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ANALYSIS OF CO-BENEFITS OF MICRO-HYDROPOWER ALONG WITH CARBON DEVELOPMENT MECHANISM: CASE STUDY OF RUMA KHOLA MICRO-HYDROPOWER LOCATED AT WESTERN NEPAL

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Abstract - Decentralized micro-hydropower was considered one of the affordable options to lightening the remote and isolated areas. Micro –hydropower was became the entry point and provide holistic development approach to many unreached villages of Nepal. This study analyzes the socio-economic benefits along with CDM achieved through the installation of micro-hydropower in five villages of Mangla Rural Municipality of Western Nepal. Closed type questionnaire was used to collect the data along with Key informant survey and focus group discussion. The research reveals that this micro hydro power plant is contributing to CDM as a Micro hydro is listed in CDM Project of Nepal. Beside the CDM benefit, micro-hydropower plant has brought series of positive development like access to clean electricity developing entrepreneurships, reducing rural drudgery of women, reducing indoor pollution, and access to information and health facilities. Thus, Micro-hydro project can be the cheap, clean and sustainable solution for rural energy demands.

Key words: Clean Development Mechanism, Renewable Energy, Micro-hydropower Plant, Socio –Economic Benefits

I. INTRODUCTION

Electricity grid expansion for rural electrification is often unfeasible and highly costly. Renewable Energy Technologies (RETs) such as micro hydropower is one of the effective solutions to provide lighting to the remote rural communities. The abundance of fast-flowing rivers and streams, requirement of less infrastructure and capital compared to larger power plants, having community involvement and constrained impact on environment have made Micro Hydropower one of the proven technologies for rural electrification in Nepal. The recent data published by Alternative Energy Promotion Center reveals that around 9.75 % households in Nepal have access to electricity including electricity from renewable sources as Micro Hydropower (MHP) and solar photo voltaic. Over past four decades, several isolated micro hydropower projects having installed capacity 32.159MW as of F.Y.2018/2019 AD (Progress at Glance: A Year in review F.Y. 2018/19, AEPC). The impact of project and therefore the installation of micro-hydro system not only provided electrical power to the households, but also improved the standard of lifetime of the whole village by providing opportunities for income generation and education. Not only for lighting, it also provided energy for milling, husking, grinding, carpentry, spinning and pumps irrigation within the village which paid off within the variety of higher local income. Various small and medium scale enterprises that run on electricity produced by MHP could enhance the social and economic conditions of rural communities. The energy produced could be used to drive small and medium scale enterprises at local level like agro processing units, sewing business, welding shops, telecommunication centers and computer institutes to create the employment opportunities.

Pokharel (2006, p.32-33) states that "Economic development is achieved through MHPs from two aspects: firstly, because of investment in manufacturing and service providing sectors and secondly, from availability of electricity for end-uses, i.e. for small-scale local industries. Economic development process will also be induced or enhanced in the local villages once technology based small-scale industries are installed in the periphery of MHPs.

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Clean Development Mechanism (CDM) is only mechanism related to developing countries and main objective is to help Annex I[1]to meet their quantified emission reductions obligations at lower cost while helping Non- Annex[2] countries in achieving sustainable development (UNFCC,1997) CDM has been introduced as a strategy to curb the huge GHG emissions in the atmosphere through the adoption of Kyoto Protocol in 1997 (Maharjan, 2008).Under the CDM, public and private project developers can generate and sell certified emission reductions(CERs)from projects that reduce emissions in developing countries (Maraseni et.al, 2007). CERs are measured in terms of CO_2 equivalent, 1 CER= 1 ton of CO_2 reduced by the CDM project Activity. Like other developing countries, the projects in hand for Nepal are limited in number and volume. Only Bio-Gas, Micro hydro, improved cooking stoves (ICS) and improved water mill (IWM) projects were eligible till the date.

