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Full Length Research Paper

Socio-economic impacts of a micro-hydropower plant on rural livelihoods

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Electricity is one of the key determinants for economic growth of a nation. Although the benefits of rural electrification are immense, more than 44% of the people do not have access to electricity in Nepal. Micro-hydropower (MHP) scheme is considered the most feasible decentralized renewable energy option for providing reliable and affordable electricity to the remote and isolated areas of Nepal. This study assesses the impact of a MHP plant on socio-economic conditions in the remote village, Sikles, in Nepal. Cross-sectional research design was used to collect information with a structured questionnaire, key informant interviews, and focus group discussions. Results revealed that the village electrification had brought a series of positive changes in the rural livelihoods. Traditional kerosene lamps like Tuki and Panas were completely abandoned, and firewood consumption was reduced. Electric lights in households extended the day providing additional hours for evening reading and work. The micro-hydro based electricity was used to power modern agro-processing mills in the village, which reduced drudgery for women as they no longer had to use ineffective and distant traditional water mills. Thus, micro-hydro scheme provides clean, affordable and sustainable renewable energy both locally and globally.

Key words: Renewable energy, micro-hydropower, poverty, rural electrification, socio-economic.

INTRODUCTION

Electricity, the most efficient and cleanest form of modern energy, is a critical component of economic development (Pokharel, 2007). An efficient provision of electricity can improve the socio-economic conditions and technological aspects of a nation that ultimately improves the living standard of the people (Kanagawa and Nakata, 2008; Sihag et al., 2004). However, more than two billion people still lack access to electricity and rely on traditional biomass such as firewood, agricultural residues, charcoal, and animal dung for cooking, heating and lighting in their homes (IEA, 2002; WDR, 2010). Using these insufficient technologies, basic energy needs can hardly be met and contributes to maintaining the cycle of poverty in developing countries (IEA, 2002; Peters et al., 2009).

Nepal, located on the lap of the mighty Himalayas, has no proven deposits of petroleum products or natural gas, and hence the only native supply of commercial energy is electricity (Ghimere, 2008). Nepal is bestowed with water resources where more than 6,000 perennial rivers and rivulets flow with an annual average water runoff of 225 billion m^3 thereby providing huge hydropower potential (Sangroula, 2009). It is estimated that Nepal has a total hydropower potential of 82,000 MW of which 42,000 MW is technically and economically feasible (Pokharel, 2003). Despite having huge hydropower potential, by the end of fiscal year (FY) 2009/2010, only 716 MW (including 53 MW from thermal plants) of electricity has been generated in Nepal and 44% of the population live without electricity (MOF, 2010; WECS, 2010; Wegstein, 2010). Nepal has a very low electricity consumption rate

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averaging 87 kWh/year-person (NEA, 2008). During 2010, the total national annual energy demand was 4367.13 GWh (NEA, 2010). Since only 3689.27 GWh was met through available resources, there was a power deficit of 677.86 GWh, which caused blackouts 16 h per day country wide (NEA, 2009; NEA, 2010). Power deficits are further exaggerated during the long dry period (October to March) as most of the larger hydropower projects are based on the seasonal flow of rivers.

Nepal's rural electrification through the 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 (Ghimere, 2008). Also, rural electrificationis often awarded as a political favor in Nepal, which ultimately put major portions of poor rural population in darkness if the areas are not within the interest of political leaders (Pandey, 2009). Nepal is one of the poorest countries in the world with a per capita income of $447/year, where about 25% of the population lives below the poverty line (ADB, 2009; NPC, 2010). Nepal's energy sector is small, inefficient, unreliable, poorly managed, and hugely dominated by traditional energy sources including firewood, agricultural residues, and animal dung (Dhungel, 2009). During the 2009/2010, 87% of the country's energy demand had been met through traditional sources whereas commercial (petroleum, coal, and electricity) and renewable energy sources contributed 12.2 and 0.7%, respectively (MOF, 2010). The heavy reliance on traditional biomass for energy results in a poor quality of life, makes local resources scarce, reduces agricultural productivity since nutrient rich agricultural residues are transferred from the farm to the fireplace, and damages the fragile hill ecosystem (IEA, 2002; Koirala, 2007).

