Sustainability of Micro-hydropower in Nepal: A case study of Rukum District

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Abstract: Nepal has sufficient hydroelectric potential but around 1% of the hydropower potential has currently been developed and micro-hydropower generation potential in half century is more than 27MW and more than 300,000 households are beneficiaries. Micro-hydropower includes more positive socio-economic impacts in Nepal. This paper aims to study the socio-economic impacts and impacts in MHP due to change in environment in Nepal through the case study of Athbiskot MHP of Rukum. Rukum is rich in hydropower resources, around 20 years ago three hydropower were constructed 250 kW in Syarpu Taal, 150 kW in Bijeshori and 11 kW in Athbiskot of Rukum district were constructed by Nepal Electricity Authority of Nepal. Alternative Energy Promotion Centre(AEPC) is installing 87 MHPs in Rukum among them 11 micro-hydropower serving 3097 household generating 308 kW power, seven micro-hydropower are under construction having estimated power 239 kW and beneficiaries households 2518 and eleven number of Pico-hydropower are generating 53 kW and beneficiaries' households are 624 of Rukum district and remaining MHPs are in process. For sustainability technical, social and economic factors play vital role in community. The micro-hydropower sustainability with social, economic and environmental aspect is under a broad point of view it may be assumed that the advantages generally overcome over the limitations and a solid trend of further energy generation by the installation of hydropower plants can be identified in Nepal.

Keywords: Energy, Micro-hydropower, sustainability, Social, Environment, Economic

1. Introduction

Nepal has tremendous hydroelectric power potential, estimated at around 83,000 MW [1]. Nepal is facing power shortage and demand supply gap is increasing with time. The government has initiated measure to increase the supply of the country but increasing of supply has not been realized due to financial as well as political reasons. It is necessary to take measures to increase power generation capacity and also to reduce electricity demand. With increase in demand of electricity and due to uncertainties in oil supply and fluctuating price of conventional fuels, demand side management can be an important opportunity for the electric power utilities as well as for the customers.

Energy is a crucial factor for nurturing economic and social development. As it is evident from the history of human society, economic growth requires increasing amount of energy. The development of industrial and agricultural production and people's standard of living are directly or indirectly related to increase energy consumption [2]. The current generation capacity has been unable to cope with the rising electricity demand and electricity consumers in several sectors have been affected by regular load shedding.

Nepal has tremendous hydroelectric power potential, estimated at around 42,000 MW is considered to be economically viable. However, only around 1% of the hydropower potential has currently been developed [3]. The main energy resource base in the Nepal are Fuel wood, Hydropower, Petroleum products and other fuels like Crop residues, Livestock manure, Biogas technology, Micro- hydro turbines, Coal, Solar energy and Wind energy etc. The country has installed capacity of 719.6 MW [4]. The production of electricity varies due to various financial and management issues. Recently in 2014, electricity demand is 1026.65 MW. The deficit Electricity is about 375 MW [5]. The supply demand gap is increasing with time. Load management is being carried out through extensive load shedding which is being carried out across the country. Load shedding of 12 hour is being carried out in some months of recent years [6].

Rukum is rich in hydropower resource. In 1996, three hydropower plants were constructed, 250 kW in Syarpu Taal, 150 kW in Bijeshori and 11 kW in Athbiskot of Rukum district by Nepal electricity authority of Nepal (NEA). There are 11 micro-hydropower serving 3,097 households, generating 308 kW power. Seven micro-hydropower are under construction having the estimated power 239 kW and 2,518 households of Rukum district. There are eleven Pico-hydropower plants are generating 53 kW and 624 beneficiaries' households. The MHPs in Rukum is done through Alternative Energy Promotion Centre (AEPC) [7].

Sustainability Analysis is defined as the presence or absence of the factors that are likely to impact, either positively or negatively on the prospects of sustained

delivery social, environmental and economic aspects of new and existing hydropower projects are the three pillars of sustainability analysis as shown in Figure 1.

The union of any two aspects will create either bearable, equitable or viable situation, but the intersection of all the aspects will create a sustainable situation and ensure social, environmental harmony at its best and, if not, they will at least mitigate or compensate and on same run maximize the positive outcome referred as shown in figure 1 [8]. Sustainability simply means the ability of a project to maintain its projected operations, targeted services and benefits during its projected life time. To sustain the existing Micro-hydropower plants, these three aspects should be simultaneously combined as shown in Figure 1.