II. MATERIAL AND METHOD

Study Area

Ruma Khola MHP is located at Mangala Rural Municipality of Myagdi district[3] of Gandaki province Nepal. It lies in south west part of the district at an altitude of 1328m amsl. The longitude and latitude of the site is 83^0 20'0" to 83^0 22'30"and $28^0$22'30" to 28^0 25'0" respectively. The main source of the project is Ruma Khola. The design discharge of the project is 200 liter per second (lps) and the gross head available is 51m. The installed capacity of the project is 51 KW and the beneficiary Households (HHs) at the time of installation were 541 HHs but it now reaches to about 702 HHs at the research time. It is a community based plant installed in 2007 with the financial support from AEPC, REDP, DDC, VDC, DECS, ADB/N and others. This MHP is selected based on the i) It had larger installed capacity and It had covering comparative larger geographical area than other micro hydropower located in the vicinity. ii) It had comparatively high load factor. iii) The beneficiary area is full of heterogeneous in socio-economic, cultural and geographical structure in Mangala Rural Municipality. Iv)It has been successfully running from the commissioning period.

After completion of the project, there is large intervention of various micro enterprises. However the scope of the study is limited only at Darbang Bazzar because it is the main load center of the project. The major enterprises are concentrated at this market center; the second business place after Beni, the district headquarters of Myagdi. Out of 35 micro enterprises developed in the beneficiary zone, more than 25 major enterprises are established at this VDC.

Research methods

Sampling Size and Procedure

The MHP beneficiary community, Community Organizations, members of the MHP users' group, members of the MHP advisory committee, owner of the enterprises, MHP operator and manager et al. are the potential respondents of the study. The respondent is selected from different groups of people within the community depending upon their knowledge, gender, ethnicity, education etc. As the size of the population (N) in the study area is 198.

Using statistics formula to find the sample size, n0 = $z^2p(1-p)/ e^2$

We know, z= 1.64 at confidence level of 90% p= degree of variability; taking this value as 0.5 e= level of precision, taking ±10% so, sample size, n0 = 1.642 *0.5*(1-0.5) 0.1 2 = 67.24~ 67

For the small population size, the sample size can be reduced slightly. The sample size can be adjusted using below equation:

Adjusted sample size, $n=n_0/((1+(n_0-1))/N=67/((1+(67-1)/198 =50.25 \sim 51$

So the sample size of the study is 51.

Sample is selected from different groups of the people within the community depending upon their knowledge, education, gender, ethnicity etc. Above selected sample is from Darbang area only. Being the community group types, economic activities of the people; the result from the study is expected for the learning for the users in other program area also.

Primary Data Source:

The primary data were collected from the MHP households, members of the MHP users' and advisory group, owner of the energy based enterprises, school teacher and plant operator and manager. The types of data received from primary sources are different, eg. types and number of energy based enterprises, average monthly energy consumption in HHs and enterprises, number of

[1] High Carbon emitting industrialized countries

[2] Developing countries

[3] Hilly district of Gandaki Province of Nepal

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employment creation after arrival of MHP, monthly revenue collection from energy selling, number of households electrified, amount of kerosene, fuel wood, diesel and other traditional energy sources replaced, gender and ethnicity participation in management and the decision making process of MHP related activities, etc.

Interview

Structured questionnaire was designed to get qualitative, multi aspect information of the beneficiary area. Respondents were categorized first into five: beneficiary households (28 numbers), entrepreneurs (13 numbers), members of the users' and advisor group (5 numbers), school teacher (2 numbers) and plant operator and manager (3 numbers). Questionnaire was designed then differently based on type of the respondents. A total 51 respondents out of 198 were selected based on snowball sampling from different community group. Either the head of the household or family member responded to the questionnaire.

Key Informants Interview

The primary data was also collected from Key Informant Interview (KII) using the direct or indirect interview method. The interview was taken as cross reference for the data obtained from the questionnaire. Respondents interviewed were also chosen with the help of key informants. Key informants were the executive members of the MHP users' group; plant operator and manager and school teacher. Four KII was carried out.

