

## **Environment and Social Impact Assessment of Hydropower Project on Surrounding Community. Case of Rusomo Hydropower Plant in Kirehe district, Rwanda**

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### **Abstract**

Rural electrification has the ability to improve the standard of living of individuals who inhabit remote regions of the world. Electrification is widely believed to contribute to the achievement of the sustainable Development Goals, based on the assumption that sustainable access to modern energy services fosters economic and social development, and leads to improvements in the quality of life. The purpose of the paper was to investigate the social impact of hydropower project among the surrounding community in Kirehe district where, it is realized in most of local areas of the district. The purpose of this paper was the Environment and social impact Assessment of hydropower project on surrounding community in Rusumo hydropower plant in Kirehe district, the study targeted a population of 580 respondents including the 365 households with electricity, 195 households without electricity and 20 local leaders. The purposive sampling technique was used while sample of the study obtained by using Morgan and Robert table to get sample size of 232 from in local area of Kirehe district. Data collection was done through questionnaires and interview. Findings shown that hydropower project affect the community surroundings positively where it influence different service such as education service, communication and technology service, agricultural service, household services , income generating activities and security service and those service have the mean of 1.7643 and its standard deviation of 0.79462 and results revealed that the hydropower project improved the socio economic development of the community of KIREHE with the correlation coefficients of  $r=0.861$  which is strongly positive and statistically significance mean that hydropower project impacted positively the surrounding community in Kirehe district and this study will help the community administration about the environmental impact on community surrounding due to the hydropower power plant.