Despite having limited access, the numbers of electricity consumers are growing annually in Nepal. During the year 2008/2009, the total number of customers reached 1,677,000 (represents a growth of 10%) and in the year 2009/2010 it was estimated to be 1,879,000 (12% growth) (MOF, 2010). With the given economic condition of the country, the task of providing electricity to all through capital intensive large hydropower projects seems daunting to meet the existing power demand (Ghimere, 2008). Therefore, to meet the challenge of ever-increasing energy demand, small-scale renewable energy technologies have been adopted throughout the country (Koirala, 2007; Wegstein, 2010). Rural areas are electrified using decentralized renewable energy technologies such as photovoltaics, wind, geothermal, and MHP, and are competitive with electricity delivered via the national grid (Lhendup, 2008; Mahapatra et al., 2009). MHP has turned into one of the most promising indigenous technologies to satisfy rural electrification because of their simple design, simple manufacturing processes, low price per kilo watt, easy maintenance, and no dam has to be built (Fulford et al., 2000; Greacen, 2004). Additionally, many researchers have reported that MHP not only provides lighting for rural communities but also helps to accelerate rural economic development if the power is integrated with agricultural production and other income generating businesses; plus less fuel wood is consumed (Blanco et al., 2008; Dhanapala and Wijayatunga, 2002; Kirubi et al., 2009). Overall, MHP can fulfill the technological, environmental, economic and social sustainability criteria in remote and isolated areas in developing countries like Nepal.

In Nepal, the installation of MHP has been supported by bilateral donors and banks who have not been effective in providing reliable and affordable energy to poor rural areas (Fulford et al., 2000; Khennas and Barnett, 2000; Pandey, 2009). In addition, due to poor planning and execution, most of the existing MHP plants were not functioning in many rural parts of the country (Mainali and Silveira, 2011; Rijal, 2000). Also, there is a lack of data regarding rural energy supply and consumption patterns since energy planners overlook rural enterprises as less-productive members of the economy. Moreover, rural electrification follows a top down approach in Nepal (Pandey, 2009). However, primarily rural energy sector has to be improved in order to improve the economic status of the country. Because more than 80% of the Nepalese people still live in rural parts of the country (Ghimere, 2008).Therefore, more attention should be given towards the rural household who are deprived of electricity especially, in mountainous region like "Sikles". The objective of the current paper was to investigate the impact of decentralized small-scale renewable energy technologies in a rural community, Nepal. A case study was carried in in order to assess the socio-economic conditions of a village impacted by the MHP plant using qualitative as well as quantitative methods.

MATERIALS AND METHODS

Study area

Sikles is located on the southern belt of the Annapurna Conservation Area. It lies in the Parche Village Development Committee[1] (VDC) of Kaski and is situated about 24 km northeast

[1]Nepal is divided into 14 administrative zones, which are stratified into 75 districts. The 14 zones are grouped into five development regions namely: Eastern Region, Central Region, Western Region, Mid-Western Region and Far-Western Region. Each district is headed by a chief district officer (CDO) responsible for maintaining law and order and coordinating the work of field agencies of the various government ministries. A village development committee (VDC) is the lower administrative part of its local development ministry. The main purpose of the VDC is to organize village people structurally at a local level and to create a partnership between the community and the public sector for improved servicedelivery system. Each district has several VDCs and altogether there are 3913 VDCs in Nepal. A VDC is further categorized into wards, the number depending on the population of the district (average 9 wards in a VDC).

of Pokhara, the headquarters of Kaski District, Gandaki Zone and the Western Development Region. It lies between 1,100 to 3,331 m above sea level and has two types of temperature zones: the lower part which is below 2000 m above sea level lies in the warm temperate zone with an annual temperature of 15 to 20°C; the upper part lies in the cool temperate zone with an annual temperature of 10 to15°C (Khanal and Watanabe, 2006).

Altogether there are 360 households in the village with more than 4,000 inhabitants. Sikles is a traditional Gurung[2] village in which more than 81% of the households are occupied by Gurung people and the remaining households belong to occupational castes or dalit[3] such as Kami and Damai. The village includes six traditional neighborhoods: Ghairi-Thar, Sava-Thar, Koi-Thar, Dhaprang-Thar, Lama-Thar, and Harpu-Thar. Agriculture is the main source of subsistence in Sikles, supplemented by animal husbandry. The higher part of the village is covered by dense forest. The middle and lower slopes are terraced and categorized as Khet (irrigated land: mainly rice) and Bari (non-irrigated land: maize, millet, wheat, and barley). People in Sikles are proficient in traditional technologies like alcohol fermentation, weaving clothes and sacks from the wild nettle plant, and weaving various bamboo products, such as wooden threshers. Pastoralism is another important source of income for households in the village.