Focus Group Discussion

One focus group discussion among members of the users' and advisory group was carried out during field visit to get range of opinions on research from different levels.

Field Observation

After listing of questionnaires, two field visits was made in the study area during the whole study period. Social, economic, technical status was directly observed in the visit. The required data were collected at the same time.

Secondary data source:

The secondary data are taken from different stakeholders. The published journal articles and unpublished academic thesis, feasibility study report are used for secondary sources.

III. RESULTS AND DISCUSSION

Excess to Electricity

Nepal's rural electrification through national grid is dwindling (karki, 2004).This is because the extension of the national grid to rural areas is unrealistic both technically and economically due to the rugged mountainous terrain, and the sparse nature of human settlement. Also, rural electrifications awarded as a political favor in Nepal which ultimately put major portions of poor population in darkness if the areas are not within interest of political leaders (Pandey, 2009). There is trend to migrate to in the search of facilities and job opportunities. Only financially oppressed people are living in that area. The difficulties has been experienced in rapid extension of the National Grid for rural electrification due to remote topography, dispersed settlement pattern and the limited financial resources of the Government of Nepal (Rural Energy Policy, 2006).The potential site for micro hydro is remote and isolated areas, which are not connected to the national grid.

Currently, Total 702 households of five villages Niskot, Darbang, Ruma, Okharbot, Devisthan,of Managla Rural Municipality of have access to electricity. The ownership of this micro-hydro has taken by the community itself for equitable participation of all household. Benefit sharing is equitable between different groups including both upper and lower caste people and only differentiated according to their buying power.

Developing entrepreneurship among local people

It is obvious that having access to reliable and affordable supply of electricity, small enterprises can be developed at the community level that ultimately increases the rural economy (Kirubi et al.,2009; Koirala, 2007.) However, in rural communities electricity is mainly used for lighting rather than commencing commercial enterprises (Fulford et.al., 2000). The electricity generated form this project is used mainly for domestic lighting purpose at night time. Moreover, the backward and forward linkages of industrial and commercial activities, other social activities will also have significant employment generation impacts.

At the time of research, there are more than thirty five numbers of small scale enterprises running from MHP based electricity. Enterprises range to agro-processing, grill udhyog, concrete block udhyog, saw mill, Poultry, Dairy udhyog, saw mill bank and financial institutions, computer institutions, hotels and restaurants etc. Total connected load of the enterprises is more than 86 KW; however difference in running time of the

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enterprises has made it more productive on diversification of the load.

A hundred numbers of people getting direct employment from rural enterprises after establishment of micro-hydro in that area. The Micro –hydro receives about a million of Nepali rupees as revenue per year from selling of electricity to all these enterprises.

Table:1 List of enterprises as end users of Micro hydropower

S.N	Enterprises Type	Number	Total Connected Load(KW)	Average Monthly energy Consumptions (KWH)	Number of Directly Employed People
1.	Agro Processing (Huller/Grinder)	6	18	1080	8
2.	Grill Udhyog	2	9.50	570	6
3.	Concrete Block Udhyog	2	11.0	660	10
4.	Saw Mill	5	20.50	1230	14
5.	Dairy industry	1	2.0	350	1
6.	Cotton Udhyog	1	0.8	500.0	1
7.	TV cable network, computer institute & photocopy center	4	4.20	330.0	6
8.	Bank & Cooperatives	8	11.0	1365.0	67
9.	Hotel & Restaurants	5	5	400.0	10
	Total	**39**	**86.30**	**6735**	**98**

Source: Field Survey, 2020

According to the interviewed respondent, the community electrification from Ruma Khola MHP has brought series of positive changes in the rural livelihood. Having access to electricity, women can grind their grains on modern agro processing mills which ended the rural drudgery of rural women at some extent. Similarly, Electric light in the homes extend the evening hours.

