital of Badakhshan provinces. Currently Fayzabad residents are using from diesel generator electricity which is available from 5 to 10 PM with high fee of 29 Afn per kW, whereas the neighboring city of Taliqan residences in Takhar province are paying 3 to 5 Afn for per kW. Approximately all Takhar's districts including Taliqan city capital of province is electrified through imported electricity from neighboring country Tajikistan. Therefore, this research is designed to estimate the efficiency of Shorabak small hydropower plant through analysing the welfare composing variables, considering the wellbeing that beneficiaries gained as result of round the clock electricity in Takhar province.

Theoretical Background

Energy is the key input for urban and rural development which directly effects social welfare components. From daily activities to industrial production its role cannot be ignored (Christine. W. Njiru, 2018). Considering the rapid economic development and intense global competition, governments invest more on electricity production than any time else as reliable source of renewable energy. The case for suburbs and remote areas, particularly in least developed countries are differ than developing and developed country. Lack of infrastructure, decay system and financial instability are the main reasons why least developed countries still do not have national grid and their less electricity produced in old plants are concentrated in most populated urban cities (Anup Gurung, 2011). Considering the least developed countries' features, most of them use the decentralized off-grid hydropower production system to electrify their remote areas. The reason behind applying the decentralized electricity system is definitely rooted in high cost of grid system and following the weak financial status (Yah, 2017). At the same time, countries with less renewable electricity production use from environment polluting elements that are harmful for human and are strictly prohibited by international environment advocates, thus hydropower preferred because of less CO2 emission (Prasad G. Senarath, 2017). Access to cheap hydropower diversified the welfare of the beneficiaries in many countries. For instance, Siraj and Khan assessed the impact of micro-hydropower plants in Pakistan and their findings shows that access to electricity with low cost improved the non-farm activities. Through income obtained from non-farm activities the whole welfare of the beneficiaries are positively changed (Khan, 2019). Meanwhile, The findings of a research in rural Chine indicates that, investment in renewable energy particularly, hydropower improved the rural households welfare (Jiashun Huang, 2020). Education is an important determinant of welfare, thus education development in households partially depends on full access to electricity. A research study conducted in Rwanda indicates, rural electrification through mini-grid electricity positively affected children's home study, particularly at night shifts (Gunther Bensch, 2020). Due to lack of electricity, rural

residents use from environmental products like wood as daily fuel and other elements like plastic and animal dungs. This definitely causes forest degradation and air pollution. Therefore, access to renewable energy like hydroelectricity deemed to reduce environmental harms. Demissie and Somano evaluated the impact of hydropower plants on mitigating the indoor and environment pollution. Their findings postulates, after electricity implementation the kerosene for lightening purposes and wood for cooking in kitchen reduced from household fuel basket, meanwhile access to electricity enabled families to have clean water for agriculture mill products and green farms (Getnet Zewde Somano, 2016).

Part of household's income allocates to the health care expense. The round clock health services depends on many factors that one of them is electricity. The relation between electricity and health issues somehow evaluated indirectly in research of Kanagawa and Nakata. Their findings proves, access to electricity reduced wood, fuel and animal dungs from kitchen option for cooking that produces indoor pollution which eventually decrease health problems (Nakata, 2006).

Some research studies assessed the status of small hydropower plants in Afghanistan too. A governmental program that called NSP has invested on micro-hydropower plants all over the country based on local leader choice from package of rural development projects. Bhandari and his colleagues evaluated the impact of these projects in north-east of Afghanistan. Their result shows, small scale hydropower projects satisfied the rural residences, through lightening and business initiatives in Baghlan, Takhar and Badakhshan provinces (RamchandraBhandari, 2015).

Methodology

This research is quantitative and rely on primary data. In order to obtain correct information regarding the research topic from respondents, questionnaire used as only data collection tool. The questionnaire consisted of two part of demographic and explanatory variables. Furthermore, second-hand data and research information used as supportive in theoretical part. Residences of Taliqan and Fayzabad cities of Takhar and Badakhshan provinces constituted the target population. For the purpose of the sampling, 400 households selected, 200 in each cities using purposive sampling. This method of data collection includes respondents who have the features to be interview based on research scope. From 400 questionnaires, 370 of them were retrieved and the remaining excluded due to wrong responses or miss fillings.

In order to analysis the data collected via questionnaire, SPSS version 25 applied to run the linear regression models and tested the developed hypothesis in 95% confidence interval. This research study hypothesize some of the variables as following,

H1: Rural electrification positively impacts study time.
H2: Rural electrification increases households monthly saving.
H3: Electricity reduces illness that caused by pollution that come from burnings kerosene, wood, fuel or gas.
H4: Electricity is an environmental friendly substantial element.
H5: Rural electrification creates employment opportunities.
H6: Rural electrification increase social awareness of household members.