**Keywords:** Hydropower project, Surrounding Community, Social impact, Assessment

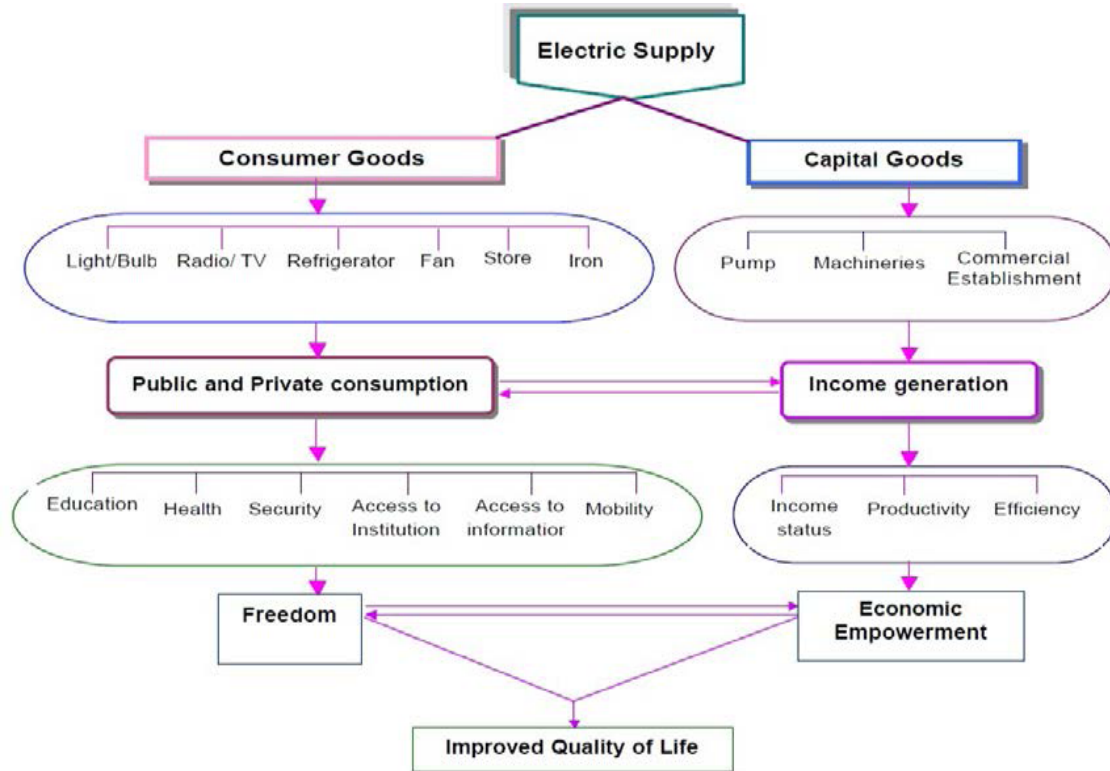
## 1. INTRODUCTION

Rwanda is blessed with a favorable topography comprising numerous hills and streams which present large opportunities for the development of community surrounding in the world (Dinkelman2010). There has been a growing realization that electrification through hydropower plants can play an important role in increasing the generation capacity in Rwanda as well as promoting the socioeconomic development of remote rural areas(Karangwa, 2008).The majority of the hydropower projects in Rwanda have been promoted through public schemes, which are financed by the Government of Rwanda (GoR) and by international development partners.Hydropower, where correctly sited can deliver an economic supply of base-load power. Government of Rwanda plan to develop around 70 MW of domestic Hydropower projects from 2010 and 2018. The individual nature of each Hydro site necessitates a feasibility study be carried out in advance of development. With the implementation of high tension transmission lines, electricity can be transmitted thousands of kilometers away from the generating plant, meaning local communities may not directly benefit from increased electricity supply (Severnini, 2014).

As a result of extremely low operational costs however, hydro is still one of the cheapest forms of generation in the long run and the Kirehe district as well as others district have different hydropower project which has different impact on the community surrounding especially the people living in Kirehe district.One of hydropower project situated in Kirehe is Regional Rusumo falls hydroelectric project which means a hydropower project under joint development by the governments of Rwanda and the government of Republic of Burundi and united Republic of Tanzania,the project were created in order to increase the supply of electricity to the national grids of Rwanda ,Tanzania and Burundi and targeted to build of an 80MW power plant and to share the electricity from that hydropower equally among the countries about 26MW directly connected to the national grids through the transmission lines and also was created to address acute shortage of electricity which affected negatively to the socio economic development and livelihoods of the community surrounding.The aim of the study is to assess environmental social impact of hydropower plant to the household welfare in area of income generation , health and education,gender,agricultural activities a case study of Rusumo hydropower plant in

Kirehe district with the target of providing knowledge and insight to hydro power services for the increase of the community awareness of the use of different

resources in Rwanda. The figure 1 indicating the flow of electricity on how the hydropower plant project affect the community population in different service.



(Source ADB, 2003)

It will also contribute additional skills on poverty reduction strategies and improve on the perception of communities on participatory development approaches; the challenges and consequences of not involving communities in planning and implementation of community projects. The findings of the study would add to the existing literature for academic use and for practitioners in the area of community growth and rural development. It will provide

insight into how to increase the level of community participation from the increase access to electricity for enterprises and households. The insights will be crucial in guiding the stakeholders to improve the standards of living of poor people .

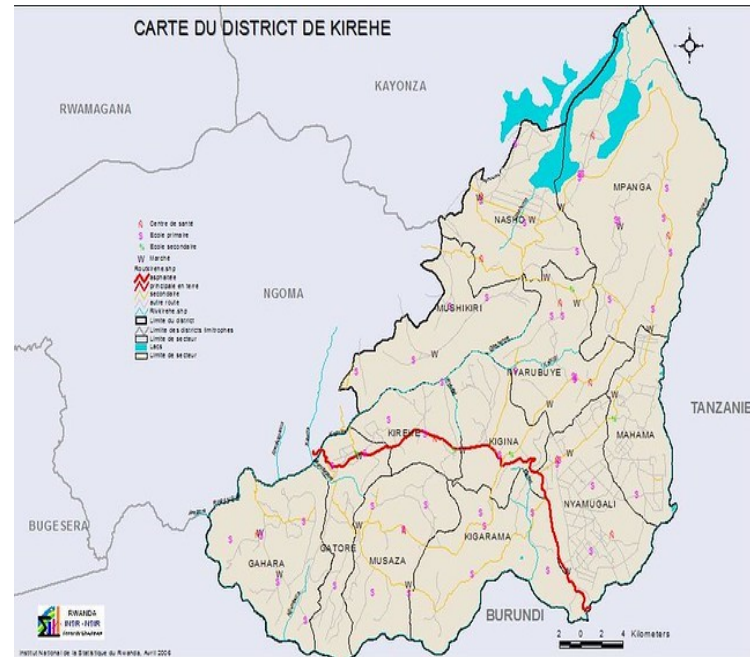
## 2. Materials and Methods

Kirehe is a district in Eastern Province, Rwanda. Its capital is Kirehe town (which is usually known as Rusumo, being the major settlement of the former Rusumo

