ECONOMIC AND ENVIRONMENTAL PERSPECTIVES OF MICRO HYDRO POWER: A CASE STUDY OF DISTRICT DIR (UPPER), KHYBER PAKHTUNKHWA

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LIST OF ABREVIATIONS

MHP	Micro Hydro Power
MDG	Millennium Development Goals
MW	Mega Watt
Kw	Kilo Watt
Kwh	Kilo Watt Hour
WAPDA	Water and Power Development Authority
WTP	Willingness to Pay
DCR	District Census Report
LPG	Liquefied Petroleum Gas
KPK	Khyber Pakhtunkhwa
CBA	Cost Benefit Analysis
NPV	Net Present Value
IRR	Internal Rate of Return
PBP	Pay Back Period
DPP	Diesel Powered Plants
BCR	Benefit Cost Ratio
EIRR	Economic Internal Rate of Return
FIRR	Financial Internal Rate of Return
CDM	Clean Development Mechanism
PRA	Participatory Reflection and Action
KIS	Key Informant Survey
UPS	Un- interrupted Power Supply
DC	Direct Current
SRSP	Sarhad Rural Support Program
SPSS	Statistical Packages for Social Scientists
PDD	Project Design Document
CER	Certified Emission Reductions

Abstract

The recent energy crisis combined with environmental degradation has led the planners to switch to renewable and clean energy technologies. The present study aims to estimate the cost and benefits of Micro hydro power (MHP) plants in rural areas of District Dir (U) Khyber Pakhtunkhwa. The study further assesses the environmental sustainability followed by identifying the challenges in the way of Micro Hydro Power plants. For the analysis, both primary data as well as secondary data is used. Descriptive statistics, Financial and Economic analysis followed by Participatory Reflection and Action (PRA) are used for the analysis of data. The result of the study shows that the expenditure made by MHP connected households on alternative energy sources is less as compared to the expenditure made by WAPDA connected households. Financial and Economic analysis show that MHP is a feasible and viable technology. Further, the available MHP units in the area can reduce the Green House Gas (GHG) emissions by 3180 tons of CO_2eq per annum by replacing the use of fossil fuels. By registering the project with CDM, it can earn $95400 per annum. Based on these results, policy makers should support and encourage renewable energy installations in rural areas in the form of Micro hydro power technology. The government should also establish technical training institutes to impart basic skills to the operators of the plants. There is also a need for proper institutional arrangement to tackle the issues of floods, repairing and other social issues. These projects can be registered with CDM to earn certified emission reductions.

Keywords: Micro hydro power, Renewable Energy, Rural Energy, GHG emissions, CDM, District Dir (upper).

CHAPTER 1

INTRODUCTION

1.1. Statement of the Problem

Energy is an important need of human life. It is the life blood of all economic activities. Due to increase in population and economic activities, the need for energy is increasing at a faster rate. Without having sufficient energy, the goal of economic and social development and the Millennium Development Goals in particular cannot be achieved.

More than 1.6 billion people in the world who are living in rural areas are without electricity (Greenstone, 2014). The reason is that it is too costly to provide electricity services to rural communities through conventional means, due to remote location and low density of population. The use of diesel and gasoline has been used for decades for provision of electricity to rural areas. But it was not so successful due to economic, technical and environmental problems (Woodruff, 2007b).

In 2004 about US$55 billion was invested in renewable energy in the world, which is just one third of the amounts that was invested in conventional power plants. In 2005, renewable energy supplied 17% of the world primary energy. This growth in renewable energy occurred in developing countries, which accounts for 44% of the world renewable generating capacity (Woodruff, 2007a).

Given this backdrop, Pakistan is also facing severe energy crisis. There are many factors that have intensified this issue. High cost with low level of energy generation compared to demand manifold this issue. While the country’s growing population and economic activities necessitates the generation of more energy. On the other hand, there are also issues of conservation, misuse and overuse of energy at household and industrial level. Line losses, electricity theft, corruption, mismanagement and lack of political consensus on the big power projects are other factors that have significantly contributed to the energy crisis (Government of Pakistan, 2013).

Now, the question arises that whether we should go for big power projects or small ones and whether we should use non-renewable or renewable resources for energy generation. In the wake of the issue of climate change and environmental degradation, the importance of clean energy technologies have been increasing. Moreover, the international environmental agreements make it necessary for Pakistan to concentrate on renewable and clean energy options to meet its growing demand for energy (Hussain & Gillani, 2012).

The renewable energy technologies are highly expected to grow in the future due to declining prices, and the need for environmental protection (Paish, 2002). The renewable energy sources include hydropower, solar energy, wind, biomass and geothermal energy etc. The energy or electricity generated from these sources is clean. It means that it causes no GHG emissions.

Hydro power is the largest source of renewable energy. Sixteen percent of electric energy in the world is generated from hydro power. Its share in the renewable energy is about four-fifths in the world (Dolf, 2012).

Hydro power is classified on the basis of its size and energy generation capacity. This classification has been made for European countries. Large hydro has a generation capacity of 100MW. While medium-hydro has a generation capacity of 20MW-100MW. Small-hydro has a capacity of 1MW to 20MW. Mini-hydro ranges from 100KW to 1MW.This may be a stand alone or grid connected. Micro-hydro has a capacity of 5KW to 100KW that supply electricity to a small community in rural areas (Dolf, 2012).

Micro Hydro Power has the advantage that it can be made on small streams, canals and river tributaries in the hilly areas. This technology does not require the storage of water or building a reservoir or dam. Water is only diverted from a river through a power channel towards a power house. The water that is used to run a turbine can again meet the same river without any loss. It requires no combustion of fuel or gas. Only water is used which is a natural capital in most of the northern areas of Pakistan.

The main grid electricity supplied to the hilly and mountainous areas face some problems. Firstly, the line losses due to the remote location are very high. Secondly, the electric poles of main grid electricity are also exposed to storms that often fell during heavy snow fall. It takes months to repair the damages and faults.

The low voltage of the main grid electricity and load shedding is also a source of concern for the rural population. The population faces about 18 hours load shedding and in some cases even more than 18 hours per day (Attif, 2013). The voltage of electricity is also low which cannot run machinery or household appliances.

To address this issue, Micro Hydro Power (MHP)[1] is the best option for providing a reliable and cheap energy to the rural communities. Northern areas of Pakistan have an immense potential of Micro Hydro power installations due to the availability of water.

More than 1200MW micro/mini hydro power potential is estimated to be available in the country. Out of this potential, less than 5% is being developed. For microhydel power plants with capacities 100 and 500KW each, an estimated potential of 300MW and more than 400MW, respectively exists in Northern Area only (Sheikh, 2010).

[1] Micro Hydro Power is a technology for generating electricity on small streams and canals that require no dam or storage of water. It is also called as run of the river technologies. Its generating capacity ranges from 5Kw to 100Kw (Khennas & Barnett, 2000).

In this technology the potential energy of falling water is used to produce kinetic energy which rotates a turbine. This turbine then operates a generator that converts mechanical energy into electrical energy. Micro hydro power provides a simple, low cost and independent source of energy for remote rural communities. Micro hydro systems can supply 24-hour power to the rural communities. This system is cost effective as compared to solar and wind energy (Dolf, 2012). Because sun light varies with respect to time and place. It is only available during the day. Similarly, wind power also depends on location and speed of wind which varies from time to time. Therefore, Micro hydro power is the best option for rural energy supply when the pre-conditions are met i.e. water availability, head and flow.

This study concentrates on this source of energy. The decision of developing Micro hydro power policy involves many steps that should be kept into consideration. For example, technical, economic and social aspect of the area must be examined before embarking on installing Micro hydro power plants. Appropriate sites must be examined technically. Volume of water, appropriate head and the twenty years flood data should be available before initiating work on the project. Project developers must also estimate the potential demand for energy so that an appropriate size of the plant may be installed keeping in view the available and the projected demand. As, with the passage of time the population of the rural areas are growing, therefore in future the demand for energy may also increase. Secondly as the Micro hydro power is also used for productive purposes in rural areas, therefore their potential demand for energy may also be taken into account while deciding on the size and capacity of Micro hydro power (MHP). Small scale businesses like retail shops, barber shops, mobile repairing shops and wielding shops are using this source of energy in the study area. These small scale businesses use the energy of

MHP's during the day while the households use this energy during night for lighting and other household activities.

The social criteria for the projects are also an important aspect of the decision making. Without consulting the local community and without a common consensus among the community members any development activity or project will not be successful.

The area that is taken as a case study is district Dir (upper) Khyber Pakhtunkhwa, where different MHP plants are operating in the area to provide electricity to the local population. Some of the plants are installed by Government organizations and some are installed by community itself. River Panjkora (river of five tributaries) is flowing in the area. The river as well as its tributaries offers a number of sites for small and Micro hydro power plants.

1.2. Research Questions

1. How Micro hydro power is important for the rural communities?
2. Is the Micro hydro power a reliable and cost effective source of decentralized power distribution?
3. Is Micro hydro power plants rely on environment friendly technology?

1.3. Objectives of the study

The study has the following main objectives:

- To show the role of Micro hydro power in generating electricity for rural community in District Dir (upper), Khyber Pakhtunkhwa.
- To assess the cost effectiveness and environmental sustainability of Micro hydro power.
- To identify the issues and problems in the way of Micro hydro power.

1.4. Hypothesis to be tested

- Micro hydro power is a source of environmentally sustainable energy.
- Micro hydro power is a cost effective strategy for rural electrification.

1.5. Study Area Description

The world Dir has originated from their inhabitants who were believed to be kafirs (infidels) long lived in the area. They belonged to Raj puts. Therefore, the original inhabitants of Dir were Raj puts who remained there for centuries. Later on Yousafzai Pathans conquered them under the command of Mullah Ilyas (Akhun Baba). Ghulam Khan, the grandson of Mullah Ilyas founded the state of Dir in 1884. The Government of India recognized him as the Nawab of Dir in 1887. In 1898, he was dethroned by Umara Khan of Jandool. The boundaries of Dir did not stabilize due to the internal and external disturbances (Government of Pakistan, 2000).

Aurang Zeb Khan ruled the state of Dir till 1925. His son, Khan Bahadar Shah Jehan Khan succeeded him in 1925. The government of Pakistan dethroned Shah Jehan Khan and abolished the state of Dir in 1968. In 1969, the state of Dir was merged into Pakistan. Dir was given the status of a district in 1970. Later on in 1996, the district was divided into two districts, District Dir (Upper) and District Dir (Lower) (Government of Pakistan, 2000)

District Dir (upper) is located in the northern part of Khyber Pakhtunkhwa. Most of the area of the district is mountainous. The famous Top of the mountains is Lowari Top or Lowari Pass. It has a height of 4189 meters above the sea level. Snow fall is common in the area. The soil of the area is shallow, rocky and slit loam (Government of Pakistan, 2000).

1.5.1. Land use information

The total area of the district is 312585 acres. Out of this cultivated area is 100547 acres. Total cropped area is 109381 acres. Uncultivated area is 212038 acres and forest area is 203048 acres (Government of Khyber Pakhtunkhwa, 2014).

1.5.2. Climate

District Dir (Upper) has a great diversity in Flora and Fauna. Summer season is moderate and slightly warm. The maximum and minimum temperature in June is 33C^{o} and 16C^{o} respectively. Winter season starts earlier and is severely cold. Temperature falls below freezing point during the months of December, January and February. The mean maximum and minimum temperature in January is 11 and 2C^{o}. Rain fall in winter is more than in summer (Government of Pakistan, 2000).