Support on CO_2 Emission Reduction

Following the Nepal MHP Clean Development Mechanism (CDM) Project Design Document, the avoided emissions from a micro hydropower project (in tons of CO2 per year) and the value of the associated Certified Emission Reductions (CERs) are calculated as follows:

Annual energy generation (in KWh) per year = 351,900 KWh

Net annual energy generation on deducing losses (25%) = 263,925 KWh

CO2 emission coefficient for displaced fuel = 0.9 kg CO2 equivalent/KWh *(Source: CDM-Executive Board, 2013. Nepal MHP Clean Development Mechanism Project Design Document)*

Avoided CO2 emissions = (0.9*263,925)/1000 = 237.53 tons per annum

CER price = USD 7 per ton of CO2

So, economic benefit from CO2 emission reduction through utilization of MHP is

= USD 237.53*7 per annum

= USD 1,662.71 per annum

Ruma Khola is a CDM registered MHP. However, according to the Carbon Revenue Utilization and Management Guideline, 2070, all the revenue generated from the selling of CER does not go back directly to the same MHP beneficiaries but it will rather be utilized to promote similar RETs elsewhere in the country. This MHP instead of its own has contributed to gain CDM benefit to the country.

Reduction of Indoor Air Pollution

Use of electricity for household electrification and partly for cooking has helped to reduce the indoor air pollution in the households. At least two smog producing kerosene lamps per household, ten diesel feeding agro processing units in the project area and firewood in small extent has been replaced by electricity which has helped to reduce risk of respiratory problems and eye infection caused by indoor air pollution. It has also helped for CO2 emission reduction thorough the utilization of MHP based clean energy. Environmental impact caused by deposition of dry cell batteries also has been partly reduced.

Change in Women's Situation and Disadvantaged Groups

Women in Nepal especially in rural areas are always seen to be in greater deprivation than men. They work considerably longer hours than men but still restricted from access to services and resources and have comparatively lower life expectancy. Similar case has been observed in study area also. Women are working primarily in agriculture sector and lacking education, training entrepreneurial skills, sufficient services such as childcare and have low nutritional status compared to man. Their greater responsibility towards family is also preventing them from moving into the formal sector. However after the commencement of the MHP electricity, there has been a strong commitment of the users to build women's status for undertaking independent action and integrating them into the decision making process. There has been the mandatory participation of one female from each beneficiary household in her nearby formed women community organization and all the initiatives implemented at community level. Representation from each woman Community Organizations (COs) is mandatory in users' group formation (Source: Field Visit, 2020). Many educated women are getting employed in local enterprises .Thirty Nine Micro Hydropower Plant (MHP) based electricity has been definitely helped to reduce their drudgery of routine chores and creating a better balance between work and leisure. They spend less time on energy related household tasks such as the collection of fire wood, kerosene and water gathering. Having access to electricity, they can grind their grains on modern agro-processing mills, which is faster and more efficient lights in the homes extend the evening hours for women and can engage in other income generating activities.

Impact of Electricity on education

Two school teachers were also interviewed to understand any effect made from electricity held on school children. Principal of Sharada Ni Ma Vi at Niskot VDC Mr. Mortiraj Upadhaya said that "Overall impact of electricity from Ruma Khola MHP has become apparent changes on education of school children. School attendance of the school children has been increased. School enrollment of the children has been increased sufficiently. Class enrollment has been increased by 20-30% annually since last 5-7 years. They are getting extended time in evening and early morning for reading and doing homework. It has also helped to increase the competition level of the students. Approach of television and mobile phone has also helping to make more forward to the children on education. Computer education is also accessible to the children at school. 4-5 cyber cafes are also operated at Darbang so that students can get surfing in the internet for extra learning. Computer, printer and photocopy machines are installed at schools which are also helping school teachers to prepare teaching materials and increase their teaching capability noteworthy".