Research methods

Three types of surveys were carried out from August 20 to October 20, 2008. These include an in-depth household interview, a key informant opinion, and a focus group discussion: (the MHP plant site was also visited and plant operation was observed):

In-depth household interview

A structured questionnaire was designed to get qualitative, multi-aspect information of the village. A total of 213 households were randomly selected. Either the head of the household or another family member were interviewed. The questionnaire was categorized into four sections: Section 1 (demographic structure: caste, gender, family member, occupation etc), Section 2 (agriculture: type of land ownership, cropping pattern, livestock etc), Section 3 (socio-economic: annual income, education, health and sanitation, etc) and Section 4 (sources of energy, consumption of firewood, access to electricity, domestic electricity usage patterns, etc).

Key informant opinion

Four people were selected (the MHP manager, mill owner, a staff from Annapurna Conservation Area Project (ACAP), and a school teacher) on the basis of previous experience of working in the area. During the survey, a face to face interview was carried out and the Gurung language was used as a medium of communication.

Focus group discussion

Focus group discussions were carried out during the study period: one in Sikles and one in Pokhara in order to get range of opinions/views on the research topic from different levels including dalit people. Focus group discussion is one of the efficient qualitative research method in which the interviewer or moderator asks research participantsspecificquestion about a topic or an issue in a group discussion (Wong, 2008). In this method, group members are encouraged to communicate with one another, exchanging ideas and comments on each other's experience or point of view on the issue raised by the moderator (Wong, 2008). In Sikles, during the focus group discussion, people with different background, age factor, and both men and women were included. In addition, participants from dalit people were also included in order to obtain knowledge, perspectives and attitudes of people about use and access to MHP, and seek explanations for other social issues.Whereas in Pokhara, scholars from Sikles (both studying and working in Pokhara) were gathered to discuss about the current status of Sikles MHP and its impacts on the society.

RESULTS AND DISCUSSION

Households having access to electricity

In rural Nepal, the establishment of MHP was initiated by private entrepreneurs rather than the Nepal government in which financial support is available from the Agricultural Development Bank of Nepal (ADB/N) (Khennas and Barnett, 2000). The target sites for MHP are remote and isolated areas, which are not connected to the national grid. The target beneficiaries are rural people residing in more distant and inaccessible areas, where the national grid will not reach within a foreseeable future (Dhungel, 2009). A MHP plant was installed in Sikles in 1994 with an output capacity of 100 kW under the Alternative Energy Programme (AEP) established by the ACAP. ACAP initiated the AEP with the main objective to provide efficient energy alternatives to firewood usage in the Annapurna Region. This MHP plant uses water from the nearby river Ngacchakhola, which is about 2 h walking distance from the village. The Sikles MHP plant was installed with the objective to provide electricity for households in Parche and Sikles. However, after some years of operation, the distribution grid had been extended to Khilang - a neighboring village of Parche and Sikles. Currently, all households in Sikles, Parche, and Khilang have access to the electricity. Altogether there are 562 households as a beneficiaries group of the Sikles MHP plant in three villages. The MHP plant is owned by the community, which is organizationally structured to include an equitable participation of all households of the community and hence, benefit sharing is equitable between different groups including both high and the low caste people and is only differentiated according to their buying power.

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[2]The Gurung people are an ethnic group of Nepal's mountain valleys. They live primarily in north-west Nepal of Gandaki Zone, specifically Lamjung, Kaski, Mustang, Dolpa, Tanahu, Gorkha, Parbat, and Syangja districts as well as the Manang district around the Annapurna mountain range.The total population of Gurungs in Nepal is approximately 543,571 (2.39% of the total National population).

[3]Occupational caste or dalit is a self-designation for a group of people traditionally regarded asuntouchables in the society. Historically dalit has often been associated with occupations regarded as ritually impure, such as anyinvolving leatherwork, butchering, blacksmith and removal of rubbish, and works as manual laborers in Nepal. Discrimination against dalits still exists in rural areas of Nepal and are not allowed to access to eating places, temples and water sources.The total population of dalits in Nepal is approximately 2,914,849 (12.82% of the National population).