1.5.3. Population and source of livelihood

District Dir (U) comprises different tribes. These tribes are Painda Khel, Ktani, Kohistan tribes. The people of the area are very simple, hospitable, and sincere and are good Pathans. Most of the people are poor. Their main source of income is Agriculture, daily wages, small businesses and overseas employment (Government of Pakistan, 2000). The total population of the district is 886,000. Urban population of the district is 3500 while rural population is 851,000. Literacy rate in the district is 31.35 % (Government of Khyber Pakhtunkhwa, 2014).

As the area of the district is mostly mountainous, therefore their agriculture land is available on the slope of hills. As a result mechanized agriculture is too difficult to apply. Major crops grown in the area is wheat, Maize and rice. Fruits and vegetables are also grown in the area. The upper parts of the mountains are covered by natural forests. Pine trees, eucalyptus, Oak, Poplar and wild olive are the most common forms of forests in the district (Government of Pakistan, 2000).

1.6. Description of Ushairy Valley

Ushairy valley is one of the most beautiful and largest valleys in District Dir (U). To its north east lies district Swat, to the north Kohistan, and to the West Dir proper and Barawal.

1.6.1. Area, Climate, Population and Settlement

The total area of the valley is 113373 acres. The share of forests, agriculture and commercial area etc are given in table1.1 below.

Table1.1. Land Distribution in Ushairy valley

S#	Nature of land	Quantity (acres)	Percentage
1	Forest land	95095	83.8 %
2	Agriculture	6175	5.50 %
3	Commercial land	3705	3.20 %
4	Vacant land	8398	7.5 %
	Total	**113373**	100%

Source: DCR (1998)

Ushairy valley is surrounded by a series of mountains that are part of the eastern Hindu Kush ranges. The valley has a number of small sub valleys. These valleys include Nishan Dara, Amrait Dara, Sadiq Dara, Barkan and Tabai Dara.

The overall population density of District Dir (U) is 156 persons per square kilometer. Ushairy valley has a rural population. They live in scattered and smaller villages or settlements. The average household size is 8.27 (Government of Khyber Pakhtunkhwa, 2014).

Ushairy valley is divided into sub humid subtropical, sub humid temperate zones climatically. Temperature varies in different months of the year and at different locations of the area.

1.6.2. Water Resources and Energy

The only source of water in the valley is the annual precipitation that is received in the form of snow and rain. Rain water runs rapidly due to the high slopes. The snow remains on hills for longer period of time and melt slowly as the temperature increases. The water that comes from snow melting is a permanent source for the natural streams and irrigation. This water is also used for running the Mills and Micro Hydro Power (MHP) units for generating electricity. These streams later on join the River Panjkora[2].

The use of fuel wood is a common source for cooking and heating in the area. Liquefied Petroleum Gas (LPG) is also used by the people who are closed to the main markets. Majority of the people collect fuel wood from their own forests or common forests. Some of the people also purchase fuel wood in the market. The excessive use of fuel wood has caused deforestation and forest degradation and is a great threat to forest resources. Therefore, alternative energy options can reduce their dependence on forests and thus preserve the precious forest resources.

1.7. Organization of the Study

This study is organized as follows:

The first chapter covers statement of the problem, research questions, objectives and hypothesis of the study. Literature review is given in second chapter. The third chapter deals with data and methodology. Results and discussion is given in chapter four. Conclusions and policy recommendations is given in the last chapter.

[2] The Panjkora River is a river in northern Khyber Pakhtunkhwa in the north west of Pakistan. It originates from Hindu Kush and flow south through Upper Dir and Lower Dir Districts. It joins river Swat at Chakdara, Malakand KPK.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

Micro Hydro power is a source of energy that provides energy to the rural households at their door step. It is a decentralized form of energy that requires no storage of water. It can be built on small rivers, streams and canals. A number of studies have been conducted relevant to the issue under consideration, which is detailed in subsequent section.

2.2. Review of previous studies

Reddy (1999) has examined the goals, strategies and policies for rural energy. He has termed rural energy as abandoned priority. Before 1970's no attention was paid to use the indigenous resources for energy generation in India. Previously the emphasis was on centralized generation of electricity from the big power projects. Moreover, there was a demand from agriculture owners to utilize energy for irrigation pumps. Now, there is a shift in policy in favor of rural areas. The paper has also highlighted the relationship between rural energy and poverty, and has also established a relationship between rural energy and human development through the Human Development Index (HDI). Now due to the global environmental problems and the decentralization of energy, countries are trying to utilize the available potential of Micro hydro power. The paper has also raised the question that why rural energy deserves special attention. It has given the reason that as the rural situation is different from the urban situation, the rural population should be treated differently from the urban population. The population of rural areas are scattered as compared to the urban areas. Thus, the urban approach for energy provision may be costly and inefficient for the remote and scattered population of rural areas. The paper also examined strategies and policies for rural energy supply and also barriers for implementation.

Woodruff (2007b) analyzed Economic assessment of renewable energy options for rural electrification in pacific island countries. The study examined the economic and financial analysis of the micro hydro power projects. It also tried to identify costs and benefits of Micro hydro power projects. Economic analysis take into account the costs and benefits of a project from the society perspectives, while financial analysis considers costs and benefits from the investors perspectives. The scope of economic analysis is much wider than the scope of financial analysis, since financial analysis considers only the direct, monetary values associated with establishing and operating a project(Woodruff, 2007a). The author has used the least cost analysis to identify a potential project. Since the benefits of providing energy to the rural population cannot be quantified. For example the MHP projects improve the education level in the communities by extending the study hours during night. Data would be needed on the earning potential of students before and after the project. This has assumed the benefits to be constant from all the options of renewable energy. Thus the comparison between them is based on cost alone. This study uses least cost analysis to assess the economic viability of the micro hydro system for rural areas. The study report should have also taken into account the potential environmental benefits of renewable energy projects in rural areas. Therefore, this is a limitation of the study.

Rio and Burguillo (2008) assessed the impact of renewable energy deployment on local sustainability. The study attempts to give an integrated conceptual frame work and then a comprehensive analysis of the impact of renewable energy on local sustainability. The study claims that renewable energy sources improve the socioeconomic conditions of the local population. It also helps in the sustainability of local environmental conditions by reducing GHG emissions. The paper gives the three dimensions of sustainability and their interrelationship. These are economic, social and environmental sustainability.

Condrea and Bostan (2008) discussed environmental issues at a new angle. Since economics and environment are inter related. This relationship has led to new goals in natural resource management. These goals are efficiency, equity and sustainability. Furthermore a relationship between environment and development has also been established.

Wazed and Ahmed (2008) have carried out a detailed analysis of Micro hydro power in Bangladesh. In this analysis he asserts that MHP is a time tested, but underutilized technology driven by water in Bangladesh. This study assessed the potential of hydro power energy and the present energy scenario in the country. It concluded that, there is an immense potential for hydro power that is to be generated from the Micro hydro power plants.

Bailey and Bass (2009) examined the feasibility study of hydro electric power from the storm water of Oregon City. In the study, they explored the methods for generation of electricity through micro hydroelectric turbines. The study takes into account different site characteristics for the assessment of feasibility. It includes site selection criteria i.e. access to water, height of drop, catchment area, ecological impacts and property status. The main objectives of the study are to examine the cost effectiveness of the resource to generate energy and to identify the most suitable way to harness this energy. Although the paper talked about technical feasibility, it ignored economic and social feasibility, which are also essential for feasibility study.

Sarala (2009) examined the economic valuation of small micro hydro power projects. The author emphasized the inclusion of environmental damages while estimating the costs associated with conventional and renewable energy resources. The author has made a point that renewable energy sources cause less or no damage to the environment. Therefore its adoption must be made as a part of energy policy. She also compared Micro hydro power with other energy resources like solar and wind energy. He concluded that solar and wind energy relies on continuity of availability of solar radiation and wind which is not the case here. These sources of energy are called intermittent sources of energy. On the other hand Micro hydro power depend on water which has continues flow. Therefore, micro hydro power can be called as non intermittent source of energy. As the Micro hydro power is a renewable and clean source of energy, therefore it can be registered as CDM project for earning revenue. She also concluded that, although initial cost of Micro power is higher than other sources and it provides power to a very limited community, yet it is useful and can be built by the people itself without undergoing any advanced training. The villagers can operate and maintain the micro hydro power system.

Arthur and Stephen (2006) analyzes hydro power options for developing countries with regard to environmental, social and economic aspects. The paper compare the different hydro power options like large hydro, small, mini and micro hydro on the basis of their economic, social and environmental criteria. Large hydro accrues economies of scale but it has negative social and environmental impacts. On the other hand, initial cost of small hydro power is higher but it has minimum environmental impacts. Cost and population data of Pakistan and Peru was used. Cost Benefit Analysis (CBA) techniques were used to compare cost and benefit of the three hydro power options. The result of the study shows that initial cost of the small scale hydro power projects can be recovered 25% more quickly than large hydro power projects. Furthermore, the study has not used Economic analysis for comparison of hydro power options. Ranking of the projects can be made on the basis of NPV, IRR, and PBP for Financial and Economic evaluation.

Sheikh (2010) has highlighted the energy and renewable energy scenario of Pakistan. In this energy scenario, the renewable energy share in the total energy supply is less than 1%, showing that this sector is of least significance for the government. The paper focused on the available data of renewable energy installations in the country, the on-going energy projects and the achievement of renewable energy organizations. Lastly it has given some suggestions for planning and exploitation of indigenous technologies and resources.

Sarala (2009) discusses community based strategic development for Micro hydro power in rural areas. The methodology used in this paper is community-based approach. The paper recognized the need for community involvement in the operation and maintenance of the micro hydro power plants. It has tried to analyze the issues and challenges in the Micro hydro power development.

González, Aristizábal, and Díaz (2009) examined the contribution of micro hydro power projects to development and equality. He also analyzed the environmental effects and sustainability of the projects in Bolivian communities. They used primary data for the analysis. Quantitative information was compared with qualitative ones. Data collection method used was semi-structured and informal interviews, Questionnaire and direct observation.

The paper focuses on the role played by energy provision in rural areas. It shows that the availability of energy services improves the living standards of the people. Access to energy is not directly included in Millennium Development Goals (MDG's), adopted by world leaders in 2000 in the Millennium Summit (United Nations), as a goal to achieve until 2015. However it is considered by United Nations Development Programme (2005) to be a prerequisite to the achievement of all eight MDG's. The paper also gave a good account of direct and indirect impacts of Micro hydro power projects established in Bolivian communities. The contribution to the environment is also assessed by estimating the reduction in the use of kerosene oil and other fuels.

Shakya (2011) carried out a detailed analysis of the Micro hydro power projects in South Africa. The overall objective of the project is to improve access to modern energy services and to provide renewable energy technologies in poor rural areas of Malawi and Zimbabwe. It further identified the policy barriers to promotion of community Micro hydro power plants in the region. The methodology used to collect information was participatory rural appraisal tools, stakeholder analysis and Focused Group Discussion. Household survey, Transect Walks and household interviews was also used to collect data. Questions were also asked from both men and women on their energy needs that became a basis for Micro hydro power design and energy output. A questionnaire for socio-economic base line is also used. The result of the study shows that 100% of the households used fuel wood for cooking. 12% of the respondents observed that the use of fuel wood causes eye problems.

Farooq and Kumar (2013) assessed the renewable energy potential for electricity generation in Pakistan. The study estimates the current and future potential of renewable energy sources for power generation. The renewable energy taken is solar energy, biomass, wind energy and small hydro. The results of the study show that the renewable energy potential in Pakistan is more than the total electricity demand (21GW) in 2010. The study has given the situation of countries like India, Thailand and Turkey regarding the use of these technologies. The study concludes that renewable energy sources can supplement the energy needs of Pakistan and can also provide a sustainable energy base.

