



Role of micro-hydropower plants in socio-economic development of rural in Afghanistan

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ABSTRACT

Afghanistan hosts the Hindu Kush, an extension of the Himalaya mountains that act as water sources for five major rivers flowing through Afghanistan. Most of these rivers provide promise for the construction of water dams and installment of micro hydropower plants (MHP). Although civil war and political strife continue to threaten the country for more than four decades, the Afghan government introduced strategic plans for the development of the country. In 2016 Afghanistan introduced the Afghanistan National Peace and Development (ANPD) Framework at Brussels designed to support Afghanistan's progress towards achieving the SDGs (Sustainable Development Goals). This study discussed the 7th Goal (ensuring access to affordable, reliable, and sustainable energy for all) and 8th Goal (promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all) alignment in Afghanistan. The Afghan government acknowledges its responsibility to provide electricity for all of its citizens, but this can only be achieved if the government can secure a reliable source of energy. Afghanistan's mountainous terrain provides a challenge to build a central energy distribution system. Therefore this study looks for alternative solutions to the energy problems in Afghanistan and explores feasibility of micro-hydropower plant installations in remote areas. This study evaluated socio-economic impacts of micro-hydropower plants in the life of average residents. We focused on one example of a micro hydropower plant located in Parwan, conducted interviews with local residents, and gathered on-site data. The findings in this study can help policymakers to analyze the effects of development projects in the social and economic life of residents. It will encourage the government and hopefully the private sector to invest in decentralized energy options, while the country is facing an ever-growing energy demand.

Keywords

- Micro-hydropower
- Afghanistan energy sector
- Socio-economic development
- Sustainable development
- Sustainable development goals (SDGs)
- Rural electrification
- Renewable energy deployment

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1. Introduction

Electricity plays a critical role in economic development. Efficient electrification can improve national socio-economic conditions and inspires technological innovation that ultimately improves everyone's standard of living. However, more than two billion people 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. These inefficient technologies do not meet basic energy needs and contribute to the cycle of poverty in developing countries [1]. According to surveys conducted by the World Bank, Afghanistan has a population of more than 35.5 million people in 2017, with more than 5 million in urban areas [2]. Less than 30% of householders have access to clean and stable electricity [3]. Around 75% of the population is living in rural areas, and 10% of rural them have access to electricity [4].

Water has historically supported the growth of civilizations around locations close to a river or waterway. The first human civilizations emerged around rivers and flourished by the fertile lands around it. The Indus valley civilization emerged around 2300 BCE (Before the Common Era), and was an agrarian society that relied on the Indus river for its irrigation and transportation. At the same

time, another civilization in Mesopotamia was emerging. These people relied on the Tigris and Euphrates Rivers heavily for agriculture and irrigation.

In contrast, Afghanistan is a mountainous country with more than 50 percent of its entire landmass at an elevation higher than 2000 meters. This terrain makes it difficult for people and goods to travel from one part of the country to another. Besides, the terrain provides a major challenge to manage a central electric grid system that provides electricity to all of the communities around this country. According to data from Afghan national electricity company DABS (Da Afghanistan Breshna Sherkat), more than 50 percent of the population (over 19 million) has no access to the electric grid. Although the government had planned to invest in a central grid system, high expenses and mountainous terrain of the country were obstacles. However, these mountain ranges are the primary water source for most of the rivers flowing around Afghanistan.

The country divides into five water zones, each zone with a major river and its smaller distributaries: Amu Darya, Helmand, Kabul/Indus, Harirod-Morghab, and Northern River Basins. They are mainly fed by glaciers and



ice caps that are located at the top of the aforementioned mountain ranges. The government's analysis determined the best option to provide energy was through using renewable sources and developing a decentralized grid system that allows more flexibility and can provide electricity even in most remote areas. The electric source for this grid can also be changed based on community needs and geological location.