End-use of micro-hydro based electricity

It is obvious that having access to a 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). In Sikles, micro-hydro based electricity is mainly used for meeting household lighting demand. During day time, the electricity is used for running some business enterprises in Sikles. At present, there are two agro-processing mills (each 7.5 kW), one furniture shop (2.2 kW), and one bakery shop (1.5 kW).

According to the interviewed respondents, the village electrification has brought series of positive changes in the daily livelihoods. Having access to electricity, women can grind their grains on modern agro-processing mills, which is faster and more efficient than traditional water wheels. Similarly, bright electric lights in the homes extend the evening hours for women and can engage in other income generating activities including weaving clothes and fermenting alcohols. Owing to the access to electricity, villagers have good facilities for mass communication media through code division multiple access (CDMA) telephone sets and TV. Mobile telephones are also available in the village. The village even has an internet facility. According to Lhendup (2008), households in rural areas are reluctant to invest much of their income on energy and appliances that are needed to benefit from a rural electricity supply. Nevertheless, this study found that households in Sikles are willing to invest more on energy and other electric appliances.

Impact of electricity on education

There is one kindergarten, one primary school, and one secondary school in Sikles. The need for electricity in schools seems to be not that important because electronic medium such as computers, TVs, and other visual equipment were not used for education in the village. Furthermore, school hours are from 10 am to 4 pm and sun light is enough to illuminate the class room. However, electricity can directly influence the education level in the rural community (Zahnd and Kimber, 2009). This is even more critical in Sikles, where secondary school children have to take the standardized national exam; School Leaving Certificate (SLC) to get admission to colleges and universities in cities as well as for getting jobs. Furthermore, they have to compete with students from urban areas, which have access to modern forms of technology for better education. In past years, students had to spend most of their productive time collecting firewood and fodder to meet their household demand in Sikles. Additionally, students had to use inefficient traditional kerosene lamps-“Tuki” and “Panas”, and firewood as a means of illumination to study at night. Also, the whole family resides in a single room, which is used as a kitchen, bedroom, study room, dining room, and living room. This creates an unfavorable environment for students to conduct their study. As a result, in the past, hardly 1 to 2 students will pass the SLC per year.

Owing to the access to electricity, the academic performance of children is greatly influenced in Sikles. Electric lights in households extend the day providing additional hours for evening reading and also, reduced drudgery for children. The level of illumination provided by the modern electric lights in the households is more efficient and brighter than that provided by Tuki and Panas. The micro-hydro based electricity has indirect impact on the school student. Generally, children used to go with their mother while grinding or collecting firewood. However, owing to the access to electricity, villagers have easy access to modern mills. In addition, the consumption of firewood reduced significantly and thus, school attendance has increased because student has no longer to go with their mother.In recent years, the secondary school is able to maintain a 80% SLC success rate. The number of students attending college in Pokhara from Sikles is also increasing. Moreover, improvement in the quality of education has brought new hope and inspiration as well as builds confidence in village students.

Positive impacts of village electrification on social structure

Traditionally, education has not been part of the culture of the people in Sikles even though the availability of a quality education plays a pivotal role in influencing the economic well-being of rural areas (Kirubi et al., 2009). Since agriculture is the main source of subsistence in the village, people spend most of their time in their fields. During the evening time, villagers gather together to share news and stories and for other social activities. According to the interviewed key informants, before village electrification the literacy rate in Sikles was very low (less than 30%). Majority of the villagers (>30 yrs old) could not read and write Nepali language, although Nepali is national language. However, having access to electricity, adult (>20 yrs old) education classes were conducted by ACAP, and illiterate people were highly encouraged to participate in this programme.The informal education conducted by ACAP brought a significant change in the social structure within short period of time. In recent years, each ward has built communal buildings in Sikles, which are electrified and used for different social activities including meetings, dancing, studying, etc. Similarly, villagers spend their evening time either watching TV or being engaged in income generating activities.

One of the encouraging benefits of the adult education classes was that the distant relationship between the

Gurung and the Kami and Damai was reduced, and Kami and Damai were also allowed to participate in the evening education programme. In the past years, dalit student were minimal in the school due to persistent discrimination. In recent years, the numbers of dalit student are also increasing in the school. Old people are habituating to the Nepali language as households have access to Nepali dramas, movies, and news through TV and radio. Furthermore, ACAP used to show documentary films about natural resources, impact of deforestation and wild life in order to create awareness of environment among villagers.