Arthur and Stephen (2006) examined the cost/benefit analysis of hydro power options for developing countries. In this paper he took a project as a case study. The gainers and losers were identified to show the impact of the project. In this paper, the author classified hydro power energy on the basis of their size and capacity. The paper has given the impact of micro hydro power projects in on the rural population in terms of increase income through productive activities, employment creation, increase in working hours during night and increase in study hours for students. These multiple benefits provide sufficient evidence that micro hydro power projects are a source of poverty alleviation in rural communities of developing countries. Thus, these power projects not only provide modern energy but also provide an opportunity to the community to diversify their earning sources. The paper has concluded that micro hydro power is the best option for rural electrification where the main grid electricity is not feasible and economical.

Edvard (2011) prepared a report of Economic Analysis of MHP project in which he explained that before deciding on the initiation of the project, the investor has to estimate the total cost and revenue of the project, the annual rate of return and the financial resources that will be needed. The cost of a MHP project is site specific and it depends on the civil works, electromechanical equipments and the distribution lines. Feasibility study is also a component of MHP project. It includes initial design, hydrological study and environmental impact assessment. The Net Present Value (NPV), Internal Rate of Return (IRR) and Pay Back Period (PBP) have been estimated for the project. However, the study did not estimate the benefits in terms of emission reductions from the project.

Woodruff (2007a) has examined mini//micro hydro power plant in Indonesia. This study covers the Economic Analysis of the Mini/Micro hydro power plants (MHP) and the Diesel Power Plants (DPP) that supply electricity to the remote areas of Indonesia. Micro hydro power is an alternative which can replace the diesel power generation. The objectives of Micro hydro power projects are not only to provide financial benefits but also to bring about development activities in the region. The author has used NPV and IRR as evaluation criteria for MHP projects. The energy supplied by diesel generators requires low investment but in the long run MHP plants have more advantages than the diesel power generation. The result of the study indicates that from the investor point of view, Micro hydro power is not as attractive as it covers only the opportunity cost of capital. But from the economic point of view it gives more social and economic benefits through the multiplier effect. More precisely, the Economic Internal Rate of Return (EIRR) is higher than the Financial Internal Rate of Return (FIRR).

2.3. Summary of the Review

The existing literature on micro hydro power mainly focuses on the cost benefit analysis, impact on local sustainability, community participation, feasibility study and the potential for renewable energy sources in rural communities.

Different studies have been conducted regarding the energy production through Micro hydro power in the countries especially, India, Nepal and China. These studies have carried out Financial and Economic analysis about the Micro hydro power projects. Some of the studies have also discussed the environmental aspect of Micro hydro power. These studies, however did not estimate the emissions that are reduced by initiating renewable and clean energy projects. Moreover, a little work is done on Micro hydro power in case of Pakistan.

2.4. Contribution of the present study

Many studies have been carried out to conduct Financial and Economic analysis of MHP projects but these studies did not estimate the emission reductions due to the installation of MHP plants. The present study attempts to estimate the emission reductions that would have been occurred in the absence of MHP plants/ projects. In Pakistan, major emphasis is on the installation of mega and fuel based power projects. This study will remind the policy makers to focus on small and clean energy projects.

CHAPTER 3

DATA DESCRIPTION AND METHODOLOGY

3.1 Introduction

This chapter is divided into three sections. First section is about data description, where the detailed procedure is highlighted regarding data sources and type. Next section explains the detailed procedure about sampling techniques, including selection of sample size and population, survey instruments and pretesting. Third section is about methodology which includes descriptive analysis, financial and economic analysis as well as environmental analysis of Micro Hydro Power units.

3.2 Data Description

Both primary and secondary data has been collected for the study. Primary data was taken through Questionnaires[3]. Two questionnaires were designed for household data. One is for the households that are connected to MHP plant and the other for households who had no MHP connections. The non-MHP households are using WAPDA electricity. This was done to capture the difference in the energy patterns and the expenditure made on energy between the two categories of households. Data was collected personally from the respondents. Another questionnaire[4] was also designed for Micro hydro power plants installed in the area.

[3] The questionnaire is divided into different sections. The first section deals with the basic information of the households and their socio economic and demographic information. The second section deals with the information regarding the use of MHP electricity and its significance to the people. The third section is for household economic activities. The fourth section is used for collecting the data regarding fuel wood and alternative energy sources used.

[4] This questionnaire is divided into two sections. The first section deals with the specification of MHP plant and the cost incurred on its different parts. The second section deals with the data taken from the operator or owner of the power plant regarding the main issues faced by MHP plants in the area.

3.3. Sampling Design

3.3.1 Selection of Households

The Ushairy valley which comprises different small villages and hamlets with scattered households has been selected for the study. The basis of selecting this area is that most of the Micro hydro power units exist in this area providing electricity to the households. These MHP units are either installed by the governmental or non- governmental organizations. However, most of the units are installed by local communities for their own use and also for commercial purposes by selling the electricity to the households.

The households are categorized on the basis of their connection to WAPDA grid electricity and MHP units. The purpose of selecting these two types of households is to highlight their differences in terms of energy expenditure, their preferences and the relative cost of MHP and WAPDA electricity to the households.

The households connected to MHP's have no WAPDA connections, as they are situated far away in remote locations. While WAPDA connected households are situated near the main markets and roads, therefore they are not connected to the MHP's. There are also households that are connected to both WAPDA and MHP units, but they were very few in number. Therefore, those were not considered in the analysis. Moreover, the area has also households that have neither WAPDA nor MHP connections. They are located on the top of hills and slopes. Electricity provision to them is costly and not feasible due to the distance involved and the difficult terrains for transmission networks. They are, therefore also excluded from sample and further analysis.

3.3.2 Population and Sample Size

The population of the study is the number of households connected to main grid electricity of WAPDA and the number of households connected to MHP units. Households are categorized on the basis of connection to WAPDA and MHP units. There are 2867 households having WAPDA connections while the MHP connected households are 2160 approximately in the area (Union Council, Palam). A sample size of 100 households is selected from each category taking confidence interval[5] as 10 and confidence level[6] as 90%. The sample size was calculated through sample size calculater. We have also taken 35 MHP plants that are functioning in the area as our sample.

3.3.3 Survey instrument

Both qualitative and quantitative data was gathered from households and other key stake holders. Quantitative information of different energy sources and their associated expenditure was taken from the households. Regarding the issues and sustainability we used questionnaires of MHP plants. Participatory Reflection and Action (PRA)[7] tool was also used to get meaningful information, confirmation of the results of quantitative data and exploring issues. These tools are focused group discussion (FGD), Expert Opinion and Key Informant Survey (KIS).

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[5] Confidence interval (also called margin of error) is a range of values so defined that there is a specified probability that the value of a parameter lies within it. The margin of error is the amount of error you can tolerate.

[6] The confidence level is the probability value (1-α) associated with a confidence interval. It is expressed in percentage. The 95% confidence level means you are 95% certain e.g. if α=0.05=5%, then the confidence level is equal to (1-0.05) =0.95 or a 95% confidence level.

[7] It is an approach to research and learning that uses different methods to address issues defined and identified by the community. It involves the participation of community members to discuss an issue openly(QUESTSCOPE, 2013).

3.3.4 Pretesting

It is necessary to test the questionnaire in the field before conducting the actual survey. Keeping in mind this, we conducted a pretesting survey for three days in the field. As a result, new questions rose and some questions needed minor amendments and refinement. The questionnaire was modified in the light of pretesting.

3.4 Analytical Tools

Basic objective of the study is to estimate the costs and benefits of Micro hydro power projects in rural areas and also assess the sustainability of the decentralized energy system. This part is further divided into three sections. In the first section, descriptive analysis is undertaken to capture the socio-economic aspects of the households, their expenditure on energy items, and the use of alternative sources of energy and the relative costs associated with WAPDA and MHP connections. In the second section, Financial and Economic analysis is undertaken which includes the estimation of Benefit Cost Ratio (BCR), Net Present Value (NPV), Internal Rate of Return (IRR) and Pay Back Period of the Micro hydro power project. In the third section, Environmental analysis is carried out to estimate the emission reductions that would have occurred in the absence of the MHP project.

3.4.1 Descriptive Analysis

As we have taken two samples, one sample for 100 households of MHP users and the other for 100 households of WAPDA users. We analyzed the data of each sample separately through statistical package for social scientists (SPSS). The information of household size, sources of income and agricultural land etc were entered into SPSS. The other variables like main sources of lighting, availability of electricity in hour, monthly bill and connection costs etc were analyzed. The satisfaction level of households regarding the MHP electricity and WAPDA electricity was also analyzed. The data of the primary fuel for cooking and heating was also considered in the analysis. Alternate energy sources for lighting for example UPS, Generators, LPG, Kerosene oil and DC chargeable lights were also a part of the analysis. This was done to capture a difference in the consumption patterns of energy sources between the two categories of households. Moreover, the extra expenditure made by the WAPDA users is also estimated. While for MHP users, the reduction in the use of other alternative sources of energy for lighting is a type of savings. This is because the MHP users pay a nominal amount for the use of electricity as compared to the users of WAPDA electricity. The use of fuel wood is also a part of the analysis.

Micro hydro power is a clean source of energy. It reduces green house gas emissions; avoid health costs, social cost (displacement of communities) and transportation costs (fuel transport).

The basic objective of the study is to conduct economic analysis and environmental analysis of Micro hydro power plants installed in district Dir (upper). For this purpose we compare the quantity of fuel and other energy sources used by MHP connected households and non- MHP connected households. Similarly the expenditure made on these sources is also compared. The availability of WAPDA electricity and MHP electricity in hours and their associated monthly bill is also compared to find the relative cost and benefit of the two categories of energy supply. The analysis was mainly done through averages, percentages, graphs, tables and charts.

3.4.2 Comparative Cost Analysis

This section attempts to estimate the relative unit capital cost (Rs. /kW) and unit energy price (Rs. /kWh) of the MHP plant. I also estimate the average unit energy price (Rs. /kWh) of WAPDA electricity. The unit capital cost is estimated based on the initial capital cost of the plant (Rs.) and its total installed capacity (kW). The energy price is calculated by dividing the monthly bill on the total units consumed per month (kWh).

3.4.3 Financial and Economic analysis

Financial analysis involves examining the activities and cash flows of an industrial or commercial firm, public institution) or group of organization. The goals of financial analysis are to inform the stakeholders involved, to conduct the financial feasibility, and to inform donors and public agencies. The outputs of this analysis are the income of entities, return on invested capital, and operating budgets of entities and estimates of foreign contributions needed. Financial analysis of the project compares benefits and costs to the enterprise. It uses market prices to check the balance of investment and the sustainability of the project (European Commission, 1997).

Economic Analysis examines the flows of resources among groups of entities and their impact on society as a whole. For projects with intangible products, cost utility analysis is used. Economic analysis assesses projects from the view of society as a whole (the nation economy). It compares costs and benefits to the whole economy. Economic analysis is based on the opportunity cost of capital. It is not based entirely on market prices. The opportunity cost reflects cost of using scarce resources of the society. Economic analysis uses economic price that is converted from market price by excluding tax, profit and subsidy (European Commission, 1997)

This analysis is estimated on excel spread sheets. Data that was used for this analysis is initial capital cost of Micro hydro power units, operating and maintenance cost and total cost. This data was obtained through primary survey from the owners of the electricity generation plants. The benefits of the project are the tariffs collected from the households and owners of businesses and service shops that use the electricity generated by Micro hydro power plants. The economic life of MHP plant taken is 25 years. In financial analysis, we estimated Net Present Value (NPV), Benefit Cost Ratio (BCR), Internal Rate of Return and Pay Back Period (PBP) detailed in subsequent sections.