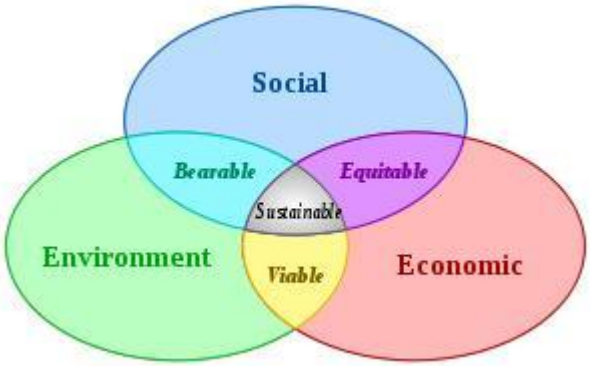

Figure 1: Three aspect of sustainability [9]

2. Methodology

2.1 Questionnaire Development

Questionnaires are typically used for feedback research to determine the current status or "situation," or to estimate the distribution of characteristics in a population. After development of questionnaire a survey questionnaire is one of the most critical stages in the survey development process. For the data collection from the different manufacturing establishments, the questionnaire was prepared and this collected data was input for the analysis.

2.2 Field Survey

After listing of manufacturing establishments, the prepared field visit to micro-hydropower site of Rukum district of Aathbiskot MHP 11 kW was performed. Social, economic, technical status was directly observed in the visit. The environmental impact was also known by the questionnaire method and required data were collected. To get socio-economic activities in this place technical aspects of this MHP and changes in society after installation of MHP.

2.3 Data Collection

Data collection was done by using questionnaire sheet in hardcopy. Collected data was then compiled in Microsoft Excel so that it would be easy to know the actual situation of micro-hydropower in Nepal. The primary and secondary data were collected from AEPC, NEA, related journals and other publications.

2.4 Data Analysis

The data analysis is done on the basis of social, technical and economic status of Athbiskot. The existing data were collected by using categorized format and on the basis of questionnaire. The analysis is done by using crystal ball.

3. Findings

3.1 Current status of Micro-hydropower in Nepal

Over the last decades there has been a growing realization in developing countries that micro-hydropower schemes have an important role to play in the economic development of remote rural areas, specifically in mountainous regions. Depending on the end-use requirement of generated power, the output from the turbine shaft can be used directly as mechanical power or the turbines can be connected to an electrical Generator. The trend of MHP development can be seen as shown in figure 2. Especially MHP were developed by NEA and then foreign donor entered in MHP development various programmes. In 2011, MHP development rapidly increased before closing the RERL project of AEPC.

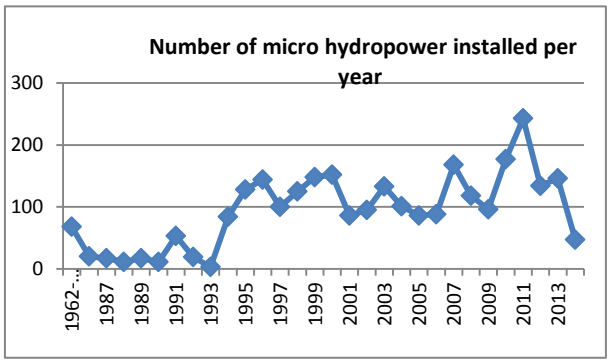

Figure 2: Trend of micro-hydropower development in Nepal [10]

There are more than 80 MHP installation companies qualified by AEPC. Firstly, Rural Energy Development programme (REDP) was conducted and developed more MHP then developed as RERL programme and nowadays MHP development is conducted by NRREP [11].

3.2 Existing Micro hydropower in Rukum

There are various micro-hydropower plants in Rukum. According to AEPC Rukum is the major hydropower generating district compared with neighbor district. Main reasons of development of MHP in Rukum are demand of resident, lack of national grid, access resources and technical feasibility. Rukum is rich in MHP and Rolpa is also rich in MHP as shown in table 1 and sustainability study can be done.