In Sikles, the majority of the household demands are fulfilled by women since their husbands travel abroad for employment. Before the village was electrified, women in Sikles had to spend 8 to 9 and 9 to 10 h, respectively, for collecting firewood and milling purposes. Access to electricity reduced drudgery for women as they do not have to travel long distances for collecting firewood and grinding foods. Modern agro-processing mills in Sikles have brought drastic improvement to a women's lifestyle, since they do not have to travel to the traditional water mill or "Ghatta" for grinding purposes. Women now save plenty of time which can be used for other household related activities including cleaning and income generating activities such as weaving, nettling, and so on.

Change in firewood consumption and its impact on environment

It is obvious that if a rural community has reliable access to basic lighting services it can have a major impact on the environment. Poor rural communities heavily rely on firewood, which is a free resource, as the only cost of firewood collection is physical effort and time (Katuwal and Bohara, 2009). Over exploitation of firewood for household purposes (cooking, heating, and lighting) leads to the degradation of natural forests that ultimately results in scarcity of local resources (Mahat, 2004).

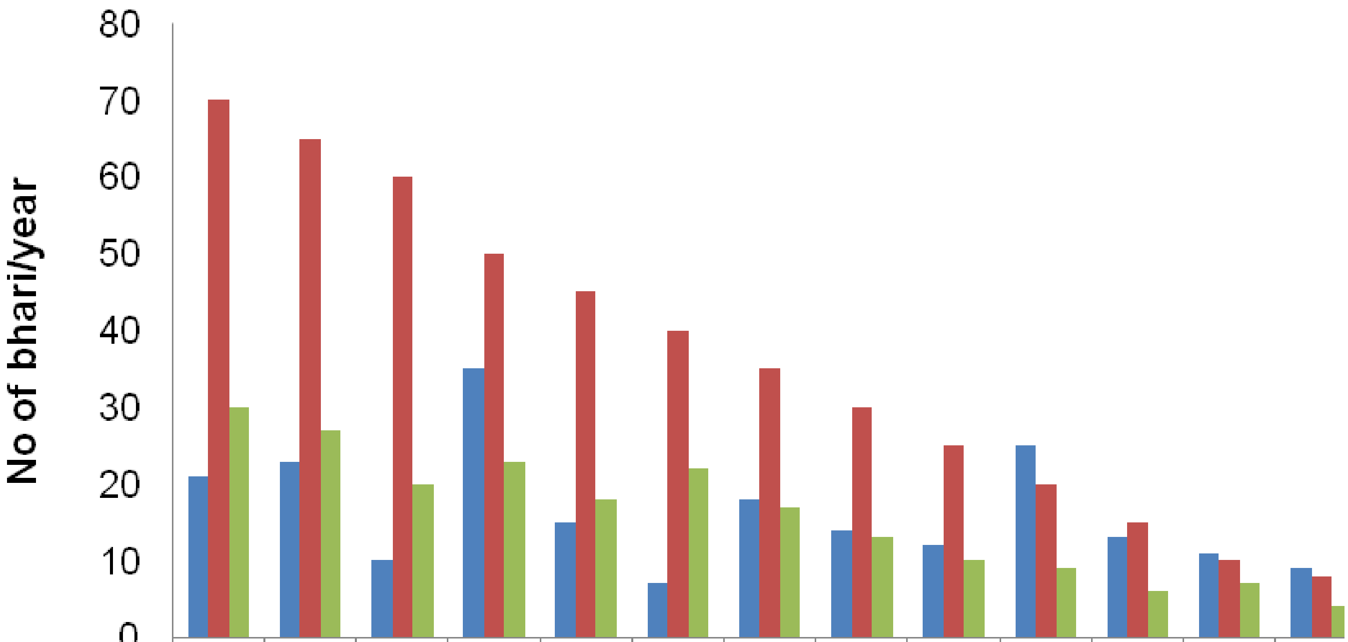
Another disadvantage of the use of traditional biomass in rural areas is that people are susceptible to indoor air pollution (mainly vision and respiratory illnesses) due to poorly ventilated kitchens (Katuwal and Bohara, 2009).