district). The district comprises areas in the far south-eastern corner of Rwanda, bordering Tanzania and Burundi. Its most noteworthy feature is Rusumo Falls, the waterfall on the Kagera River, which has been key to Rwandan history. The district is divided into twelve sectors namely: Gahara, Gatore, Kigarama, Kigina, Kirehe, Mahama, Mpanga, Musaza, Mushikiri, Nasho, Nyamugari and Nyarubuye; made up of 60 cells and 612 villages. With 77,879 households and a population of 340,983, Kirehe is one of the seven districts that make up Eastern Province. It covers 1,111 with 8.5Km<sup>2</sup> of the surface area and Kirehe district borders with Tanzania, Burundi in the south, Ngoma District in the south western part and Kayonza District in the North. It experiences favorable climate that supports agriculture with four seasons per year making it possible to make two annual harvests. A total of 90% of Kirehe district population depend on crop and animal husbandry. The analysis of this study was based upon primary data analysis carried out during 2019. This comprised of a variety of mechanisms intended to glean information on how the hydropower influenced the community. Different techniques were adopted including questionnaire, interviews and hydropower site and community visits (Kanagawa, 2005).

Denscombe, (2008) asserts that the sample must be carefully selected to be representative of the entire population and to provide information that can scientifically be tested.

**Figure 3. 1: Administrative map of Kirehe district**



**Source: Kirehe district, 2017**

Purposive sampling technique was used to select the households in the Kirehe district where the research targeted population of 1235 households and 20 local leaders. Households were the targeted units of generating primary data. We propose to utilize existing panel data that regularly collects basic data on the electrification service expansion with the accompanied electric energy consumption. Researcher used a detailed questionnaire to get data from

households on rural electrification, factors that may influence electricity from hydropower use and its level of contribution for households’ socio economic developments. It was decided to collect retrospective information on some specific indicators like ownership, property and assets for households which suffer less memory recall problems.

The survey technique included both qualitative and quantitative methods. Sample design were determined followed by the selection of households to ensure desired level of confidence with probability proportionate to size according to the number of villages electrified. The number respondents was sampled using the Robert and Morgan (1970) technique which employs the Robert and

Morgan’s table that is generated from the sampling formula:

$$S = \frac{x^2 NP(1num(n - 1)}{d^2(N - 1) + x^2 P(11nu$$

s = required sample size.

$X^2$  = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841).

N = the population size.

P = the population proportion (assumed to be .50 since this would provide the maximum Sample size).

d = the degree of accuracy expressed as a proportion (.05).

According to the formula and the table, the sample size is 232 and the sample size for the study is summarized in table above.

**Table 2.1: Targeted population and sample size**

Respondents	Households	percentage	Sample size
Households with electricity	365	62.93	146
Households without electricity	195	33.62	78
Local leaders	20	3.45	8
<b>Total</b>	<b>580</b>	<b>100</b>	<b>232</b>

Researcher test statistical difference in household per capita consumption expenditure between households in treatment and control areas. Different econometric models and estimate the impact of electricity

on poverty reduction. Using the HH survey data collected, we specified a household welfare model in (1) that control for other regressors or factors that affect household welfare. In order to investigate the causal or

partial correlation of each factor on a response variable, we used the following sets of models that address each research question of the project. Impact assessment is tricky and specifications in (1) could reveal biased estimates about the effect of electrification on household poverty

$$\ln C = \alpha + \beta H + \delta E + \psi X + \gamma \text{electric} + \varepsilon$$

Where  $\ln C$  is the natural log of per capita household consumption expenditure,  $H$  is vector of regressors accounting for households human capital,  $E$  is vector of variables representing for labor market opportunities and participations,  $X$  is vector of regressors controlling for other factors that affect household welfare, *electric* is indicators of variables measuring access to electricity or electrification infrastructure variables.  $\alpha$  is the intercept;  $\beta, \delta$  and  $\psi$  are vector of parameters to be estimated measuring the effect of human income, labor opportunities and other control variables respectively.  $\gamma$  is parameter of our main interest that measures the effect of hydropower infrastructure on household welfare.  $\varepsilon$  is a white noise disturbance term. We specify a household welfare model that

takes in to account the effect of hydropower project (Dinkelman, 2010). We also try to estimate the impact of hydropower project on socio economic by using a logic regression the model of which can be specified as under.

$$Y_i = \beta_0 + \beta_1 X_i + \gamma E_i + \varepsilon_i$$

**Where**

- a)  $Y_i = 1$  when the house hold is none poor (taking an income of one dollar a day)
- b)  $Y_i = 0$  when the house hold is poor.
- c)  $X_i$  = all determinants of the probability of becoming non poor but electricity
- d)  $E =$  electricity access = 1 for households with access and = 0 for households without access the main target of this study is to estimate the above

Equation and see the coefficient  $\gamma$ .