3.4.3 (a). Discount Rate

The rate at which future values are discounted to the present is called discount rate (Khatak, 2012). This rate is approximately equal to the opportunity cost of capital. The interest rate used in discounted cash flows (DCF) analysis to determine the present value of future cash flows is discount rate (Weitzman, 1994). The discount rate takes into account the time value of money available in the future because it could be earning interest and the risk or uncertainty of the anticipated future cash flows. The discount rate reflects two things: one is the time value of money according to the theory of time preference and the other is demand of investors because they want to be compensated for the risks that cash flow might not materialize (Bierman Jr & Smidt, 2012).

Different discount rates are used by different projects depending upon the rate of interest and the budget of the project. The World Bank uses 12% discount rate in the economic evaluation of projects (Khatak, 2012). This discount rate is neither too low nor too high. Therefore, 12% discount rate is used for the study.

3.4.3 (b) Standard Conversion Factor for Economic Analysis

Standard conversion factor is used to convert financial values into Economic values. This conversion factor is 0.9 or 90% (The World Bank, 2005). For Economic analysis, the costs & benefits of financial analysis cash flows are multiplied by 90% to get economic costs and benefits. We convert financial cash flows or prices to economic cash flows in order to reflect the true cost and benefit of a product or service to the society. Economic values of both inputs and outputs may differ from their financial values because of market distortions. The standard conversion factor has been used by different projects for economic evaluation (The World Bank, 2005).

3.4.3 (c) Internal Rate of Return (IRR)

Internal Rate of Return of a cash flow is defined as the discount rate that makes the Net Present Value (NPV) equal to zero (Bierman Jr & Smidt, 2012). The higher the internal rate of return, the more desirable it is to undertake the project. It means that at a breakeven point, the total benefits equal the total cost. If IRR is greater than the opportunity cost, the project can be considered to be carried out (Kierulff, 2008).

$IRR = \text{Lower Discount Rate } (d_1) + [(d_2 - d_1) \times NPV_1 \div (NPV_1 - NPV_2)]$……………… (3.1)

d_1= lower discount rate

d_2= higher discount rate

NPV_1= NPV at lower discount rate

NPV_2= NPV at higher discount rate

3.4.3 (d) Net Present Value (NPV)

It is the difference between net discounted benefits and net discounted costs. If NPV>0, the project is feasible. It can also be defined as the algebraic sum of the present value of the proceeds and the present value of the outlays (Bierman Jr & Smidt, 2012). It is the net benefits and net costs of the project. It is calculated by summing the total cost and total benefits and multiplying by 12% discount factor. Subtracting the discounted costs from discounted benefits we get Net Present Value.

NPV= $\sum_{t=1}^{n}(Bt - Ct) / (1+i)^{t}$ ……………………….. (3.2)

If Net Present Value is greater than zero (NPV > 0), the project is feasible.

3.4.3 (e) Benefit Cost Ratio (BCR)

It is the ratio of discounted benefits to discounted costs. Benefit Cost ratio is the ratio of the present value of benefits to the present value of cost (Bierman Jr & Smidt, 2012).

BCR= $\sum_{t=1}^{n}\frac{Bt}{(1+i)t} / \sum_{t=1}^{n}\frac{Ct}{(1+i)t}$ ……………… (3.3)

If the value of BCR exceeds 1, the project is accepted while it is rejected if BCR comes out to be less than 1. In case it is exactly equal to 1, the project is marginally accepted.

3.4.3 (f) Pay Back Period (PBP)

Pay Back Period is the length of time required to recover the cost of investment.

Pay Back Period= Cost of Project / Annual cash inflows……………(3.4)

All other things being equal, the better investment is the one with the shorter payback period. For example, if a project cost $100,000 and is expected to return $ 20,000 annually, the PBP will be $100,000/$20,000= 5 years (Investopedia, 2014).

3.4.4 Sensitivity Analysis with Variation in Capital Cost

Sensitivity analysis shows that how the project is sensitive to changes in the variables such as initial capital cost, discount rate and delaying the benefits of the project for certain years. In the present analysis, we change only the initial capital cost of the MHP project and keep all other variables as constant.

3.5. Environmental Analysis of MHP

As the Micro hydro power generate clean energy without any green house gas emissions, therefore the construction of MHP plants will also contribute to the protection of environment. These plants will replace the use of fossil fuels that are a source of GHG emissions.

3.5.1. Energy Baseline and its Development

The energy baseline is the fuel consumption of the technology that would have been used in the absence of the project activity. The emissions baseline is calculated using the aggregate of annual kWh output of all the MHP power plants times the CO_2 emission factor for the fuel displaced (Pandey, 2008).

Annual electricity generation[8] (kWh/year) = Plant Capacity (kW)* 3650 hours* Capacity Factor[9]………………………………………………… (3.5)

Annual CO_2 Emissions (tones of CO_2eq) = Power Generation (kWh/year)* Emissions Factor (tones of CO_2/ kWh)…………………….. ……………. (3.6)

To estimate the total annual emission reductions, we calculate the total annual energy generation by aggregating the installed capacity of each MHP plant in hours. We multiply it by the emission factor of the displaced fuel (assuming diesel). Then we convert it to tones of CO_2 eq. The given formula is.

KW*hours*1.83 kg CO_2eq/kWh=tones of CO_2 ………… (3.7)

An emission factor of 1.83 kg/kWh is used in this analysis.[10]

3.6. Informal survey

The qualitative analysis has been done by using Participatory Rural Appraisal (PRA) tools for the study. This method deals with the perception and attitude of the local people who are aware of the behavior of the people, political institutions and the working of the projects. Informal survey or qualitative survey may be used as a supplement to the quantitative survey. Evidence shows that this type of survey is more reliable and valid as compared with data from other

[8] As there is no metering system and proper book keeping of the per day electricity generation (in kWh) of the power plants in the study area, the annual electricity generation is estimated by aggregating the installed capacity of each MHP plant in hours.

[9] Plant Capacity Factor or load factor= Average Demand/ Installed Capacity (Akella, Saini, & Sharma, 2009)

[10] Emission factor of 1.83 kgCO_2 eq /kWh is based on a survey conducted in Gilgit, Chitral, and Baltistan. This is taken from the diesel generators sets that are being used in the area. For further detail see CDM, Project Design Document (PDD) Form Version 03, Community based Renewable Energy Development in Northern Areas and Chitral, Pakistan (Pandey, 2008)

traditional method(Kumar, 1989). This type of survey helps to understand the issue in detail and with every angle. Because the people whom you are interacting explain everything in detail and you fully grasp the meaning of what he says. Besides this, PRA saves a lot of time and is comparatively easy to conduct. It reduces the gap between the empirical and informal results which together authenticates the overall study (Chambers, 1994).

The PRA techniques used for this study include Focused Group Discussion (FGD), Expert Opinion (EO) and Key Informant Survey (KIS), detailed as under.

3.6.1 Focused Group Discussion

Group Discussion is an open discussion with a formal agenda between ten or more members of the community about an issue. It is also conducted to actually know the perceptions of the people regarding a development project or intervention. In this analysis the researcher completely engage with community members and explore some new dimensions which are not possible in a formal survey. In this method, community member's respond to certain questions raised by the researcher and in this discussion some of the members criticize others or disagree with their views or suggestions. They finally reach to a conclusion and the researcher makes his point in this method. Another objective of this method is to explore issues and problems associated with the project and also to look into the issues of sustainability(Chambers, 1994).

For this study I have arranged four focused groups. Each focused group consists of six to eight members taken from the community. The members had different socio economic backgrounds. The prospects and issues of MHP's were thoroughly discussed with the members of focused groups. Main findings were noted to reach to a conclusion.

3.6.2 Key Informant Survey (KIS)

Key informant survey is a tool of informal survey. This is a method through which information is taken with the help of key informants. Key informant refers to a person with whom an interview about a particular organization, social program, problem or interest group is conducted (Kumar, 1989). Key informant interviews are in-depth interviews from a selected group who have more information and knowledge about an issue or an organization (Kumar, 1989).

Key informants are mostly business leaders, political figures and government servants. Key informant survey is a loosely structured conversation with people who have specialized knowledge about the topic you wish to understand. This type of interview consists of open ended questions. I took a school teacher of village Tarpatar, ex-nazim of union council Jabar and health workers of rural health centre Tarpatar as key informants. Basic information of MHP plants and the issues associated with MHP were discussed.

3.6.3 Expert opinion

Expert opinion is an informal technique that can be used for identification of issues and problems, and evaluation of community projects. Experts may be personally interviewed or given questionnaires to get information (Chambers, 1994). We have taken the expert opinion from the experts working for Sarhad Rural Support program (SRSP). The experts included two civil engineers, three electrical engineers, one Ex- Director of Pakistan Council of Renewable Energy Technologies (PCRET) and two social mobilizers.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In this chapter economic analysis and environmental analysis of Micro hydro power plants of District Dir (upper), Khyber Pakhtunkhwa is given. The chapter is divided into four sections. Section one explain descriptive statistics of important variables used in the study. Section two explains the comparative cost analysis of MHP's and WAPDA electricity. Section three explains the financial and economic analysis followed by environmental analysis of MHP's.

4.1.2 Micro Hydro Power Plants Operating at Ushairy, District Dir (upper)

The table 4.1 gives the detail of Micro hydro power plants operating at Ushairy in the upper Dir district. These plants are mainly run by private sector. The total installed capacity of the 35 MHP plants is 1058 kW or 1.058 MW. The MHP units installed by government have a more capacity than the MHP's installed by the community. The reason is that they are installed with proper specification. While the community based units are installed through simple methods because of lack of funds and the required skills.

Table 4.1: Micro Hydro Power plants operating at Ushairy, District Dir (upper)

S#	Name of village	No of MHP's			Total Electricity generation capacity (KW)	Year of installation	Organization who installed	No of beneficiaries (HH)
		Govt/ NGO	Private	Total				
1	Samkote	1	2	3	100	2009	SRSP	180
2	Batal	1	2	3	100	2008	SRSP	160
3	Nashnamal	1	1	2	80	2009	UNICEF	140
4	Danele	-	2	2	50	2007	Community	70
5	Gur koi	2	-	2	70	2009	UNICEF	100
6	Shomai	1	1	2	80	2009	UNICEF	150
7	Jabai		2	2	40	2008	Community	90
8	Usharai Proper	1	-	1	48	2013	ACTED(Japan funded)	110
9	Usharai	-	1	1	30	2010	Private	60
10	Usharai	-	1	1	25	2010	Private	70
11	Tarpatar	1	-	1	40	2012	RAHA	120
12	Amrete	-	1	1	20	2009	Community	50
13	Amrete	-	1	1	20	2008	Community	40
14	Amrete	-	1	1	20	2008	Community	50
15	Amrete	-	1	1	20	2009	Community	50
16	Amrete	-	1	1	20	2009	Community	55
17	Amrete	1	-	1	20	2009	SRSP	60
18	Barkand	-	1	1	60	2007	community	200
19	Almas	1	2	3	90	2011	MNA Funds	170
20	Choran	-	1	1	15	2008	private	25
21	Kalkote	-	2	2	65	2003	private	170
22	Nagasar	-	2	2	45	2004	private	60
Total				**35 units**	**1058 kW =1.058 MW**	**---**	**---**	**2160**

Source: Field survey.

4.2 Brief Profiles of the sampled respondents

4.2.1 Sources of income of the respondents

Daily wages is the main occupation or source of livelihood. The MHP user's households mainly worked for daily wages (39%), followed by agriculture (31%), services (17%), business (10%) and overseas employment (3%). As MHP households are located in a comparatively remote and hilly area, therefore they are less accessible to the business and overseas employment. Majority of them are either engaged in manual and unskilled labor or in agriculture activities.

On the other hand the percentage of non- MHP users engaged in agriculture and manual labor is less as compared to MHP users. However, in other sectors like services, business and overseas employment, their percentage is higher than the household of MHP users.