In the past, before connecting electricity to the village, people totally relied on the local forest for meeting their household demand which includes energy, livestock fodder, and timber. In Sikles, firewood can be classified into three categories: freshly cut wood, dead branches and twigs, and crop residues. Each ward has their own communal forest in the village and is allowed to cut fresh wood once a year, whereas the collection of dead branches and twigs is allowed year round. The act of cutting fresh wood led to the massive depletion of forests in the Sikles region and also, villagers had never re-planted trees in the exploited areas. In the past, the prevailing pattern of firewood usage as an energy source was unsustainable and created adverse impacts on the fragile hill ecosystem and rural livelihoods in Sikles. As a result, villagers had to travel 8-9 h just to collect one bundle (bhari) of firewood. One bundle of firewood is approximately equal to 25 to 30 kg.

In addition, the underprivileged castes (Kami and Damai) had less access to natural resources in comparison to the Gurung people, which forced them to gather firewood illegally. According to Fox (1984), the consumption of firewood in rural areas of Nepal depends on farm size, caste, family size, and season. Similar trends were found in Sikles as well. In Sikles, being a traditional Gurung village, various festivals are celebrated during the year where relatives, guests, and visitors from nearby villages come to participate in the functions. These activities increase the consumption of firewood in the village. In addition, preparing kudo (a nutritious drink for livestock prepared from maize and millet) and distilling alcohol caused Gurung households to burn more firewood than the Kami and Damai. In addition, the temperature in Sikles decreases during the winter and is accompanied by snow fall and results in the consumption of more firewood during the winter season. As depicted in Figure 1, households consumed firewood an average of 1,091 kg/year. However, households of the untouchable castes consumed less firewood than Gurung households since they have less economic activity.They are also forbidden to enter into a Gurung's house. Due to social restrictions, Kami and Damai cannot perform commercial activities in Sikles. For example, they cannot sell local alcohol to Gurung people.

Owing to the access to electricity, firewood usage changed significantly. The consumption of firewood reduced to half (an average of 475 kg/year) after connecting to the grid. Only very few households, who prepare alcohol for commercial purposes, consumed more firewood. People are now more concern about the depletion of non-renewable energy resources and initiated a plantation of palatable and non-palatable trees in bare and fallow lands. According to the interviewed ACAP personal the greenery in the village increased by 30% as compared to past years.In recent years, more than 60% of the bare and fallow areas have been converted into green forests, especially *AlnusNepalensis*. Moreover, a concept of private forest has been developed among the villagers by utilizing non-fertile Khet and Bari.

Traditionally, kerosene and firewood were used for cooking, heating, and lighting in the households, often supplemented by agricultural residues and animal dung. Village houses were made up of flat muddy roofs with stones and wood beams. Moreover, traditional open fire kitchens were shared for most of the daily activities and social gatherings, since there was no separate room for cooking and other purposes. The use of biomass as energy in rudimentary cook-stoves releases carbon dioxide and products of incomplete combustion including mixture of gases (carbon monoxide, nitrogen compounds, and methane) and volatile organic compounds (IEA, 2002; Warwick and Doig, 2004). However, the village electrifica-



	1	2	3	4	5	6	7	8	9	10	11	12	13
HH	21	23	10	35	15	7	18	14	12	25	13	11	9
Before	70	65	60	50	45	40	35	30	25	20	15	10	8
After	30	27	20	23	18	22	17	13	10	9	6	7	4

Figure 1. Consumption of firewood before and after the village electrification in Sikles.

tion improved the indoor atmosphere significantly. Traditional cooking stoves are now replaced with improved cooking stoves. According to Pokharel (2003), improved cooking stoves can improve the efficiency of the firewood by 50%. And also, people are importing most of their daily needs from city rather than exploiting village natural forests. Dry cell batteries are no longer used in Sikles and thus, any local ecosystem impacts from improper battery disposal have been substantially reduced.

Negative aspects of the Sikles MHP plant

The MHP plant is managed and operated by local people. The community has organized a separate sub-committee for managing the MHP plant, called the village electrification committee (VEC), and appointed a local plant manager. However, the community has to rely entirely on ACAP for all problems related to the MHP plant. Due to lack of expertise, the community was unable to keep financial and technical records. The MHP plant has already been hit by two severe landslides during the past years in which the inlet and head race pipes were damaged. Since the VEC did not have enough funds to maintain the MHP plant, villagers had to wait almost a year to have electricity in the village.