In addition the research aims to answer the below questions,

1. Does electricity helps households to change current living style?
2. Is the proposed electricity sufficient to the local needs?
3. To which extend, electricity supply will help schools and educational organizations to standardize their teaching method?
4. Does electricity fully provide facilities to the households to reduce daily kerosene, fuel and gas usage?

The developed hypothesis of the research will be tested using below linear regression models,

1. Education =β0+ β1age+ β2gender+β3marital status+ β4family member + β5family income+ β6electrcity expenses+ β7number of educated children+ β8studyhours+e
2. Saving= β0+ β1age +β2gender+β3marital status+ β4family member + β5family income+ β6power expenses +e

3. Health= β0+ β1age +β2gender+β3marital status+ β4family member+β5family income+ β6sickness+ β7numberofhospital visits+ β8electracityexpenses+e
4. Information= β0+ β1age +β2gender+ β3marital status+ β4family member+ β5family income+ β6electrcityexpenses+ β7TVhours+ β8social awareness+e
5. Employment= β0+ β1age +β2gender+β3marital status+ β4family member +β5power expenses+ β6workinkhours+ β7business time+ β8newemployment+e
6. Environment= β0+ β1age +β2gender+β3marital status+ β4family member+ β5familyincome+β6electracityexpenses+β7woodconsumption+β8gasconsumption+β9fuelconsumption + β10keroseneuse+ β11coalconsumption+e

For ease of matching coefficients and easy comparison between two cities, only explanatory variables used in tables as part of each linear regression.

Results

This research estimates the Shorabak small hydropower plant located in Fayzabad city of Badakhshan province which is not in service due to being under construction and the people are using from short time diesel generator electricity, While the Taliqan city that has already benefiting from full time transmitted electricity from neighboring country Tajikistan. Part of questionnaire was demographic questions asked respondents about age, gender, education and so on. Below table assessed the respondents' from gender point of view.

Table 1: Gender composition of the respondents in two cities

Gender	Frequency	Percentage
Male	265	71.6
Female	105	28.37
Total	370	100

Source: (field survey 2019-2020)

Age of respondents were among demographic variables. Table 2 shows participants' age who joined field interview in Takhar and Fayzabad.

Table 2: Gender composition of the respondents in two cities

Age Category	Frequency	Percentage	Cumulative Percentage
18-25	120	32.4	32.4
25-35	138	37.3	69.7
35-45	87	23.5	93.2
45-55	18	4.9	98.1
55-65	7	1.9	100

Source: (field survey 2019-2020)

Education considered to be the key demographic variable, because respondents' level of Education indicates how they correctly understood the scope of the study that designed in questionnaire.

Table 3: Interviewees level of education

Education Degree	Frequency	Percentage
Primary school	42	11.35
Secondary school	54	14.6
High school	91	24.6
Bachelor	145	39.2
Master	38	10.27
Total		

Source: (field survey 2019-2020)

Explanatory variables results

The core regression analysis of the research concentrates on models that applied on two cities data. Indeed, it is kind of comparison between two cities data to find out whether the program intervention changed the welfare of the beneficiaries.

Fayzabad City of Badakhshan province

As earlier mentioned Fayzabad inhabitants are living partially without national grid-electricity. The only electricity supplying source is the diesel generators producing per kW 29 Afn, while the neighboring province is paying 3 to 5 Afn per kW for imported electricity from Tajikistan, therefore linear regression of education run to assess the contribution of electricity to the education development.

Table 4: Regression analysis of electricity effects on education

Model	Unstandardized Beta	Coefficient Std.Error	Standard Coefficient Beta	t	Sig	Hypothesis
Constant	2.939	460		6.389	.000	
Family No	.021	024	.067	.851	.396	
Income	.099	001	.083	1.069	.287	
Study Hour	-.003	.019	.011	-.138	.890	Rejected
Expense	.21	.002	-.048	-.619	.537	

Dependent Variable: Education

Easy and cheap access to electricity improves the income generating activities and increases the households saving through paying less amount of their monthly income for electricity fee.

Table 5: impact of electricity on households monthly saving

	Unstandardized Beta	Coefficient Std.Error	Standard Coefficient Beta	t	Sig	Hypothesis
Constant	-103.349	1761.774		-.059	.953	
Income	56.971	85.838	.046	.664	.508	Rejected
Education	265.630	325.184	.053	.817	.415	
Expense	.160	.152	.070	1.058	.292	

Dependent Variable: Saving

Households' health problem causes from using polluting fuel for cooking, heating and lightening purposes, therefore round clock electricity reduces health problems.