Table 1: Existing MHP in Rukum and neighbor district [12]

District	Number	Power(kW)	Household
Rolpa	60	1,239	13,370.00
Rukum	87	2,934	28,848.00
Dolpa	18	806	6,158.00
Salyan	1	10	200.00
Pyuthan	2	57	614.00
Total	166.00	5,045.20	49,190.00

3.3 Technical Aspect of Aathbiskot MHP

The 11 kW Athbiskot micro hydropower plant is operated and managed by the NEA and given to lease to private sector. Maintenance was done in various components several times such as distribution line, generator/turbine replacement and civil structure constructions. The primary data consist of number of households and population, occupations and sources of income, energy sources, energy consumption patterns, electrical appliances and energy expenditures. Data were collected from relevant offices NEA, AEPC, Regional NGOs and other local enterprises. The data consist of national policies and plans, acts and regulations, project documents, and established data archives. Information about operating histories, revenues generation, management systems, technological performance, supply reliability, operational issues and cost, inventories of spare parts, and associated costs with the micro hydro-power were collected from Athbiskot Committee. The community has a secondary school, an agriculture and livestock extension office, a Health post, a informal learning center, and more than 93 households in Asthbiskot.

Table 2: Summary of technical aspect [13]

Power output	11kW	Total cost of repair and maintenance	Rs. 11,057,500
Hours of usage per day	18 hr	Skill of local operator	Trained on the job, 3 nos.
Served HH	93	O&M Cost of Electromechanical	11
Nos. of times shut - down for maintenance	31	Civil infrastructure	5

The power output of Athbiskot MHP is 11 kW which operates 18 hour per day and beneficiaries' households are 93. The MHP was shutdown 31 times for repair and maintenance. The repair and maintenance expenses is above one million, three local operators are trained and civil infrastructure was damaged 5 times by different landslides of this MHP.

The power generation and sales are shown below in different table 2 and table 3 from the logbook of Athbiskot MHP. The power generation and sales shows that higher the generation and lower the sales of energy because the lower use and consumption of end-user behavior. Lacks of income some people use low electricity and they use other energy such as biomass for cooking and heating. They use electricity only for lighting.

The annual power generation and power sale of this micro-hydropower is given below.

Table 3: Power generation of Aathbiskot MHP [14]

Month	kWh		
	2048	2060	2070
Poush	-	3946	6285
Magh	-	4725	5343
Falgun	-	5085	5165
Chaitra	-	4758	4982
Baishakh	-	5038	4732
Jestha	-	5027	6204
Ashad	-	4243	8432
Shrawan	1440	5183	8423
Bhadra	1684	4882	6562
Ashoj	630	3816	5745
Kartik	565	4863	5234
Mansir	376	4940	4365

The power sales of Athbiskot MHP is shown in table 4 below.

Table 4: Power sales of Aathbiskot MHP [15]

Month	kWh		
	2048	2060	2070
Poush		654	694
Magh		676	687
Falgun		679	710
Chaitra		672	694
Baishakh		665	687
Jestha		654	684
Ashad		669	694
Shrawan	587	667	720
Bhadra	634	683	690
Ashoj	638	665	667
Kartik	646	678	623
Mansir	633	687	610

3.4 Economic Activities and Source of Income in Aathbiskot

To sustain any hydropower plant, financial sustainability is most important factor. To analyze sustainability of the MHP Net present value and Benefit cost ratio are calculated. In this work one MHP is selected for financial analysis. There are various MHP with different management models in Rukum. Athbiskot MHP is government owned MHP and is leased now to the private sector. Analyzing the source of income obtained from the survey data shows that the Athbiskot population largely derives its livelihood from agriculture and in many cases, subsistence activities. These households are predominantly engaged in agricultural and forestry activities which are both seasonal and yield low incomes. The main sources of cash income are from the sale of farm and dairy products. On the average, a household produces about 2500 kg of field crops and mainly potatoes annually, which are sold for income at Rs. 10/kg. They do not sell these products within the village; they go to relatively large town Rukumkot, Khalanga, Banphikot and chaurajahari. Less than 3% of the total households in village are engaged in home based businesses such as a small grocery or local hotel. Rural cash It also shows that the villages are characteristically similar in terms of the distribution of income sources. About 5% of the total households are engaged in waged and salaried activities, consisting of government and corporate employees. Only 3% of households are engaged in small scale non-agricultural businesses and 11 % are unskilled workers/labor in various private and social work, Common features of these households includes: limited land holding, low agricultural productivity, food insecurity, lack of access to financial capital, limited sources of income and limited access to markets. They are primarily dependent on their labor to get an income and they buy the majority of their food [16]. Poor households find it difficult to create a surplus of either time by doing work, as they end up working to pay off debts rather than to accumulate food or cash. Intuitively, land and livestock ownership should provide a reliable indicator of household income. Main economic activities are dependent upon various activities shown in table 5. For sustainability of MHP, lower income people should be strong in economic activities.