In Afghanistan, although bilateral donors and banks have financed MHP projects, the projects have been ineffective in providing reliable and affordable energy to poor rural areas. Due to poor planning and execution, most of the existing MHP plants are not operational. Insufficient data on rural energy supply and consumption patterns make it easy for energy planners and administrators to overlook the needs of rural residents and enterprises. Moreover, the regulation of rural electrification follows a top-down bureaucratic approach. Because around 80% of the people still live in rural parts of the country, improving the rural energy sector is imperative to improve the economic status of the country. Therefore, more attention should be given towards rural households who are deprived of cost-effective electricity supply [5]. In this study, we focus on a small community located in northern Afghanistan, which has been using hydropower to provide for their electricity needs for more than a decade. In recent years, the Afghan government has put forward with rural socio-economic development programs, but due to various reasons, most of these efforts have been failed [6].

2. Introduction to Honarway Sofla

The village of Honarway Sofla is located north of Kabul under the jurisdiction of the Salang District of Parwan province. With an altitude between 2,000 to 3,800 m above the sea level. It is located in an arid temperature zone with an annual temperature of 15° to 20° C [7]. There are 102 households with more than 500 inhabitants, most of whom work in agriculture and animal husbandry while the Afghan government employs a small number in various positions.



Figure 1. Photo of the village.

The village is isolated without a paved road connected to it; the only way to enter the village is through a narrow passage through the mountains. However, it is located near the Salang river and has the potential to harvest its hydropower.

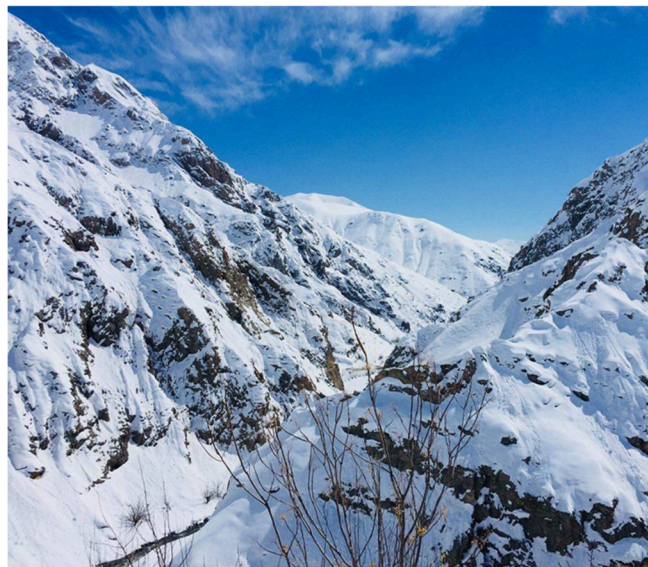


Figure 2. Entrance way to the village in winter.

Flowing through Parwan Province, the Salang River is a 438 Km long. A tributary of the Indus, the Ghorband, the Panjshir, and the Kabul Rivers, the Salang originates on the south side of the central mountains of the Hindu Kush northeast of the Salang Pass which links the region to Kabul. The Salang flows into the Ghorband at the locality of bal Saraj in Parwan. At Jabal Saraj, the average annual flow as measured between 1961 and 1964, was about 763 millimeters per year, which is considered a high rate [8].

3. Case study of the micro-hydropower plant (MHP)

An MHP was constructed in 2004 by the Afghan ministry of rural rehabilitation and development, with a capacity of 26 KW. It is currently owned by the local village council and maintained by a local technician. According to locals, the MHP usually needs service every two to three weeks, and the money required is raised from the community. Local council members also pay the local technician.

Two surveys were administered in 2019 from August 20 to October 20, involving an in-depth household and stakeholders interview. The MHP plant site was also visited, and plant operations were observed. A total of 102 households were given a structured questionnaire designed to get qualitative, multi-aspects information of the target study. Either the head of the household or another family member was interviewed. The questionnaire was categorized into four sections:

- 1- Section 1 demographic (family structure, gender, occupation, etc.)
- 2- Section 2 agriculture (type of land ownership, cropping pattern, livestock, etc.)