Table 6: Health effect of access to electricity

	Unstandardized Beta	Coefficient Std.Error	Standard Coefficient Beta	t	Sig	Hypothesis
(Constant)	2.311	.558		4.139	.000	
Education	-.078	.079	-.077	-.992	.323	
Expense	2.655E-5	.000	.056	.718	.474	
Illness	.004	.004	.069	-.867	.387	Rejected

Dependent Variable: Health

There is a connection between utilizing fuel and environment. People in remote areas of Afghanistan are living in poverty with less access to primary facilities, thus the only way to overcome the cooking and heating problems is using wood and other environmental element.

Table 7: Environmental impact of access to electricity

	Unstandardized Beta	Coefficient Std.Error	Standard Coefficient Beta	t	Sig	Hypothesis
(Constant)	116.931	39.068		2.993	.003	
Expense	-13.016	5.777	.100	-2.253	.026	
Wood	1.351	1.435	.041	.942	.348	
Gas	.001	.003	.013	.280	.779	
Fuel	.607	.032	.825	18.76	.000	Accept
Kerosene	-.220	.118	.086	-1.854	.066	Reject
Coal	-.417	.594	.031	-.702	.484	Reject

Dependent Variable: Environment

Electricity boost the income-generating initiatives through motivating SMEs in rural areas that indirectly creates job for rural residences.

Table 8: Effect of electricity of employment.

	Unstandardized Beta	Coefficient Std.Error	Standard Coefficient Beta	t	Sig	Hypothesis
(Constant)	55.648	8.671		6.418	.000	
Expense	.000	.000	.216	2.890	.004	
Working hours	.050	.066	.057	.764	.446	Rejected

Dependent Variable: Employment

Technology development, particularly in media and information section made the media facilities accessible to even low-income families. Utilizing such media facilities definitely needs for electricity which could alter the living condition of beneficiaries.

Table 9: Effect of electricity on household-level of information

	Unstandardized Beta	Coefficient Std.Error	Standard Coefficient Beta	t	Sig	Hypothesis
Constant	1.448	3.689		.392	.695	
Family income	.017	.153	.009	.114	.909	
Expense	3.562E-5	.000	.092	1.16	.247	
TV hours	.000	.000	.039	.498	.619	Rejected
Social Awareness	-.056	.027	.103	-2.04	.042	Accepted

Dependent Variable: Information

Taliqan City of Takhar province

The second phase of analysis is to apply the same regression model on data gained from Taliqan city, which helps to match the coefficients and find how the program intervention helps beneficiaries. Taliqan city residence has full-time access to electricity imports from Tajikistan and per kW electricity fee is between 2 to 5 Afn. The cost interval increases as the number of kW usage increases. The following tables show the result of the linear regression analysis on Taliqan respondents' data gathered via questionnaire.

Table 10: Regression analysis of electricity effects on education

	Unstandardized Beta	Coefficient Std.Error	Standard Coefficient Beta	t	Sig	Hypothesis
Constant	.296	1.168		.254	.800	
Family No	.409	.043	.582	9.48	.000	
Income	-4.605E-5	.000	-.035	-.574	.567	
Study Hour	.002	.008	.017	.293	.770	Rejected
Expense	-.023	.033	-.042	-.708	.480	

Dependent Variable: Education

Table 11: impact of electricity on households monthly saving

	Unstandardized Beta	Coefficient Std.Error	Standard Coefficient Beta	t	Sig	Hypothesis
Constant	1.967	1790.695		.001	.999	
Income	.160	.020	.524	7.850	.012	Accepted
Education	.108	.017	.417	6.25	.000	
Expense	.132	.155	.056	.853	.395	

Dependent Variable: Saving

Table 12: Health effect of access to electricity

	Unstandardized Beta	Coefficient Std.Error	Standard Coefficient Beta	t	Sig	Hypothesis
Constant	1.900	.523		3.63	.000	
Education	.055	.022	.189	2.50	.013	
Expense	-9.538E-6	.000	-.157	-2.10	.037	
Illness	31.833	15.430	.094	2.063	.041	Accepted

Dependent Variable: Saving

Table 13: Effect of electricity on household-level of information

	Unstandardized Beta	Coefficient Std.Error	Standard Coefficient Beta	t	Sig	Hypothesis
Constant	60.267	7.696		7.83	.000	
Family income	.001	.001	.148	2.11	.035	
Expense	-.292	.210	-.095	-1.38	.167	
TV hours	.199	.222	.062	.896	.372	Rejected
Social Awareness	.377	201	145	1.874	.063	Rejected

Dependent Variable: Information

Table 14: Effect of electricity of employment.