### 3. Results

The researcher set out the classification of respondents due to their demographic characteristics and study findings. The demographic characteristics were the gender, age, marital status, schooling level and daily activities.

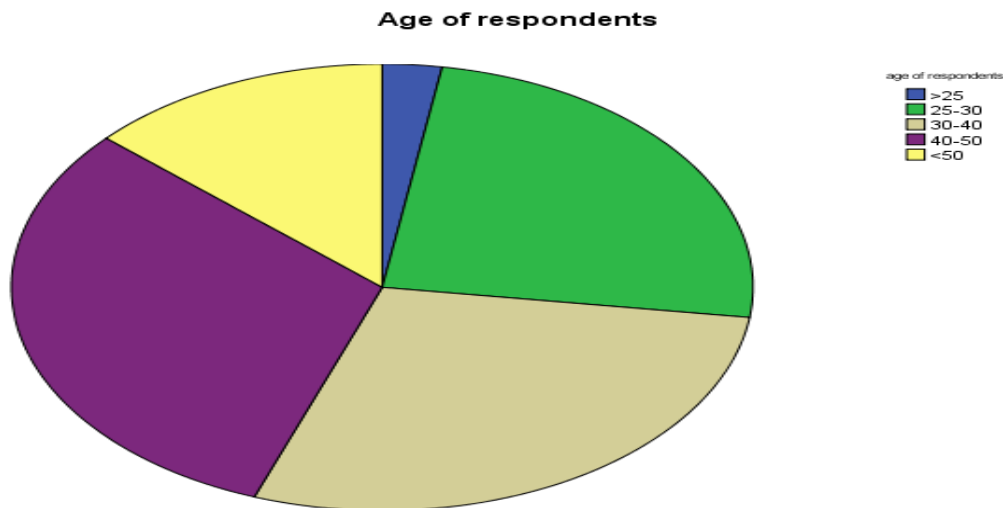
**Table3. 1 Gender of respondents**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	.4	.4	.4
Male	101	43.5	43.5	44.0
Female	130	56.0	56.0	100.0
<b>Total</b>	<b>232</b>	<b>100.0</b>	<b>100.0</b>	

**Table 3.2 Marital status of respondents**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid single	17	7.3	7.3	7.3
Married	106	45.7	45.7	53.0
Divorced	42	18.1	18.1	71.1
Widow/widower	45	19.4	19.4	90.5
separated	22	9.5	9.5	100.0
Total	232	100.0	100.0	

**Figure 3.1 Age of respondents**



**Figure 3.2: Education level of respondent**

**Table 3.3. the services areas to be affected by hydropower plant project outcomes**

Statements	Mean	Std. Deviation
Income activities( Business)	1.3802	1.76655
Healthcare service	2.7851	1.54492
Agricultural service	2.0083	.83042
Household service	1.4463	1.55430
Security service	2.1736	.73964
Communication and technology service	1.1903	1.34325
Education service	2.1125	.78743

**\*\*Std = Standard Deviation; Me: mean and Mean= [1-2]= Very high mean; [2-3]= High mean; [3-4]= Moderated mean; [4-5]= Low mean; [5-6]= Very low mean**

**Table 3.6. Correlations of independent and dependent variables**

Statements		hydropower project	Socio economic development of the community
Hydropower plant project	Pearson Correlation	1	.861**
	Sig. (2-tailed)		.000
	N	232	232
Socio economic development of the community	Pearson Correlation	.861**	1
	Sig. (2-tailed)	.000	
	N	232	232

**\*\*Correlation is significant at the 0.01 level (2-tailed).**



**Table 3.4. Social impact of hydropower project on the social economic development of the community surrounding**

	Mean	Std. Deviation	Variance
Hydropower project electricity increased the level of irrigation to enhance agriculture productivities	1.1919	1.79495	3.222
Hydropower project alleviate Poverty and the welfare of beneficiaries	1.0556	.71385	.510
The rural electrification influence industrialization level in our district	1.2828	1.29458	1.676
Hydropower projects stimulate in the protection of environment in your area	4.6414	.85953	.739
Increase rural literacy, improve education, schooling and adult literacy programs	2.6768	.84094	.707
Hydropower projects electricity help investments in our area	2.7020	.79151	.626
Households with the energy from hydropower improved the regional economy	3.7020	.77858	.606
Hydropower project energy facilitate the education of your children	1.7222	.76643	.587
Hydropower project affect the business activities in order to raise the economic developments	1.7525	.69397	.482