- 3- Section 3 socio-economic (annual income, education, health and sanitation, etc.)
- 4- Section 4 energy (sources of energy, consumption of firewood, access to electricity, domestic electricity usage patterns, etc.)

The MHP manager, mill owner, health officer working in the local clinic, a local leader, and a school teacher were selected because of their previous working experience. Face-to-face interviews were conducted personally by an interviewer. This study is planned to assess the following areas:

3.1. Impact on local education

To describe the impact of MHP on local education levels, family education background was solicited to compare the levels of education among locals attained in the past generations and those in a new generation after access to electricity was provided.

3.2. Impact on health

To identify the effects of electrification on the health of the local community, an interview with local health officers working in local clinics were conducted with a focus on common health problems and the effects of local MHP on the individual health of village residents.

3.3. Impact on the local economy

To measure indicators of economic growth due to rural electrification despite the lack of significant economic entities located in the village, questionnaires were given to local women who weave and sell fabrics. Indirect impacts of local electrification, such as the use of mobile services and access to the internet, were also assessed.

3.4. Education

As a war-torn nation since the 1970s, Afghanistan has suffered from political instability and civil war since the Soviet invasion. The ongoing instability has stalled economic growth and has negatively impacted national education and literacy rates. With the installation of a new government in Kabul, Afghanistan made education among its citizens a main priority. The country has received vast amounts of international aid to fix its devastated educational system that was damaged or destroyed during the civil war and the reign of the Taliban regime. Most of the communities around the country have had no access to educational facilities, and more than 75% of Afghans were illiterate [9].



Figure 3. A young girl attends a community-based school under a tent in a returnee settlement in Laghman province in eastern Afghanistan [10].

In this study, we discuss how new technology changed the education system in the Honarway Sofla. We focus on the role of local religious institutions in promoting public education and see the impacts of modern technology provided by the installation of MHP in the village. These data do not include any information regarding female population, so no data about female literacy rates in the village were collected.

4. Conducted survey and discussion

In our survey, we asked about literacy rates in the previous generation to see any changes when compared to the current generation. The results were promising: among the 83 families living in the village during the 1990s, these villagers had very low literacy rates among them. Only 20% of the population was able to read and write. The village had no school of its own, and most of the children were forced to travel long distances in order to attend public classes. Most of these children belonged to relatively wealthy families who could afford to send their children to school. Families with smaller incomes needed their children as a labor force to do different chores around the village, especially since during the civil war in Afghanistan, most older men in the village were armed and fought. Elder in the village were forced to take responsibility and act in most cases as the sole breadwinner of their families.

Today, almost all of the children in the village attend school regularly. Our gathered data show a 40% increase in literacy rates among local villagers. Reflecting a shift in the importance of education, all of the villagers seem eager to send their children to school; even those in lower-income families show great enthusiasm about the education of their children.

4.1. Role of mosques

Although the reported literacy of the villagers was only 20% during the 1990s, this calculation did not include a large number of people who are considered “semi-literate”. While they could read Arabic script, they were unable to write or had difficulty when trying to read Farsi or Pashto texts. This group comprises another 60%. Traditionally, it is common for Afghan families to send their children from an early age of 5 to attend religious studies in local mosques, where they learn the Language alphabet, read Arabic scripture and the Holy Quran, memorize some surahs, learn about basic religious festivals and rituals, and some early Farsi poetry. These mosques acted as a local educational center where most of the children were taught basic reading skills. Even today, many of the kids in the village attend mosque classes daily even though they have access to public schools in their village. This point shows the significant and positive effects that local religious institutions had on the life of these villagers.