In the very beginning, devices called “police switches” (miniature circuit breakers) were installed in each household to ensure that electricity usage did not exceed a certain quota. However, the original police switches were not effective and households could cheat the power supply easily. In addition, all the staff were from the same village and they did not sincerely follow up in the inspection process as they showed sympathy towards some households being relatives, etc. Hence, monitoring mechanisms were faulty.

The original installed capacity of the MHP plant was 100 kW. However, during the first few years of operation, total electricity generated from the MHP plant was in excess for two villages. Therefore, the VEC extended the grid to the neighboring village, Khilang. After extending the grid to Khilang, the VEC often experienced a problem with the transformer due to a low load factor. However, due to the increase in the number of consumers, more electrical appliances were introduced into households which ultimately exceeded the supply of the MHP plant. In order to decrease the demand, the VEC decided to ban the use of low-wattage cookers in Sikles and Parche. Consequently, people reverted to firewood for cooking

Figure 2. The arduous traditional water mill (Ghatta).

and complained to ACAP for taking back the low-wattage electric cookers as these were supplied by ACAP to the village. According to Peters et al. (2009), households in rural areas do not utilize electricity efficiently, which gives generally gives unproductive outputs. A similar situation was observed in Sikles as well. In Sikles, due to the provision of paying electricity on a per watt basis, electric lights are misused-households do not turn off lights during the day time.

Few households earn their living by operating traditional water mills (Ghattas) in Sikles (Figure 2). However, owing to the access to modern agro-processing grinding foods, and this put a few households in economic hardship. Due to traditional farming systems, the production is not sufficient to sustain their family, that is, their production hardly sufficed for 5 to 6 months. Because of such miserable status, a trend of abandoning agricultural land is increasing in Sikles. A study carried out by Khanal and Wanatabe (2006) found out that more than 49 and 37% of productive Khet and Bari were abandoned in Sikles and Parche in recent years. This trend is further excavated by better employment opportunities of abroad employments. In recent years, due to the increased access to modern mass communication systems, out-migration becomes a normal phenomenon in Sikles.

Conclusions

This study found that a MHP had a significant impact on the consumption of firewood in rural households. It was revealed that Sikles children have lesser propensity to go for wood collection once their homes have been connected to the MHP. Similarly, modern electric lights in the households allow more time for students to conduct their study during night time. Access to electricity reduces drudgery for women in the village allowing them to have enough time to be involved in other household related activities including income-generation and social and community development activities. Moreover, the micro-hydro based electricity reduces CO_2 emissions significantly. Thus, this study comes to conclude that the MHP has positive impact on socio-economic conditions of the rural communities.

RECOMMENDATIONS

However, due to lack of technical and financial as well as entrepreneurial skills, majority of the existing MHP plants are out of function in Nepal (Khennas and Barnett, 2000). The Sikles MHP plant is suffering from a series of problems including lack of funds, technical and nontechnical problems, low load factors, and ineffective policing measures.The current status of Sikles MHP revealed that decentralized energy-access plans and budgets often do not adequately take into account the capacity development activities required for adoption of off grid energy technologies by poor and rural populations in Nepal. Although the rural electrification campaign begun before 40 years ago, the current status of electric coverage via national gridline in rural areas is unrealistic and implausible. Currently, subscribers are enjoying the low tariffs for electricity in Sikles.However, providing electricity at the current rate (US$ 0.007/Watt), results in a poor financial condition for the VEC. The Sikles MHP plant is getting older but to date there is no concrete plan for regular performance observations. According to the plant manager, the power supply can be halted at any time if something goes wrong with the generator. There is no savings and also no longer will there be technical support from ACAP.

In order to use electricity from the existing plant, the VEC has to increase tariffs at least by 3 to 4 fold. Also, meters should be replaced in each household in order to control and monitor the efficient usage of electricity. Local technical capacity should be strengthened. The improved cooking stove (ICS) program can become additional agent for reducing pressure on natural forests as ICS can significantly increase the efficiency of firewood. Therefore, a detailed analysis would help to find the critical point regarding how much electricity has to be available for a significant change in poor rural livelihoods. Additionally, a policy measure for an increase in the number of MHP installations in rural areas of Nepal has to be ensured.Furthermore, the establishment of an energy regulator, with the responsibility to oversee the rural energy sector, ensure fairness, and promote transparency and competition, would encourage the private entrepreneur in development of the rural energy sector.

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