**\*\*Std = Standard Deviation; Me: mean and Mean= [1-2] = Very high mean; [2-3] = High mean; [3-4] = Moderated mean; [4-5] = Low mean; [5-6] = Very low mean\*\***

**Table 3.5 Hydropowerplant project towards economy developments activities**

Statements	SD		D		N		A		SA		Mean	Std
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%		
Rural electrification from hydropower plant	31	24.8	27	21.6	10	8.0	12	9.6	45	36.0	3.10	1.66
No technology nor communication without electricity	3	2.4	10	8.0	2	1.6	24	19.2	86	68.8	4.44	1.03
Enhancement the quality of education in Rwanda	11	8.8	6	4.8	4	3.2	47	37.6	57	45.6	4.20	2.01
Welfare in rural area population	66	52.8	47	37.6	12	9.6	0	0	0	0	2.67	1.40
The security service improvements in the district	24	19.2	41	32.8	5	4.0	29	23.2	26	20.8	2.94	1.47
The improve the health service	28	22.4	35	28.0	8	6.4	24	19.2	30	24.0	3.10	2.99

**SD:** Strongly disagree, **D:** Disagree, **N:** Neutral, **A:** Agree, **SA:** Strongly agree and **Std:** Standard deviation.

**4. Discussion**

In regards of the demographic characteristics, the researcher were based on gender, age, marital status, schooling level and daily activities the 56.5% were female and 43.5% were male means that the gender were

respected in the research, it seems that all population were engaged in the hydropower project profits and the researcher indicated the marital status, education level of the respondents which indicated that all respondents attended the school even if it is primary school helping them to know how they are gifted to have hydropower project toward community and the range of ages of respondents were participate in the research

and most of them were aged in the range of [30-40],[40-50] where they know how the hydropower project affect the community surrounding and the use of electricity provided by hydropower project and the production of the activities generating income through the electricity provided by hydropower project in kirehe district.

The study were focused on services areas to be affected by hydropower plant outcomes and the study on this objective reveled the service area where the electricity from hydropower project influence and show that it affect education service, healthcare service, security service, communication and technology service, household service, business service and agricultural service. The results indicated that in education service have the mean of 2.1125 and its standard deviation of 0.78743 which shown that it is high mean indicating that the electricity provided with hydropower project facilitate education where it help the learners to revise their course, to do their homework at home ,to facilitate the school administration in reporting their daily activities and helping in lighting appliances enable children to study after sunset, to reduce the literacy rate in the community .also other service revealed was healthcares service where the means f this service were 2.7851 and its standard

deviation were 1.54492 which were high mean also showing that electricity help heath service in using modern energy for reduction exposure to hazardous pollutants and avoiding drudgery such as collections of fuel, wood and in improving the health condition, the respondents also shown that it helped them in reduction of child maternity mortality and accessibility of electricity enabling the vaccination and medicine storage , purification of health service materials by a refrigerator. The agricultural service were also raised as improved service by electricity provided by the hydropower project at the mean which were the 6.0083 and its standard deviation of 0.83042 shown that it it was low mean meaning that the electricity were lowly used in agricultural service in Kirehe district and most of respondents raised that the electricity provided with hydropower project in the service of business of activities generating income in their village where the means indicated were the 1.3802 and its standard deviation were 1.76655 which is high mean ,it helped in the service like performing different service such as construction, masonry, used in restaurants service, transport service and the also other service raised the electricity provided by hydropower project were communication and technology

where the respondents indicated they improved their communication and technologies in the use of the mobile phone charging , TVs watching, use of frigo at their home , computer, and cooking their meals by using the electricity.