Improved Access to Information and health facilities

After arrival of electricity, people are getting contact to television, FM radio, mobile phone and other telecommunication media which have provided quick access for latest news happening in the globe. During evening time, villagers gather together to share news and stories and for other social activities. Many informal education classes have been conducted at the community at night time which has also helped to increase literacy rate. During evening hours, villagers spend their evening time either watching television or being engaged in income generating activities. One of the encouraging benefits of the informal education and gathering is that the close relationship have been increased to the neighboring villagers; either between same or different community group. In the past, dalit students were minimal in the school due

to discrimination. In recent years, the numbers of dalit students are also increasing in the school. Health post office in Darbang has been equipped with different medical equipment's and medicines after getting electricity which has helped to improve the health situation of the community people.

Employment Generation Opportunity

After village electrification from micro hydro power project, small and medium scale energy based enterprises are running at project areas. There are more than thirty nine enterprises which have provided direct and indirect benefits to the villagers. Ninety eight peoples are directly employed in the enterprises where as two micro hydro plant operators and one plant manager are directly employed in the plant on monthly basis. Many people are getting indirect benefits from the running enterprises.

IV. CONCLUSIONS

This study reveals that MHP had major contributions towards the reduction of Co_2 and earning revenue from CDM. It was also revealed that electricity at night time in household allows more time for student to spend the time for study. Rural drudgery for women is reduced somehow and they have got some opportunities to engage income generating activities and community development activities. Therefore, this study concludes that the micro hydropower was entry point of development of community and brought series of positive benefits in the villages.

V. RECOMMENDATIONS

However, due to lack of technical, financial as well as entrepreneurial skills, majority of the existing MHP plants are out of the function in Nepal (Khennas and Barnett,2000). But, Ruma Khola MHP is a successful scheme from various perspectives because it is completed through good community participation as well as multi stakeholders. It is well operated and managed by the communities themselves. Many MHP energy based enterprises are established there in the project area which has beneficiated to the local people on various aspects. These business activities have helped for livelihood changes for the rural people both directly and indirectly. It has positive impacts on education, communication and health etc. There is equal participation of both male and female in overall management of the plant. There is fifty percent participation of female in user's committee and every decision has to be done in fifty percent presence of female.

After doing this research, recommendation for the users of Ruma Khola MHP has been made in the points below:

- Connected load at households and enterprises is more than installed capacity of the plant which is more than 100 KW but the average energy consumption is only about one third of the generation capacity ie. Plant capacity factor is 36%. Rest 64% of the plant capacity has not being utilized. So it is recommended for the users not to add the new load and increase approved load of the previously connected enterprises. To increase the plant factor, it is recommended to run enterprises with full capacity in day time and maximize the households load at night using electrical appliances.
- No energy meter has been installed at enterprises. It is highly recommended to connect the same as soon as possible so that actual energy consumption record can be found that will help for increasing revenue and load management. It is also recommended for the users' to interconnect the energy meters at both generation and load site so that exact generated and consumed energy can be found.
- Energy tariff should be timely revised to make it more competitive with national grid supply while arrives there for the sustainable running of the plant. The capacity of the users' committee and the user community should be built to adopt energybased metered tariff rather than power-based non-metered tariff. In addition, they should be trained in setting tariffs such that revenues are adequate to cover operating costs including salaries, loan payments, as well as repair and maintenance.
- It is recommended for the community to make Community Organizations functional. It is advised that there may not only discussed about MHP related jobs, they might discuss about community development related activities or saving and investment what will help to organize and mobilize them to do anything beneficial to themselves. They can find the forum for public discussion, conduct numbers of social activities and organize them to form a self-governing broad based community organization. They can continue the regular saving procedure and raise the fund so that one can take loan at nominal interest rate easily to meet daily needs and invest in the business activities.
- Financial records of the plant should be more transparent to know actual financial status to the users.
- There is no repair and maintenance schedule of the plant. Usual practice is when the plant closes after. Schedule has to be made from

intake to tailrace including all equipment's and components of the plant.