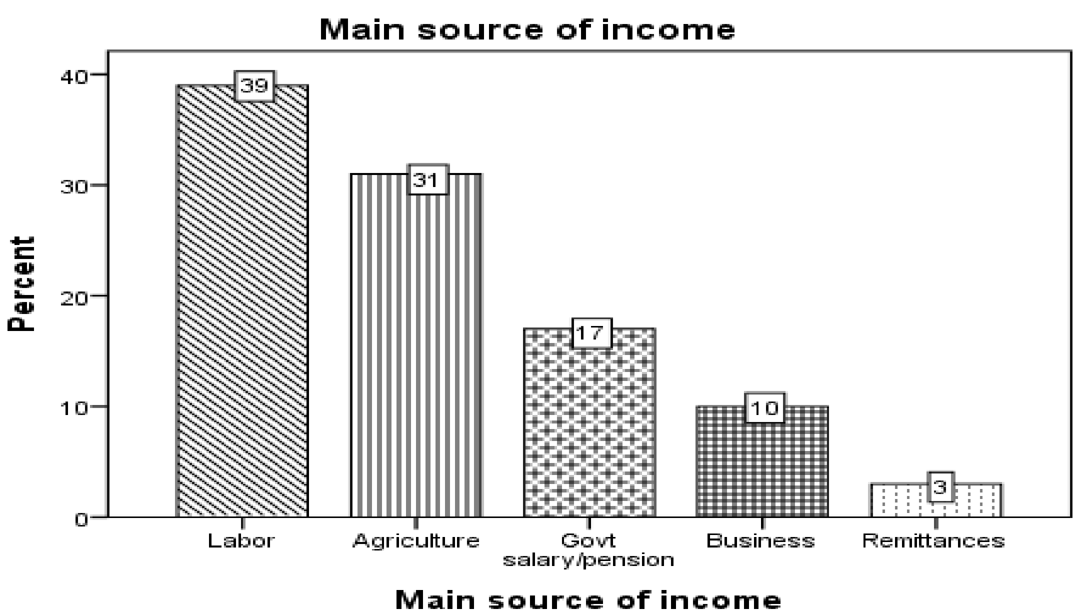

Figure1. Main source of income (MHP households)

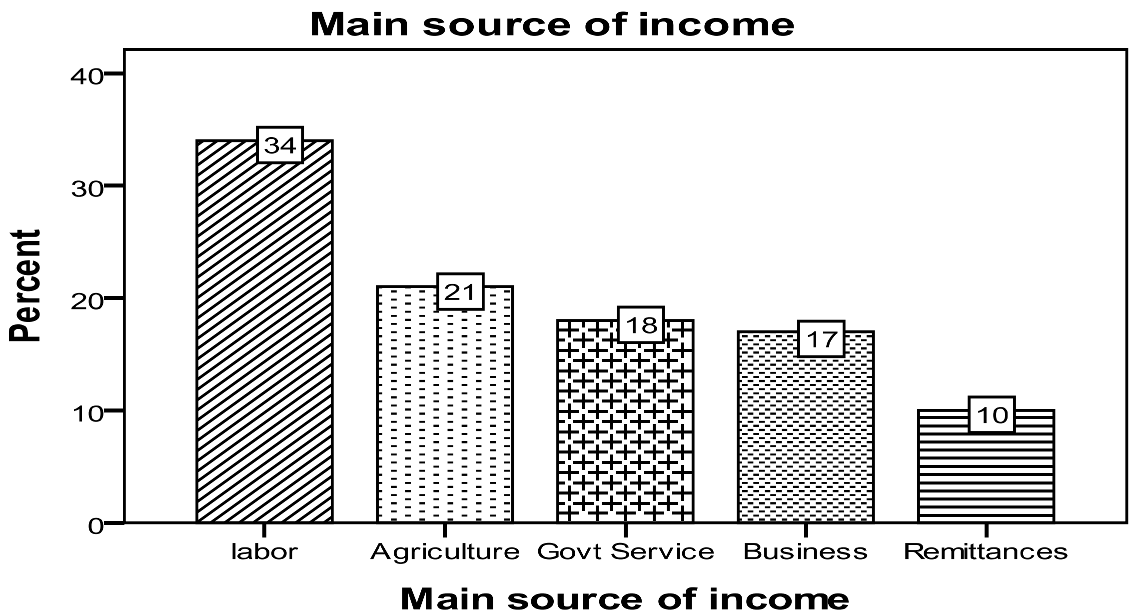

Figure2. Main source of income (Non-MHP households)

4.2.2 Land holding status of sampled respondents

Both MHP and non- MHP households are different with respect to ownership of agriculture land. MHP user's households have more agriculture land than the non-MHP user's households. The former rely more on agriculture than the latter one. This is also evident from the fact that the main source of income of MHP users is daily wages and agriculture.

Table 4.2 Land holding status of the sampled respondents

Agriculture land holding (acres)	MHP users households %	Non – MHP users household in%
0.1-2	60	50
2.1-4	21	25
4.1-6	11	20
6.1-12	8	5

Source: Field survey

4.2.3 Main source of lighting of the households

As the duration of light in the households of users is greater than the duration of light from WAPDA electricity, therefore non users uses other alternatives like kerosene oil, LPG and DC chargeable lamps to meet their needs. In the survey questionnaire the respondents were asked about their main source of lighting. Majority of MHP users responded that their main source of lighting is MHP. According to the non-MHP users, the DC chargeable lamps were the main source of lighting.

Table 4.3 Classification of MHP and non- MHP users with respect to their sources of lighting

Type of users		**Sources of lighting**				
	WAPDA	**Kerosene Oil**	**Solar Cells**	**Generators**	**DC Lamps**	**MHP**
Non-MHP (WAPDA) Users in %	7	19	2	10	62	0
MHP Users in %	0	2	0	0	13	85

Source: Field survey

The results clearly show that the main source of lighting of non- MHP households is DC chargeable lights. This is 62% of all other sources of light (Table 4.4). On the other hand, the main source of lighting in the households connected with Micro hydro power is the electricity supplied by these MHP power plants. In other words 85% of households stated MHP as the main source of lighting. While the main grid electricity, kerosene oil and DC chargeable lights have 4%, 2% and 9% share in the source of lighting respectively. Moreover, the WAPDA connected households' uses DC chargeable lights as an alternative source of lighting. Their expenditure on these sources will also be higher as compared to MHP connected households. Households that use Kerosene oil is only 2% in case of MHP, while 19% of WAPDA connected households use kerosene oil. The consumption of kerosene oil is also higher in WAPDA connected households as compared to the MHP households.

Fossil fuels like diesel, kerosene oil, and coal and fuel woods are the main sources of Green house gas emissions causing global warming and the associated extreme events(Jaffrey, 2013). Diesel emits a complex mixture of gases and fine particles. These include particulate matter (PM), Carbon monoxide (CO), Nitrogen Oxide (NO), Hydro carbons and volatile organic compounds (VOC). These gases also affect human health negatively causing asthma, allergies, bronchitis and lung diseases (Jaffrey, 2013). In poor households in developing countries, people live with and inhale the smoke generated from cooking and heating.

The result of the study shows that the MHP connected households uses fewer quantities of fossil fuels as compared to the non- MHP connected households. It implies that the non- MHP users causes increased emissions of green house gases. Therefore, the provision of electricity through the installation of MHP plants will lead to emission reductions. In other words the MHP technology is renewable and environmentally sustainable source of energy provision. This will not only mitigate climate change but also reduce the risks to human health.

Table 4.4 Daily availability of electricity

Type of users	Availability of light	Household response in %
Non-MHP users(WAPDA)	2-3 hours	95
	4-5 hours	5
MHP	8-12 hours	90
	13-17 hours	10

Source: Field Survey

The above table shows the electricity or the availability of light for both categories of households. The duration of light available to households using WAPDA electricity is 2-3 hours daily. While the duration of light available to the households using electricity from MHP is 8-12 hours daily. It means that about 20 hours load shedding is faced by non- MHP users.

4.2.4 Monthly electricity bill and connection charges

This part of the study analyzes the average monthly electricity bill that the household pay and the expenditure made on the connections and meter installation. After analyzing the data, it was found that the households who are connected to WAPDA electricity pay more monthly bill than the MHP connected households. The average connection charges are also higher for WAPDA users than the MHP households. Even though, the duration of light is more in case of MHP connected households. This shows that the consumers of MHP electricity are better off than the consumers of WAPDA electricity.

The data in table 4.6 shows a comparison of average monthly electricity bill and connection costs that household pay for using WAPDA electricity and electricity from MHP. Both types of households are significantly different with respect to their monthly payment and connection costs. The minimum and maximum bill households pay for WAPDA electricity are Rs 500 and Rs 3000 per month, respectively. On the other hand, the minimum and maximum bill that households pay for MHP is Rs 100 and Rs 400 per month respectively. The users of MHP pay a fixed sum of money to the operator or owner of the plant per month. Secondly, the connection charges of WAPDA electricity and MHP are also different. The average connection charges of WAPDA electricity is Rs 6500, while that of MHP is Rs 4000. In case of MHP, the users take their own connection from the power plant. The cost of wire depends on the distance between the plant and the household. The greater the distance the greater the connection cost. This analysis concludes that the use of electricity from MHP is cheaper than the WAPDA electricity in terms of monthly payment and connection costs.

Table 4.5 Monthly electricity bill and connection charges

Type of users	Monthly bill (Rs.)			Connection charges (Rs.)		
	Min	Max	Mean	Min	Max	Mean
WAPDA connected	500	3000	920	5000	7000	6500
MHP connected	100	400	200	1000	7000	4000

Source: Field survey

4.2.5 Use of Fuel wood and other sources of energy

This part of the analysis shows the amount of fuel wood and other energy sources used by MHP users and non- MHP users (Table 4.7). This analysis also estimates the difference in consumption of energy items and their associated cost of the two categories of households. As kerosene oil, LPG, Diesels and DC chargeable lights are used in greater quantities in non-MHP households; therefore their associated cost will also be greater than the cost in the case of MHP households. On the other hand the MHP households use the electricity from the MHP plants and the availability of electricity from those plants is available for 8 to 12 hours, therefore they use other alternative sources in fewer quantities.

Table 4.6 Use of fuel wood and other sources of energy

Energy sources	Unit	Non users of MHP(WAPDA)			MHP users		
		Min	Max	Mean	Min	Max	Mean
Quantity of fuel wood used per month	Maund	2	30	10	5	10	11
Monthly expenditure on fuel wood	Rs.	800	20000	4650	1000	8000	4675
Monthly expenditure on kerosene oil	Rs.	120	2000	525	240	500	350
Monthly expenditure on LPG	Rs.	500	2700	1462	300	3000	1000
Monthly expenditure on others (DC lights, UPS, Diesels etc)	Rs.	300	7000	1750	100	4150	532

Source: Field survey

The non- MHP users uses kerosene oil, Liquefied Petroleum Gas (LPG) and DC chargeable lamps as an alternative source of energy for lighting. The expenditure made on these items is compared with the expenditure of MHP users.

The average quantity of fuel wood used per month by the non- MHP users is 10 Munds, while the average quantity of fuel wood used by MHP users is 11 Munds which is about the same in both the households. The reason is that both categories of household's uses fuel wood for cooking and heating. The electricity whether from WAPDA or MHP is not used for cooking or heating purposes in the study area. It is used only for lighting and operating home appliances.

The average monthly expenditure made by non-MHP users on kerosene oil is Rs 525 while that of MHP users it is only Rs 350. The average monthly expenditure made by non- MHP users on LPG is Rs 1462 while that of MHP users it is Rs 1000. The average monthly expenditure made by non-MHP users on others (DC lamps, UPS, Diesels generators etc) is Rs 1750 while that of

MHP users it is 530. In the above analysis it is clear that the monthly expenditure of MHP households on energy is lower than the expenditure made by non- MHP household**.** Because the excessive load shedding from WAPDA compel people to shift their preferences to other alternatives. They use Liquefied Petroleum Gas (LPG), Diesel generators, Kerosene oil and DC chargeable lights for lighting and other purposes. This leads to an increase in expenditure on energy. On the other hand the MHP users use electricity for 8 to 12 hours and pay a nominal bill per month to the owner of the power plant. Thus, it is cost effective and economical for the households to use electricity of MHP instead of WAPDA electricity.