The study targeted to Investigate the social impact of hydropower project on the social economic development of the community surrounding in Kirehe District, Rwanda and the study revealed that the hydropower project contributed in the regional economy, affect the business activities in order to raise the economic developments, facilitate the education of your children, alleviate Poverty and the welfare of beneficiaries, stimulate in the protection of environment in your area, Increase rural literacy, improve education, schooling and adult literacy programs, The rural electrification influence industrialization level in our district, Hydropower projects results increase the level creativity and innovative action with the use of technology (technology use), Through electricity provided by hydropower projects improved health service in your district as it shown in the table 3.6 with their means and their standard deviation and the study revealed the relationship of variables where they are correlated at correlation coefficients of  $r=0.861$  where

they were strong positive correlation and statistically significance.

## 5. Conclusions

The study has shown that hydropower project have significance effect on the surrounding community in the socioeconomic developments and the recommendation were formulated as follow:

- a) The study revealed that the electricity provided by hydropower project especially regional Rusumo falls hydropower project affect the community significantly
- b) The hydropower project effect also found to improve and to increase consumption spending which indicated that there is an improvement in wellbeing and life conditions and children schooling means that the impact is not one short rather kind of sustainable development
- c) There is a need of government of Rwanda to connect rural village of Kirehe district to national grid and also enable them to have access to electricity using various means like solar energy because the study indicated many service offered in

Kirehe and those service use high power.

- d) The effect of electricity from hydropower project on household income is found to be insignificant with different means and also theoretically wrong with available resources this shows that there is a need to carry out further research on different topic closely related with this one to confirm the expansion of electricity in the rural village

### Conflicts of Interest

The authors declare no conflicts of interest

### References

- Barakat, A., Khan SH., Rahman M., Zaman, S., Poddar, A., Halim S., Ratna NN., Majid M., Maksud AKM., Karim A., Islam S., 2002. Economic and Social Impact Evaluation Study of the Rural Electrification Program in Bangladesh.
- Barnes, Douglas F., Henry Peskin and Kevin Fitzgerald. 2003. *The Benefits of Rural Electrification in India: implications for Education, Household Lighting, and Irrigation*. Draft paper prepared for South Asia Energy and Infrastructure, the World Bank, Washington, DC
- Cabraal, Anil, and Douglas Barnes. 2006. "Productive Uses of energy for Rural Development," *Annual Review of environment and Resources*. vol. 30 pp. 117-144.
- Cecelski E., 1992, Enhancing Socioeconomic and Environmental Impacts of Rural Electrification, in Saunier G. (ed.),
- Colin Christian & Associates. (2009). *Technical Report on Hydro-electric Power Development in the Namibian section of the Okavango River Basin* (pp. 1–39). Okavango River Basin Trans-boundary Diagnostic Analysis Technical Report, Windhoek, Namibia
- Dinkelman Taryn: 2010. *The Effects of Rural Electrification on Employment: New Evidence from South Africa* Princeton University
- Fraser, J. (2010). Lao PDR Development Report 2010 - Background note: *Hydro Power Background Summary Note and Sector Assessment* (pp. 1–9). The World Bank, Washington DC.

- Harvey, Adam. Micro-Hydro Design Manual: A Guide to Small-Scale Water Power Schemes. Practical Action: 1993.
- Kanagawa, M., Nakata, T. 2008. "Assessment of access to electricity and the socio-economic impacts in rural areas of developing countries", *Energy Policy*, No. 36.
- Kanagawa M., Nakata T., 2005, Analysis of the Energy Access Improvement and its Socio-Economic Impacts in Rural Areas of Developing Countries, Tohoku University, Japan.
- Manual on Micro Hydro Development. Centre for Rural Technology, Nepal. Prepared for: NGO Capacity Building for Poverty-reducing Sustainable Energy Solutions in South Asia Project. Available at [www.inforse.org/asia/pdf/Nepal\\_Micro\\_Hydro\\_Manual.pdf](http://www.inforse.org/asia/pdf/Nepal_Micro_Hydro_Manual.pdf)
- Mugenda, O. M. and Mugenda, A. G. (2003). *Research Methods: Quantitative and Qualitative Approaches*. African Centre for Technology Studies. Nairobi.
- Rosenthal, S.S., Strange, W.C., 2004. *Evidence on the nature and sources of agglomeration economies*. Handbook of Regional and Urban Economics.
- Smanta, B. B. and K. K. Sundaram. 2003. *Socioeconomic Impact of Rural Electrification in India*.
- WB et al. – World Bank et al. (eds.) (2003), *Energy, Poverty, and Gender. Monitoring and Evaluation in Rural Electrification Projects: A Demand-Oriented Approach*. Washington, DC.