Table 5: Main economic activities [17]

Economic Activity	HH % Aathbiskot
Waged/salaried - Government/Official	5%
Agriculture	78%
Traders & Small Business Operators	2%
Plant & Machinery Operators	2%
Skilled Workers	2%
Labor/Unskilled workers	11%

Table 6: Annual cash income distribution by household [18]

Annual Cash Income	HH % Athbiskot
High (Above Rs.100,000)	9%
High Medium (Between Rs. 61000 – 100,000)	31%
Low Medium (Between Rs. 21000- 60000)	23%
Low (Below Rs. 20000)	37%

3.5 Social Aspect

Hydropower schemes must have significant role in poverty alleviation, and raise the economic standard of the society. Electricity approach, children and woman empowerment and the infrastructure development are the positively influencing factors for making the society beneficial such as fresh drinking water and irrigation water, flood control, fishing profession development has convinced the people on the positive side of hydropower development in Nepal and many places have seen the uplifting of the overall social status. These impacts were mitigated by offering the cash compensation for those who lost their land, house and property. Alternative indirect mitigation measures were also taken in the projects including the rehabilitation of the affected families, providing the

replacement land and house and providing the job in the project according to their skill and qualification. This is the trend in Nepal and till today almost all the displaced people are rehabilitated.

Mostly proactive during the planning phase, the element involves the following considerations to ensure the sustainability of the project:

- Improved life conditions
- Improved health conditions
- Direct or indirect project benefits distributions
- Information and economics transparency

The hydropower development has contributed to the development and establishment of new hospitals in Aathbiskot. This has created a positive output to the new developments in Aathbiskot. It can be said that the hydropower development has brought many new development opportunities in the area. The new outcomes such as jobs, infrastructure, education, health care and electricity can always be considered as the supporting tips to advocate the sustainability of hydropower project in Nepal.

3.6 Environmental Aspect

The factor Environmental Aspects involves the overall and the integrated environmental issue of the impact of hydropower projects. The environmental issues may arise because of various factors and at different stages. There are many environmental issues that must be analyzed during analyzing the sustainability criteria. The IHA suggests the following basic and important elements of the environment factor to be assessed: Environment Impact Assessment (EIA) procedure, water quality, sediment transport and erosion, downstream hydrology and flow, rare and endangered species, construction activities, health issues, flora and fauna [19].

Table 7: Kerosene & dry-cell replacement and saving

Particulars	per month	Rate (Rs)	Per month (Rs)	Annum/ HH	Total (Rs)
kerosene	3	153	459	5508	512244
Dry cell	3	80	240	2880	267840
Electricity	30	8	240	2880	267840
Saving			459	5508	512244

The Kerosene and dry-cell are replaced by electricity and saving after introducing the MHP is NRs 512,244. Due to change in climate water level is decreasing, sometimes abnormal condition may happen. In this work due to access amount of water no change in power generation of this micro-hydropower plant but Sometimes landslide damaged canal.

4. Conclusion

Since energy is widely needed for almost all human activities, it is necessary to make a balance of pros and cons related with hydropower generation. No universal recipe can be here established, since regional peculiarities will play a striking role in the decision process. In the case of Nepal micro-hydropower is essential in rural area. More than 27 MW power is generating from micro-hydropower of Nepal and going on progress for more MW power.

Higher the generations of electricity but lower the sales because of several factors and failure rate is higher which takes more time in repair and maintenance and more expenses due to weak equipments and natural disasters.

Nepalese are socially conscious and know national and international rules and provisions that the project must make to the society and they must contribute to the projects to make the MHP plants more sustainable. Hence, the cooperation of people and society with the hydropower developers is always positive, which is the best factor suggesting the sustainability of the hydropower projects.

The benefits of rural electrification are incontestable, especially for the enhancement of rural people's livelihood. Evidence from other developing countries reveal that access to electricity in combination with simultaneous access to markets and other infrastructure has contributed to growth of rural areas in clear and compelling ways. The electricity demand for productive uses is insignificant; the power is mainly used for lighting and cooking. Less than 3% of the households in the case study communities are involved in running small grocery shops and hotels.

It can be seen NRs 512,244 is saving after use of electricity. Electricity replaced the kerosene and dry-cell. Due to the geology and soil strata of Nepal, sedimentation and erosion are permanent issue but their effects can be minimized. Hence, sedimentation and erosion do not affect the sustainability parameter as sediments can be flushed off and erosion can be minimized.

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