4.2.6 Degree of satisfaction over availability of electricity

This part of the analysis deals with the people's perceptions about the electricity provided by WAPDA and MHP. For this purpose questions were asked from both categories of households about their attitude that whether they were satisfied from the electricity provided by WAPDA and MHP. The results of the analysis are given in table.

Table 4.7 Degree of satisfaction on availability of electricity

Type of users	**Satisfaction categories**				
	Highly satisfied	Satisfied	Neutral	Dissatisfied	Highly dissatisfied
MHP users (%)	25	60	4	11	0
WAPDA users (%)	0	12	2	56	30

Source: Field survey

The study clearly shows that only 12% households are satisfied with WAPDA electricity. The remaining 56% and 30% are dissatisfied and highly dissatisfied with WAPDA electricity respectively. Only 2% of the respondents are neutral regarding WAPDA electricity.

On the other hand 60% households are satisfied with MHP electricity and 25% are highly satisfied. Only 11% are dissatisfied with MHP. 4% of the respondents are neutral. Comparing both the results give us a clear picture of the WAPDA and MHP sources of energy provision. Majority of the people are not satisfied with the WAPDA electricity because of its un- scheduled and excessive load shedding.

4.3. Comparative Cost Analysis of MHP and WAPDA electricity

4.3.1. Cost of electricity generated from Micro Hydro Power (MHP) plant

In this section we estimate the relative unit capital cost (Rs /kW) and the unit energy price (Rs /kWh) of the Micro hydro power plant.

The average MHP plant size/ capacity = 30 kW[11]

Unit capital cost or installed capital cost = 400000/30= Rs **13333/kW**

1 kWh= 1 unit of energy

The MHP plant operates for 10 hours on average per day. Therefore, the total energy generation per day will be 30 kW* 10 hours= 300 kWh.

Assume that average household consumption = 5 kWh per day.

Per month consumption= 5 kWh *30 = 150 kWh

The average bill that the consumers pay for using MHP electricity = **Rs 200**/ **month,** therefore the electricity price per unit= 200/150 kWh= **Rs 1.33/ kWh**

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[11] The average plant size or capacity is derived from the total capacity of 35 surveyed MHP plants in the area which is 1058 kW i.e. 1058/35= 30kW.

4.3.2. Cost of electricity generated from WAPDA

Per unit cost of WAPDA electricity in Pakistan is Rs 12. It is Rs 23/unit for High Speed Diesel (Government of Pakistan, 2013).

The tariff rate is Rs 9 per unit for consumers whose consumption is in the range of 101- 200 units. For commercial consumers the rate is Rs 18/unit (IESCO, 2013).

Hydro power in the total energy mix in Pakistan is 35%. Furnace oil based is 34% of the total power supplies. The fuel cost of this energy generation is Rs 14.76 per unit. The gas based power generation is 25%. The diesel power generation cost is Rs 15.63 per unit. The average fuel cost of the power generation is Rs 6.07 per unit (Government of Pakistan, 2013).

1 unit= 1 kWh

Price per unit of WAPDA electricity for consumers using 100kWh to 200 kWh equals Rs. 9. Assume that per day consumption of a typical household is 5 kWh. Then, the monthly bill will be 150*9= Rs.1350

Table 4.8 Electricity price per unit (in Rs)

Type of electricity	Household energy consumption in kWh/day	Per month consumption	Electricity price per unit in Rs.
MHP electricity	5 kWh	150 kWh	1.33
WAPDA electricity	5 kWh	150 kWh	9
Difference	---	---	7.67

Source: Field Survey

4.4 Financial and Economic Analysis of MHP

The results of Financial and Economic Analysis are given in detail in Table 4.10 and 4.11. Initial capital cost of MHP is Rs 402000. The life of the MHP projects ranges from 20 years to 35 years. But we have taken the life of the project as 25 years on average. Completion time for the project is one year. Initial costs, operating and maintenance cost, expected benefits and net benefits are calculated on excel spread sheet.

In case of MHP, the Financial Internal Rate of Return (FIRR) is 24 %, which is greater than the discount rate of 12 %. On the other hand, the Economic Internal Rate of Return (EIRR) is 27 % and is greater than the FIRR. The reason is that the financial return take into account only the benefits or return to the investor and does not take into account other benefits (tangible and intangible) to the whole society or the economy. In Economic analysis the benefits that accrue to the society increases through the multiplier effect. As both the FIRR and ERR are greater than the discount rate, therefore the project is acceptable from both investor and society's point of view.

I have estimated the IRR without carbon revenue. Therefore, if carbon revenue is added, its rate of return will be higher than the rate of return estimated without carbon revenue. Moreover, I have also not taken grants for the projects in the analysis. With more grants, the IRR will be high and without grants it will be low.

In this case the Financial NPV is 350 which are greater than zero. The Economic NPV is 459 which is also positive and hence the project is feasible and worth to undertake.

The BCR in financial analysis is 1.25 and in the Economic analysis, it is 1.26 which are both greater than one (Table 4.10 and 4.11). Therefore, we can conclude that according to this criterion, the Micro hydro power project is viable and worthy to be undertaken.

In Financial Analysis, the Pay Back Period (PBP) is five years. While in Economic Analysis, the Pay Back Period is 3.6 years. The PBP of Financial analysis is more than the PBP in Economic analysis. The reason is that there are more returns from MHP projects due to its impact on the education, health and other economic and social activities through the multiplier effect.

Table 4.9 Financial Analysis of Cash Flow of MHP Plant

(In 000 Rs.)

	Year	Initial Capital Cost	O and M cost	Total Cost	Benefit of the project	Net Benefit
0	2010	402	0	402	0	-402
1	2011	0	120	120	216	96
2	2012	0	120	120	216	96
3	2013	0	120	120	216	96
4	2014	0	120	120	216	96
5	2015	0	120	120	216	96
6	2016	0	120	120	216	96
7	2017	0	120	120	216	96
8	2018	0	120	120	216	96
9	2019	0	120	120	216	96
10	2020	0	120	120	216	96
11	2021	0	135	135	233	98
12	2022	0	135	135	233	98
13	2023	0	135	135	233	98
14	2024	0	135	135	233	98
15	2025	0	135	135	233	98
16	2026	0	135	135	233	98
17	2027	0	135	135	233	98
18	2028	0	135	135	233	98
19	2029	0	135	135	233	98
20	2030	0	135	135	233	98
21	2031	0	135	135	233	98
22	2032	0	135	135	233	98
23	2033	0	135	135	233	98
24	2034	0	135	135	233	98
25	2035	0	135	135	233	98

Net Present Value 350.01

Benefit Cost Ratio 1.25

Inter Rate of Return 24%

Payback Period 5Years

Source: Study Survey

Table 4.10: Economic Analysis of Cash Flow of MHP

(In 000 Rs.)

	Year	Initial Capital Cost	O and M Cost	Total Cost	Benefit of the project	Net Benefit
0	2010	396.18	0	396.18	0	-396.18
1	2011	0	108	108	216	108
2	2012	0	108	108	216	108
3	2013	0	108	108	216	108
4	2014	0	108	108	216	108
5	2015	0	108	108	216	108
6	2016	0	108	108	216	108
7	2017	0	108	108	216	108
8	2018	0	108	108	216	108
9	2019	0	108	108	216	108
10	2020	0	108	108	216	108
11	2021	0	121	121	233	111
12	2022	0	121	121	233	111
13	2023	0	121	121	233	111
14	2024	0	121	121	233	111
15	2025	0	121	121	233	111
16	2026	0	121	121	233	111
17	2027	0	121	121	233	111
18	2028	0	121	121	233	111
19	2029	0	121	121	233	111
20	2030	0	121	121	233	111
21	2031	0	121	121	233	111
22	2032	0	121	121	233	111
23	2033	0	121	121	233	111
24	2034	0	121	121	233	111
25	2035	0	121	121	233	111

Net Present Value **459.16**

Benefit Cost Ratio **1.36**

Inter Rate of Return **27%**

Payback Period **3.6 Years**

Source: Study Survey

4.5 Sensitivity Analysis of MHP project

Suppose the capital cost is increased by 10%, then how the IRR, NPV, BCR and PBP are sensitive to this increase in capital cost. Sensitivity analysis is done using the same procedure and tools that are used in financial and economic analysis. The same 12 % discount rate is used for the analysis. IRR, NPV and Benefit Cost Ratio (BCR) are all sensitive to the changes in capital cost. The results are given in the tables given below.

Table 4.11: Sensitivity Analysis of Cash Flow of MHP

(In 000Rs.)

	Year	Initial Capital Cost of the project	0 and M Cost	Total Cost	Benefit of the project	Net Benefit
0	2010	440.2	0	440.2	0	-440.2
1	2011	0	120	120	216	96
2	2012	0	120	120	216	96
3	2013	0	120	120	216	96
4	2014	0	120	120	216	96
5	2015	0	120	120	216	96
6	2016	0	120	120	216	96
7	2017	0	120	120	216	96
8	2018	0	120	120	216	96
9	2019	0	120	120	216	96
10	2020	0	120	120	216	96
11	2021	0	135	135	233	98
12	2022	0	135	135	233	98
13	2023	0	135	135	233	98
14	2024	0	135	135	233	98
15	2025	0	135	135	233	98
16	2026	0	135	135	233	98
17	2027	0	135	135	233	98
18	2028	0	135	135	233	98
19	2029	0	135	135	233	98
20	2030	0	135	135	233	98
21	2031	0	135	135	233	98
22	2032	0	135	135	233	98
23	2033	0	135	135	233	98
24	2034	0	135	135	233	98
25	2035	0	135	135	233	98

IRR	**22%**
NPV	**317.7**
BCR	**1.22**
PBP	**5.5 years**

Source: Field survey

Table 4.12: Sensitivity Analysis with 10 % Increase in Capital Cost

Description	Financial Analysis	Economic Analysis
IRR	22%	23.10%
NPV	317.7	315.6
BCR	1.22	1.40
PBP	5 Years	5 years

Source: study result

The above table shows the results of sensitivity analysis of the project when capital cost is increased by 10%. The result shows that IRR, NPV, BCR and PBP, all are sensitive to the changes in capital cost.

4.6 Environmental Analysis of MHP

We know that micro hydro power is a clean source of energy that causes no green house gas (GHG) emissions. The generation of clean energy through micro hydro power will replace the use of diesel generators and kerosene oil in the project area and thus lead to a reduction in CO2 emissions.

My case study area is District Dir (upper), where these micro hydro power plants are operating and generating electricity. Some of the plants are installed by government and some by the community itself. The total number of MHP plants that were surveyed is 35. These MHP plants have different installed capacities ranging from 10kw up to 100kw. Most of the private plants are installed by simple methods without any proper specification. This results into low capacity and thus low electricity generation. However, the government one is at least installed with proper design and specification of electro mechanical equipments.

4.6.1 Description of the Small Scale Project Activity

Assuming the total MHP plants as a single Community- based Renewable Energy Project. The project is a registered Small- scale CDM project activity. The project will provide the needed power to the community. It will also substitute the use of diesels and kerosene oil, thereby reducing the green house gas emissions.