	Unstandardized Beta	Coefficient Std.Error	Standard Coefficient Beta	t	Sig	Hypothesis
Constant	1.562	.188		8.30	.000	
Expense	1.742E-6	.000	.009	.119	.905	
Working hours	1.683	1.359	.091	1.238	.217	Rejected

Dependent Variable: Employment

Table 15: Environmental impact of access to electricity

	Unstandardized Beta	Coefficient Std.Error	Standard Coefficient Beta	t	Sig	Hypothesis
Constant	-.887	2.539		-.350	.727	
Expense	.000	.000	-.076	-1.12	.260	
Wood	-.003	.005	-.070	-.606	.545	Rejected

Gas	.004	.004	.105	.894	.373	Rejected
Fuel	.008	.032	.017	.246	.806	Rejected
Kerosene	.221	.040	.372	5.57	.000	Accepted
Coal	.478	.231	.174	2.067	.040	Accepted

Dependent Variable: Environment

Discussion

This research assessed the efficiency of electricity on household welfare. Households welfare analyzed through education, saving, education, employment, information and environment. Since the assessment method is comparison between two coefficients of the same variable, therefore it was found residence of Fayzabad city coefficient for electricity impact of study hour was 0.011, while the same variables coefficient in Taliqan city is 0.017. Although this relation is statistically rejected but implies full access to electricity improves the study hours, because there is more free time for kids and elder of the families to arrange their studying at night in Taliqan city rather than Fayzabad. Meanwhile educational institution are in better situation too as result using technology during the day that operates by electricity. Following the second linear model focused on saving effects of electricity, it was found that the income coefficient among Fayzabad residence was 0.046, while the same coefficient in Taliqan city is much higher 0.546 and statistically accepted in 0.05 p-values. The reason behind this finding is huge discrepancies between per kW fee in two cities. It clear households in Fayzabad city pays 29 Afn per kW more than households in Taliqan who pays 3-5 Afn per kW. The difference between fees could be a good determinant of saving in Taliqan.

The factors of health problems are multi-faceted and polluting element could be one of them. Households with less access to electricity uses wool, fuel and animal dung for cooking, heating and lightening purpose. In this research it was deemed that access to electricity could facilitate households' kitchen with electrical equipment and avoid from using natural aforementioned elements as illness factors. The result shows, residences of Fayzabad city still use wool, gas and fuel for indoor cooking, heating and lightening purposes with 0.056. In contrary, households in Taliqan city are much better with low level of sickness as result of less polluted homes with 0.094 coefficient. The finding implies access to electricity replace traditional kitchen and lightening tools to modern facilities like stove, boiler, oven, microwave and so on, which reduce any kind of indoor pollution. Furthermore the relation proved statistically as well.

A meaningful relation exist between environment, electricity and health in way that concentrating on wood, fuel and coal for indoor purpose increases forest degradation. In this research a connection build between access to electricity and green environment. Low access to electricity could motivate people to collect environmental resources like trees' wood and use more fuel on daily bases. The finding of this research nicely proves that residences of Fayzabad city use more fuel with coefficient of 0.825, whereas the same variable shows 0.017. This result come from the reality of the low cost electricity decreased the environmental polluting factors at least like fuel. It approved practically by many studies that electrifying rural areas boost working time and increase employment. This research somehow reached to the same finding. The result of employment model in Fayzabad city show 0.053 coefficient against the coefficient in Taliqan city 0.093. Electricity naturally facilitate the opportunity of business at night shifts and new market initiatives which seen in Taliqan city, but as result of high electricity cost, people cannot effort to use in for their income generating activities in Fayzabad.

Households' level of information measured via hours invested for watching TV and level of social awareness through media. It was found, hours for watching TV has 0.039 coefficient in Fayzabad, while it is 0.062 in Taliqan city.

Conclusion

This research through quantitative approach assessed the welfare of electricity beneficiaries in two cities of Fayzabad in Badakhshan and Taliqan in Takhar provinces. Generally, households welfare measured via education, saving, health, information, environment and employment. Residence of Fayzabad are using from diesel generator electricity, while Taliqan city electrified via imported electricity from Tajikistan. The main aim of this research was to estimate the Shorabak small hydro-power welfare impact which is under construction and technically 90% completed in Fayzabad city. It was revealed by the Shorabak hydropower plant inauguration, a huge change will be seen in households' welfare in terms of increase in study hours, saving, health, environment, employment and information. It will definitely change the life in Fayzabad city as well, because access to electricity alters the life of beneficiaries as it happened in Taliqan city. Furthermore it revealed that full time electricity increase educational performance through supply modern services via technology and changed the traditional life to modern which seems in kitchen and home equipment like freezer, boiler, stove and so on.

Policy implication

This research suggests, government should invest in local off-grid hydropower plants and electrify the remote area by their own local resources, this could reduce national electricity dependence on import and improves the living standard in rural areas for long term.

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