4.2. Community literacy classes

During the early 2000s, before the new government was established, the literacy rates in Afghanistan were around 25%. The Afghan government supported a national strategy to promote literacy and social growth in communities around the country. Honarway Sofla was home to some of these programs that were supported by international organizations and the Afghan Education Ministry. Locals were able to attend classes in order to learn how to read, write, and learn about other general information. According to our data, more than 200 locals attended these programs at different times. These programs reflected the government’s commitment to the United Nations Sustainable Development Goals to increase literacy rates and provide quality universal education.

A major impact of these programs was the inclusion of women. Many local women who were unable to attend school during their childhood due to war or lack of access to educational centers showed interest in participating in the literacy program. The enthusiasm among the locals toward public education can be traced to an increase in public awareness from the modern public media. The introduction of television changed many aspects of a local villager’s life, especially for women.

Electric lighting allow local women to divide their chores between day and night, rather than restrict all their work to daylight hours. Women could now engage in any income-generating activities during the night.

4.3. Education

The village now has a school that serves primary to secondary grade students. All the village children attend school regularly, which shows an 80% increase from the 1990s. This school has a small computer laboratory provided by an international organization, and it uses electric

power from local MHP. Student from Honarway Sofla learn basic computer functions and become familiar with a computer’s operation. There are no high schools in the village, and most of the local students must attend nearby Ghulam Nabi Shahid School and Zokor Salang School. This does not deter locals from sending their children to school, even though the nearest high school is 40 minutes away from the village.



Figure 4. A community-based education class [11].

According to our interviews, during the 1990s, only three people from the village attended higher educational institutions. Now, over 15 young undergraduates from this village attend public universities around the country, and every year, more students from Honarway Sofla take the university entrance examination to graduate from high school and to enroll at a national university. In addition, more families express interest in sending their daughters to school, having grasped the idea that educating women can have a positive impact on every family.

4.4. Health

In an agrarian society, most of the people in Afghanistan earn income by working in the fields or farming. Few people are employed in the health sector around the country [12]. According to data from the Afghan Ministry of Public Health and World Health Organization (WHO), there are only 7.26 doctors, nurses, and midwives per 10,000 people [13], among some of the worst statistics around the globe.

Honarway Sofla, however, had better luck with health services. Although an isolated community located deep within the mountainous heartland of Afghanistan, it has access to a local clinic. This medical outpost provides basic medical services and acts as a joint pharmacy and local clinic. In addition to that, this medical center also conducts very simple and basic blood lab analysis. These tests require a very small amount of electric power, which is provided by the local MHP. Most of the villagers rely on this

clinic's health services when faced with sickness, and the remoteness and inaccessibility of the village emphasize the importance of the local clinic. We conducted extensive interviews with local health officers in order to gather data about the MHP's impact on the life of an average villager.

4.5. Reduction in goiter cases

Goiter is an abnormal enlargement of one's thyroid gland located in your throat. Although goiters are usually painless, a large goiter can cause a cough and make it difficult to swallow or breathe. The most common cause of goiters worldwide is a lack of iodine in the diet, which is also commonly observed among isolated communities and rural areas around Afghanistan. Based on our survey, goiter cases were very common among the elderly population. During 2005 the Afghan Ministry of Public Health encouraged the government to introduce a new plan to increase public awareness about goiter and encourage using iodinated salt in their daily diet. A mass media and public marketing campaign were aimed at affected communities. According to a local officer, with the introduction of new communication means like television and radio, people were more aware of the effects of an iodine-deficient diet and goiter. As a result, while most cases of goiter show symptoms in patients older than 40, no new patients have been diagnosed with goiter since the beginning of 2008.

4.6. Personal hygiene

Proper personal hygiene practices can affect one's vulnerability to infectious diseases than can transfer from person to person. Because of the smaller density of health care providers (7.26 per 10,000 Afghans), most people living in rural communities around the country would not have received proper education about many common health problems and hygiene practices. Most of the children living in these communities face serious health problems and even death due to neglect of personal hygiene.