The area has also the most precious and rare forest resources. The total forest area of district Dir (upper) is 694333 acres. Out of this protected area under forests is 277311 acres, communal forests is 107714 acres, private plantation is 220930 acres and area under miscellaneous forests is 88378 acres (Government of Khyber Pakhtunkhwa, 2014). These forests are being used by the local people in an unsustainable way for cooking and heating. The survey results show that the average fuel wood consumption per month of each household is 10 maund. This reaches to120 maund per annum. If this practice continued, the available forests will disappear in a few years. If high powered mini and micro hydro power projects are established, it will reduce the consumption of fuel wood to a greater extent. This will not only reduce the use of fuel wood but will also protect the local forests. The flow of water from snow melt gives the area an immense potential to produce hydro electricity through micro and mini off-grid power projects.

4.6.2 Emission Reductions through MHP plants in District Dir Upper

As there is low access to national electricity grid due to remoteness and the difficult topography, there is more probability of using diesel generators by the local population. This practice will lead to more use of costly fuels. This will not only lead to more expenditure on fossil fuels but also cause Green House Gas (GHG) emissions. The projected population of district Dir (upper) is estimated to be 643114 in 2003 with growth rate of 2.76% (Government of Khyber

Pakhtunkhwa, 2014). Due to this increase in population and demand for energy, there are high chances that there will be more diesel generators to be installed in the area. Therefore, the existing MHP plants and expected new power plants will reduce the green house gas emissions that would otherwise be produced from the use of diesel based generators.

The total installed capacity of the 35 MHP plants is 1058 kW which is equal to 1.058 MW. From the household survey, we found that each MHP plant operates from 8- 12 hours. Therefore, we take 10 hours as average operating time per day. This will give us electricity generation in kWh per day.

Annual power generation (kWh) = Plant Capacity (kW)* Plant Capacity Factor* hours

Annual power generation (kWh) = 1058 (kW)* 0.45[12] * 3650 hours

= 3861700 kWh* 0.45

= 1737765 kWh

Multiplying by the emission factor of 1.38kg CO_2eq/ kWh, we get total baseline emissions.

Annual Baseline Emissions (tCO_2) = 1737765kWh*1.38 kg CO_2eq/kWh/1000 = **3180 tones CO_2eq /** annum.

$E_{reductions} = E_B - E_{Project}$ ……………………………………………………………………… (3)

$E_{reductions}$= Emission reductions

E_B= Baseline Emissions

$E_{Project}$= Project Emissions

[12] The installed Micro hydro power plants are expected to have an average load factor or capacity factor of 0.45. This also includes 2% of down time for the system for repairs. The demand for electricity reaches to the capacity of the power plant during evening peak hours (Pandey, 2008).

As emissions from Micro hydro power plants construction are negligible or zero and MHP do not require the storage of water or dam. Moreover, projects with less than 5 MW capacities require no Environmental Impact Assessment (EIA). Therefore, emission reductions are equal to base line emissions (E_B).

$E_{reductions} = E_B - E_{Project}$

$E_{reductions} = E_B - 0 = E_B =$ **3180 tones CO_2eq /** annum.

This value is the estimated emissions equivalent to tones of CO_2 that are reduced by the MHP plants.

4.6.3 Benefits of Micro hydro power technologies through CDM

Pakistan signed the United Nations Framework Conventions on Climate Change (UNFCCC) in 1992. Thus it qualifies to take benefits from market based flexible mechanism under the convention for addressing the issue of climate change. One of the mechanism is called Clean Development Mechanism (CDM) (Nizami & Bukhari, 2010).

Pakistan is a "Non- Annex 1"country[13]. It ratified the UNFCCC in 1994 on voluntary basis. Kyoto protocol of the UNFCCC is dealing with climate change mitigation. It is a milestone towards global carbon mitigation efforts (Ahmad & Salman, 2012).

The protocol led to the establishment of carbon markets through Clean Development Mechanism (CDM). Pakistan ratified the Kyoto Protocol in January 2005, and thus became eligible to benefit from CDM. While the CDM is a great opportunity for Pakistan, the country has not yet optimally

[13] Non – Annex 1 countries are mostly developing countries. These countries are not listed in Annex 1 to the UNFCCC. Certain developing countries are recognized by the convention as being more vulnerable to the adverse impact of climate change. Therefore, these countries are eligible to be the host parties for CDM projects. In other words they are not bound to reduce their emissions of GHG gases(UNFCCC, nd).

utilized this mechanism to get financial benefits through selling Certified Emission Reductions (CERs). This may be due to the lack of knowledge and capacity building of the concerned ministry and investors in Pakistan. Therefore to get full benefits we have to initiate renewable energy projects as micro hydro power. This will on the one hand provide the needed energy to the rural population and on the other hand earn revenue through CDM by reducing green house gas emissions. Taking the current price of one tone of CO2eq as $23,[14] if the given project of all the MHP's is registered with CDM will earn $ 95400 per annum.

4.7 Issues relevant to the installation and operation of MHP plants

4.7.1. Unskilled Operators and illiteracy

Most of the operators have no prior experience of operating and maintaining the power plant. Among 35 operators only five have a little experience in operating electro mechanical equipments. Moreover, majority of them are illiterate and have no technical skills.

Table 4.13: **Education level and skills of the operators in percent**

Education level	% of operators
Illiterate	70
Middle	18
Inter	8
Graduation	4

Source: Field survey

[14] This is the price of 1 tones of CO_2 equivalent used in CDM projects(sharon & Angela, 2012).

4.7.2. Reduction in Water Flow and risk of floods

In winter season when the temperature falls and the snow freezes on hills, the flow of water reduces. But according to the survey response it has no impact on electricity generation. Because, there is still sufficient water available to run the MHP plant.

The most serious issue with the plants is the risk of floods in summer. The floods that hit the entire country in 2010 had severely affected the power plants. The plants that had no protection walls or stone crates were mostly affected. According to the survey respondents, about 9 MHP plants have been swift by floods in 2010.

4.7.3. Financial Constraints

The owners or operators whose plants are affected by floods are mostly poor and cannot bear the cost of civil works. Therefore, they are more prone to the risk of floods. For example, according to the survey estimates, the cost of construction of water channel is about Rs. 40000. If it is swept by floods, it is very difficult to repair the channel. On the other hand, the plants that were installed by government or other organizations with proper specification and having protection walls were protected from floods.

4.7.4. Institutional Arrangement

There is no institutional mechanism that addresses the issue of repairing or rehabilitation after these disasters. The community members through their own efforts deal with these issues.

4.7.5. Risk of electric shocks

As the poles that supply electricity from the power plants are wooden, there is a greater risk of felling those poles through cyclones and bad weather. This also poses a risk to the lives of the people especially children. It has been reported that 3 to 4 children had been electrocuted in the past according to the information shared by the community members.

4.7.6. Land Disputes and Site Selection

As most of the plants are often installed on the common property land along the river, therefore there is no issue of land. Still, there are some cases in which the land adjacent to the plant belongs to a community member and he is not willing to give its land for plant construction. Consequently, this often leads to the cancelation of the project on the proposed site. Moreover, the disagreement among communities over site selection for the project also jeopardizes the efforts for provision of electricity to the communities. There is a case of dispute between villagers of the two adjacent villages of ushairy and tarpatar over the installation of MHP plant in the area. In this dispute some 12 electric polls were stolen away by the community members of the other village, and this dispute is yet to decide.

4.7.7. Low Capacity of Power Plant

Another important issue is the low capacity of power plants to provide electricity to the additional households although; there exist a potential demand for the Micro hydro power electricity. About two third of the households are connected with the MHP, the remaining are without electricity. According to the survey, 60 households in village ushairy got connections from MHP plant while 60 households are without electricity. Similarly, in village palam 100 households are provided with MHP electricity while 150 households are without this electricity. This shows that the capacity of the existing power plants is low and cannot feed each household.

4.7.8. Scattered Houses

The houses that are connected to the power plants are scattered. This causes a high transmission cost for the households, as the connection cost increases with the increase in distance from the power plant.

4.8. Findings derived from Informal Survey

4.8.1. Findings from Key Informant Survey (KIS)

- Community members are not cooperative with the committee and violate the rules laid down by the committee. This practice leads to low voltage and even damages the power plant.
- The spare parts of the plant are not easily available.
- The people in some areas use wooden poles for the transmission of electricity. This is dangerous during rain and snow fall.
- Political interference in site selection is an issue.
- The community based MHP's are less efficient as compared to the MHP's installed by the government.
- For the successful operation of the plant public awareness and honesty is must.

4.8.2. Findings of Focal Group Discussions

- The private owners consider their personal likes and dislikes and give connection to the households of their choice. The project one has no such preferences and provides electricity without any discrimination. Therefore, the project one is more preferable.

- The community members after a long discussion concluded that the community members should be the decision makers regarding bills collection, operation and maintenance of the power plants.
- It was proposed that the village committee should be empowered to tackle the issues of maintenance, repairing, and overuse of power and collection of bills. For this purpose, coordination between village committee and local district administration is necessary.
- Public sector MHP's are considered by the people as a public good. Therefore, they don't care about the repairing and maintenance of MHP plants.
- Consumers are charged the same flat rate of electricity irrespective of the fact that whether the household has used more or less units of electricity. This leads to overuse of the electricity generated by MHP plant.

4.8.3. Information derived from the experts opinions

Ex- Director, Alternate Technology Development Board (ATDB) was consulted to give his opinion about the Micro hydro power projects. The findings were as follows.

- When the people in rural areas install the MHP units by themselves, it means that they are successful.
- It is a simple technology without transformer. It is used for flour milling and rice husking.
- It requires no specific training.
- Line losses in telephone wire are more than the copper wire for the transmission of electricity to the houses.

a. Social Mobilization

The first and foremost task before an intervention in the rural community is the preparing of ground for the project. It includes social mobilization and sensitization of the community about their problems and also the realization that they can play a role in transforming their lives.

For Micro hydro projects, a Term of Partnership (TOP) is signed before starting work on MHP. Under this partnership, a Village organization (VO) and Community Organization (CO) is established. Then three committees are constituted.

1. Project committee
2. Audit committee
3. Maintenance committee.

After that, village organization (VO) passes a resolution in which they make a demand from SRSP to come and conduct a survey for feasibility. That resolution comes to the social section of SRSP. The social section, give its remarks and then is forwarded to engineering section.

To conduct the survey, the social organizer and engineer go to the site. They determine the social and technical feasibility.

b. Conducting Social Feasibility

The social feasibility determines the number of tribes and total households residing in the area. The distance of households in the area from the power plant is calculated. The questionnaire asks questions about the urgent need to the community, that is whether they need the facility or not. Moreover, it is also determined that whether or not there is a dispute on the land on which the project is proposed. Therefore, prior to the decision, it is determined that whether the people want MHP to be installed or not.

c. Conducting Technical Feasibility

A number of technical parameters are considered before deciding on the proposed site. The head, the flow of water and hydraulic pressure is estimated. The water that flows freely without a platform has low density. The speed of water increases with the increase in length of penstock, keeping the slope and friction constant. The total installed capacity of the site and household spread is also taken into account. If the household spread is more, then a step-up transformer is installed to increase the voltage in transmission lines.

CHAPTER 5

CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Introduction

This chapter is divided into four sections. The first section deals with the major findings of the study. The second section deals with the conclusion of the study. Policy recommendations are given in fourth one. The last section elaborates limitations and future research directions on the issue under consideration.

5.2 Major Findings of the Study

Major findings of the study are as follows:

1. The expenditure made by non- MHP users on alternative energy sources is more than the expenditure made by MHP users.
2. Per unit price of electricity generated by MHP to the consumers is Rs. 1.33 while for WAPDA electricity it is Rs. 9 for consumers using an average150 kWh.
3. There is a saving of Rs. 7.67 per unit for MHP consumers.
4. The values of Net Present Value (NPV), Benefit Cost Ratio (BCR), Internal Rate of Return (IRR) and Pay Back Period (PBP) favored the feasibility of this project.
5. The MHP projects are sensitive to the increase in the initial capital cost.
6. The estimated emission reductions by MHP plants are 3180 tones of CO_2.