- Users' are also recommended to form a repair and maintenance fund for the plant. They can allocate at least 10% of the annual plant income for repair of the plant components for emergency overhauling.
- Users' group can enter into a cooperative framework for operation and management of the plant in more effective way. Activities in community organizations can also be strengthen through integrating in this approach.
- Distribution transformer of capacity 25 kVA installed at Darbang Bazzar needs to replace with higher capacity one. Feeder Line is getting frequently trip due to overloading of the transformer.

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VII. REFERENCES

1 AEPC,(2019). *"*A Year in Review July 2018- July 2019". Khumaltar, Lalitpur, Nepal: Alternative Energy Promotion Centre (AEPC).

2 NEA, (2019). "A year in review-fiscal year 2018/19". Durbarmarg, Kathmandu, Nepal: Nepal Electricity Authority (NEA).

3 CDM-Executive Board,(2013). "Nepal MHP Clean Development Mechanism Project Design Document: Clean Development Mechanism".

4 WB,(2015). "Nepal: Scaling Up Electricity Access through Mini and Micro Hydropower Applications, A Strategic Stock-taking and Developing a Future Roadmap"*:* The World Bank Group, Nepal Office, Durbar Marg, Kathmandu

5 Bhatta, S.P., (2005). "Study of Socio-economic Impact of Khimti I Hydropower Project in Dolakha District",M.A., Trichandra Campus, Tribhuvan University, Nepal.

6 Pokharel, G.R., (2005). "Promoting Sustainable Development by Creating Enterprises on Renewable Energy Technologies in Nepal: Case Studies Based on Micro Hydropower Projects", PhD, University of Flensburg, Germany.

7 Shrestha,V., (2012). "Role of Micro Hydropower Plants in Local Development: A Case of Two Villages in Shankhuwasabha District, Nepal". M.A., International Institute of Social Studies, The Hague, The Netherlands.

8 Suraj Regmi and Anand Mandal (2021). "CHALLENGES FOR CONSTRUCTION OF HIGH VOLTAGE ELECTRICITY TRANSMISSION LINE IN NEPAL", Int. J. Engineering & Applied Science and Technology , Vol. 5, No. 7, (pp. 46-52)

9 Koirala, B., (2007). "A Community based micro hydro: A promising technology for rural development in Nepal". Department of Economics, University of New Maxico, USA

10 Dahal, S., and Shrestha, R., (2014). "Sustainability of Micro-hydropower in Nepal: A case study of Rukum District". Proceedings of Graduate Conference, 2014, pp. (414- 419.)

11 Gurung, A., Bryceson, I., Joo, J.H. and Oh, S.E., (2011). "Socio-economic impacts of a micro-hydropower plant on rural livelihoods". Scientific Research and 46 Essays,[Online] 6(19), (pp. 3964-3972)

12 Khennas, S. and Barnett, A., (2000). "Best Practices for Sustainable Development of Micro Hydropower in Developing Countries": In Association with London Economics & deLucia Associates, Cambridge Massachussetts, USA for The Department for International Development, UK and The World Bank

13 Gurung, A., Bryceson, I., Joo, J.H.and Oh, S.E., (2011). "Socio-economic impacts of a micro-hydropower plant on rural livelihoods". Scientific Research and 46 Essays,[Online] 6(19), pp. (3964-3972)

14 Karki NR,(2004). "Reducing the cost of rural electrification: A key to improve the quality of life in developing countries". International conferences on Power system technology –POWERCON 2004,Singapore (pp. 14-21)

15 Khoju, J.K., (2014). "Hydro Power Development in Global Energy Market: Mini/Micro Hydro Power as an Important Segment"

16 "Detail Feasibility Study Report of Ruma Khola MHP" (Volume I- Technical Report),(2007). Available at DDC: DECS, Myagdi.