Teaching children proper hygiene practices – especially regular handwashing with water and soap – is one of the most effective ways to save their lives as well as guaranteed access to clean drinking water and adequate sanitation. Without these, children can suffer from diarrhea and stunting (low weight for age and delayed cerebral development). In fact, two out of five young Afghan children are stunted. More than 65 percent of Afghans have clean drinking water through “improved drinking water sources” that are protected from outside contamination – dramatic progress from a decade ago when drinking water reached only 20 percent of people.

While a little more than 80 percent of families have toilets or latrines, only about 40 percent are improved and safe – meaning they hygienically separate human waste from human contact. Open defecation continues to be a dangerous challenge in Afghanistan because human waste

near waterways and living environments can spread diseases quickly and puts children and their families at risk.

According to the local health officers, villagers paid more attention and learned a lot about personal hygiene and sanitation after the introduction of television to their daily life. The television, as a mass media outlet can be used to raise public awareness by spreading information about common diseases and ways to prevent them.

4.7. Reduction in respiratory diseases

Although the actual number of respiratory disease cases was not available, we received anecdotal claims about a reduction of these illnesses among villagers. Most of the villagers had used kerosene lamps and firewood for lighting before the MHP was installed. Kerosene is similar to diesel fuel in chemical composition [14], and kerosene heaters can substantially increase indoor levels of fine particles (PM2.5), sulfate aerosol (SO₄²⁻), and acidic aerosol (H⁺), as well as CO. The existing evidence is inconclusive about a causative link between kerosene heater use and respiratory and asthma symptoms in developed countries. Still, in developing countries, there is an association with usage of kerosene lamps and increased risk of respiratory infections, especially tuberculosis. Since the villagers now use more affordable electric lighting during the night, which avoids risks associated with the use of kerosene lamps. It shows a positive impact of the local MHP on the healthy life of local villagers.



Figure 5. Children practice improved handwashing hygiene in Afghanistan's Daykundi province [15].

There remain problems with local women's usage of firewood and animal dung for cooking and heating. The isolated nature of the village, economic unaffordability of other heating sources, and small power output of the MHP means that the locals still use traditional methods for heating their houses and cooking their meals. Wood smoke is made up of a complex mixture of gases and fine particles including several toxic harmful air pollutants:

- Benzene
- Formaldehyde

- Acrolein
- Polycyclic aromatic hydrocarbons (PAHs)

According to studies conducted by the Environmental Protection Agency (EPA), the use of firewood for cooking and heating is more dangerous than smoking. Wood smoke can affect everyone, including children, teenagers, older adults, people with asthma and Chronic Obstructive Pulmonary Disease (COPD), and people with heart diseases, obesity, or diabetes. New or expectant mothers should take precautions to protect the health of their babies as some studies indicate they may be at increased risk.

5. Impact on the local economy

Most of the people living in the Honarway Sofla work in agriculture or animal husbandry. The main source of income is revenue received from crop sales. Due to its small power output, the MHP is unable to support major revenue-generating activities and industries. However, we evaluate the impact of the MHP on the economic life of these villagers.

In Honarway Sofla, 77 families are engaged in farming, and 8 families raise animals as their main source of income. The farmers commonly grow wheat, corn, beans, potatoes, onions, and barley and sell them in the local markets to provide for their families. Due to the high altitude, most of the farmers face difficulty providing water for their farms. A series of small waterways that guide water from the upper stream is used for irrigation. Because people have access to MHP, some farmers now use small water pumps to irrigate their lands, allowing for a more flexible farming approach. Farmers can water their farms whenever they want. Otherwise, it seems that the MHP had no specific effect on the farming life of these villagers. The remaining eight families that work as animal farmers generate the bulk of their revenue from selling dairy products and livestock in the village and nearby markets, but no benefits were apparent.

Two families in this village own a local shop, which is their source of income. These shops provide most of the daily-needed items and are venues for selling locally-farmed crops. The majority of the village's economic activities are centered around these local shops. Also, 15 remaining families work in different services. Eight heads of families work in government offices in the nearby city of Charikar. One local cleric works and lives in the local mosque. One officer works in the local clinic. Eight others work in other sectors. The MHP had no direct impact on their lives except for allowing them to extend their effective working hours at night.

6. Results and conclusion

6.1. Households have access to electricity

In rural Afghanistan, the establishment of MHP was initially funded by private entrepreneurs before it was fully

financed by the Afghan Ministry of Rural Rehabilitation and Development under the Rural Development Program (RDP) whose main objective to provides efficient energy alternatives to local electric generators. The MHP plant installed at Honarway Sofla in 2004 has an output capacity of 26 kW and uses water from the nearby Salang River, which runs through the village. Owned by the community, the MHP is organizationally structured to ensure equitable participation and benefit of all households of the community.

6.2. End-use of micro-hydro based electricity

With access to a reliable and affordable supply of electricity, small enterprises can be developed to support the rural economy, but, in rural communities, electricity is mainly used for residential lighting. This is shown in Honarway Sofla where micro-hydro based electricity is mainly used for meeting household lighting demand. During the day, the electricity is used for running some business enterprises in Honarway Sofla.

According to the interviewed respondents, village electrification has brought a series of positive changes in daily livelihoods. With access to electricity, bright electric lights in the homes extend the evening hours for women who can engage in other income-generating activities including weaving clothes. Villagers can access modern telecommunication media through television, the internet, and mobile cellular networks. According to reports, households in rural areas were reluctant to invest much of their income on energy and appliances that could take advantage of a rural electricity supply. In contrast, this study found that households in Honarway Sofla are willing to invest more in energy and other electric appliances.

6.3. Impact of electricity on education

While no local high school conveniently supports in Honarway Sofla, a local school named Maktab Sanawi Qarye Honarway Sofla (secondary school) provides education for children up to the secondary level. Although it seemed that the need for electricity in schools was not important, this school is equipped with a small computer laboratory for training local students. Since school hours are from 8 am to 3 pm, ambient sunlight is enough to illuminate the classroom. However, electricity can directly influence the education level in the rural community. Students in Honarway Sofla Secondary School can compete with students from urban areas who have access to modern forms of technology for better education. In the past, village students had to spend most of their productive time collecting firewood and doing chores for their household. In addition, nighttime studying would have to be done using inefficient, traditional kerosene lamps and firewood as a means of illumination. Usually, the whole family resides in a single room that functions as a bedroom, study room, dining room, and living room. This creates an unfavorable environment for students to do homework assignments. In the past, only 3 or 4 village students annually were able to pass the national university entrance examination for

admission to national urban universities. With access to electricity, the academic performance of children is greatly improved. Residential electric lights provided evening hours for studying that were brighter and more energy efficient than kerosene lamps. Firewood consumption decreased, as did student absenteeism since young students no longer needed to collect wood. More village students were prepared to attending college at National Universities. Thus, the improvement in the quality of education has built confidence, hope, and inspiration among village students.

6.4. Change in firewood consumption and its impact on the village's local environment

Reliance on hydroelectric power also has a major impact on the environment. While firewood is generally free in cost, overexploitation of firewood for household purposes (cooking, heating, and lighting) degrades the natural forests and leads to scarcity. Use of traditional biomass fuels in poorly ventilated kitchens also makes people susceptible to indoor air pollution (vision and respiratory illnesses). Before the MHP in Honarway Sofla, villagers relied on the local forests to meet their household demand. The act of cutting fresh wood led to the massive depletion of forests in the Salang region because villagers had never replanted trees in the exploited areas. This made the pattern of firewood usage unsustainable and created adverse impacts on the fragile hill ecosystem and rural livelihoods. As a result, villagers had to travel 8-9 hours just to collect one bundle of firewood. Access to electricity reduced consumption of firewood reduced by half (an average of 475 kg/year).

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