7. The monetary benefits from the CDM projects of MHP's are estimated to be $95400 per annum.[15]
8. The issues relevant to MHP plants are unskilled operators, risk of floods in summer, financial constraints, risks of electric shocks, land disputes in site selection, low capacity of power plant and no proper institutional arrangement.

5.3 Conclusion

The study attempted to find out the cost effectiveness, economic and financial viability and environmental sustainability of Micro hydro power plants in district Dir (upper), Khyber Pakhtunkhwa. The study is based on the primary data collected through questionnaires. The study is important because it carried out the financial and economic analysis and environmental analysis for the first time in Pakistan. To find out the viability of the MHP projects NPV, IRR, BCR and Pay Back Period is used and all these favored the project under consideration. For estimation of emission reductions, emission factor of diesel is used. The MHP plants have no adverse environmental impacts like, sedimentation, water logging, disturbance of ecosystem and habitat of animals and plants. Site selection, excessive use of electricity, low maintenance, unskilled operators and finance are some of the issues that need to be addressed while deciding the installation of MHP plants. Solving these issues will make MHP a success story in the future. The electricity generated from the MHP plants is sustainable and environment friendly. This technology replaces the electricity generated by fuel based generators. The estimated emission reductions by MHP plants are 3180 tones of

[15] The price of $23 for one tone of $CO_{2\,eq}$ is taken from the report "Carbon Pricing Mechanism", Association of Victorian Regional Waste Management Group, Australian Government (sharon & Angela, 2012).

CO_2 eq. Financial and Economic analysis indicators shows positive signs and therefore the technology is cost effective. Its benefits exceed its costs.

5.4 Recommendations/ Policy implications

The results derived from the present study have important policy implications

- The per unit price of MHP electricity is less than the price charged by WAPDA. Therefore, the provision of electricity through MHP is a viable option for the government.
- The MHP projects are financially and economically feasible and give higher rate of returns. Therefore there is an incentive for private investors to invest in this sector.
- The MHP plants generate clean energy. It avoids the production of GHG emissions. Therefore, there are good prospects for the government to register these projects with CDM.
- There is lack of skilled operators and staff for successful operation of MHP plants. To tackle the issue, the government should establish technical training institutes to impart basic skills to the operators of the plants.
- The government should design a proper institutional arrangement to tackle the issues of floods, repairing and other social issues associated with Micro hydro power.
- As majority of the community based and private hydro power plants are installed without its required specifications, therefore the government should provide technical trainings to the operators for maintenance and repairing.

5.5 Limitation of the Study and Future Research

This study has not covered the cost and sustainability of MHP projects relative to other renewable energy technologies i.e. Solar, Wind and Biomass technologies. Further research in this direction will identify the most promising technology in terms of initial cost and life time of the technology. The present study has been carried out in the context of district Dir (upper). The study in other contexts may give different results. Moreover, Willingness to Pay (WTP) for MHP electricity can be estimated to come up with the most acceptable price for the consumers.

However, it is hoped that the results derived from the study will be robust and will provide a foundation for future research in the issues of sustainable energy exploration in Pakistan.

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ECONOMIC AND ENVIRONMENTAL PERSPECTIVES OF MICRO HYDRO POWER: A CASE STUDY OF DISTRICT DIR (UPPER) KHYBER PAKHTUNKHWA (KPK)

Study survey for MS/M.Phil Thesis

Questionnaire

(For users of MHP electricity)

Department of Environmental Economics

Pakistan Institute of Development Economics (PIDE)

Islamabad

Household Roster

PART A: GENERAL INFORMATION

A1. Name of the head of the household…………………………………………………………………..

A2. Father name ……………………………………………………………………………………………..

A3. Name of the respondent if other than head of house hold………………………………………………………….

A4.Quom/zaat/Baradri of (HH)………………………………………………………………………………………

A5. Religion…….

A6. Union Council…………………………………… A7. District…………………………………………………

A8. Ward/village………………………………………A9.Tehsil……… A10.Mohalah…..............

Enumerator's Name………………………………………

Signature………………………………………………………

Date …………………………………

PART B: House hold socio economic and demographic information.

B1.Total number of household members…………………

B2. Area of agricultural land in Acres…………………

B3. Main source of income

1 ☐ Agriculture

2 ☐ Livestock

3 ☐ Govt salary/pension

4 ☐ Remittances

5 ☐ Business

6 ☐ others

B4. Monthly Expenditure :(in RS)

#	Item	Expenditure
1	Food	
2	Clothing	
3	House rent(if rented)	
4	Health	
5	Energy	
6	Education	
7	Transport	
8	Social events(marriages)	
9	Miscellaneous	
Total		

SIGNIFICANCE of MHP

PART C: Households connected with Micro hydro power plant (MHP)

C1. Is your house connected to the electricity generating MHP plant?

1 ☐ Yes

2 ☐ No

C2. If yes, for what purpose do you use electricity in your home?

1 ☐ Home lighting

2 ☐ Home appliances

3 ☐ Heating

4 ☐ Cooling

5 ☐ Economic activity

6 ☐ Others

C3. For how much time do you use light in 24 hours?

1 ☐ <8 hours

2 ☐ 8-12 hours

3 ☐ 13-17 hours

4 ☐ ≥18 hours

C4. Is there any time frame for the availability of MHP electricity?

1 ☐ Yes

2 ☐ No

C5. If yes, mention the time in which it is available.

From……………………PM TO…………………………AM

C6. Do you pay any bill for using electricity of MHP plant?

1 ☐ Yes, 2 ☐ No

C7.If yes, how much? ………………………………

C8. Do you pay any connection charges including cost of wires etc?

1 ☐ Yes

2 ☐ No

C9.If yes, then how much in RS…………………………..

C10. Do you use electricity of WAPDA?

(If No, Then Go to Q No C15)

1 ☐ Yes 2 ☐ No

C11.For how many hours electricity of WAPDA is available?

Winter	summer
1 ☐ <5 Hours	1 ☐ < 5 hours
2 ☐ 5-8 hours	2 ☐ 5-8 hours
3 ☐ 9-13 hours	3 ☐ 9-13 hours
4 ☐ > 13 hours	4 ☐ > 13 hours

C12. What is the average monthly electricity bill that you are paying for WAPDA electricity?

RS……………………………………………………………………….

C13.The connection charges/meter installation charges in RS………………………………….

C14. Load shedding is scheduled or unscheduled?

1 ☐ Scheduled 2 ☐ Unscheduled

C15. What electric appliances do you have in your household?

1 ☐ Fridge	4 ☐ Blenders
2 ☐ TV	5 ☐ Computers
3 ☐ Washing machine	6 ☐ Others

C16. Are they functioning now?

1 ☐ Yes 2 ☐ No

C17. Are you satisfied with the present availability of electricity from the MHP?

1 ☐ Highly satisfied
2 ☐ Satisfied
3 ☐ Neutral
4 ☐ Dissatisfied
5 ☐ Highly dissatisfied
6 ☐ Uncertain

D: Household Economic Activities:

D1. Do you have any economic activity in your household that uses MHP electricity?

1 ☐ Yes
2 ☐ No (If No, go to Q No E1)

D2. If yes, what type of activity?

1 ☐ Tailoring
2 ☐ Knitting
3 ☐ Food processing
4 ☐ Embroidery
5 ☐ Grain grinding
6 ☐ Others

D3. For how many hours in a day do you use electricity of MHP in this activity?

1 ☐ 2-4 hours
2 ☐ 4-6 hours
3 ☐ 6-8 hours
4 ☐ > 8 hours

D4. Income per month from this activity in Rs……………………………………

D5. Do you experience any fluctuation in electricity while you are working in the household activity?

1 ☐ Yes   2 ☐ No

D6. If yes, then does it cause any damage to the machinery or appliances in the house?

1 ☐ Yes   2 ☐ No

D7. If yes, then how much it cost to repair in Rs? ……………………………………

E: ENVIRONMENT

Note. *The data of fire wood, kerosene oil, diesel, LPG, and other energy sources will be taken from households who are using the electricity of MHP so that the reduction in the use of fuels may be estimated.*

E1. What is your main source of lighting?

1 ☐ WAPDA electricity   4 ☐ Car batteries

2 ☐ MHP   5 ☐ LPG

3 ☐ Kerosene oil   6 ☐ DC lights

E2. What does it cost per month? -------------------------

E3. What is your primary fuel for cooking?

1 ☐ Fuel wood   4 ☐ MHP   6 ☐ Dung cakes

2 ☐ LPG   5 ☐ Kerosene oil   7 ☐ others

E4. What is your primary fuel for space heating?

1 ☐ Fuel wood   3 ☐ MHP

2 ☐ LPG   4 ☐ Others

E5. Quantity of fire wood and fuels used per month and their associated cost

SNO	*Fuels used*	*Unit*	*Price/unit*	*Total Q*	*Expenditure*
1	Fuel wood	Kg			
2	Dung cake	No			
3	Kerosene oil	Liters			
4	LPG	Kg			
5	Others. Specify………………..				
Total					

E6. Do you use car batteries for lighting in your home?

1 ☐ Yes

2 ☐ No

E7. If yes, what is its purchasing price?---------------------------Rs

E8. Do you use solar cells?

1 ☐ Yes

2 ☐ No

E9. If yes, what is its purchasing price?--------------------------Rs

Thank you for your cooperation

ECONOMIC AND ENVIRONMENTAL PERSPECTIVES OF MICRO HYDRO POWER: A CASE STUDY OF DISTRICT DIR (UPPER) KHYBER PAKHTUNKHWA (KPK)

Study survey for MS/M.Phil Thesis

Questionnaire

(For Non-users of the MHP electricity)

Department of Environmental Economics

Pakistan Institute of Development Economics (PIDE)

Islamabad

Household Roster

PART A: GENERAL INFORMATION

A1. Name of the head of the household…………………………………………………………………..

A2. Father name ………………………………………………………………………………………………..

A3. Name of the respondent if other than head of the house hold………………………………………

A4. Quom/zaat/Baradri of (HH)…………………………………………………………………………………

A5. Religion…….

A6. Union Council…………………………………… A7. District………………………………………………………..

A8. Tehsil…………………………………………………A9. Village……………………………………………………….

A10. Mohalah…..

Enumerator's Name…………………………………………

Signature…………………………………………………………

PART B: Household socio economic and demographic information.

B1.Total number of household members…………………

B2. Area of agricultural land in Acres…………………

B3. Main source of income

1 ☐ Agriculture

2 ☐ Livestock

3 ☐ Govt salary/pension

4 ☐ Remittances

5 ☐ Business

6 ☐ others

B4. Monthly Expenditure :(in RS)

#	Item	Expenditure
1	Food	
2	Clothing	
3	House rent(if rented)	
4	Health	
5	Energy	
6	Education	
7	Transport	
8	Social events(marriages)	
9	Others. Specify	
Total		

PART C: *Households not connected to Micro hydro power plant (MHP)*

C1.Do you use electricity of WAPDA? 1☐ yes 2☐ No

(If NO, then go to Q No D1)

C2. If yes, for what purpose do you use electricity in your home?

2 ☐	Home lighting	4 ☐	Cooling
2 ☐	Home appliances	5 ☐	Economic activity
3 ☐	Heating	6 ☐	Others

C3. For how much time do you use light in 24 hours?

1 ☐ <8 hours

2 ☐ 8-12 hours

3 ☐ 13-17 hours

4 ☐ ≥18 hours

C4.For how many hours electricity of WAPDA is available?

Winter		summer	
1 ☐	<5 Hours	1 ☐	< 5 hours
2 ☐	5-8 hours	2 ☐	5-8 hours
3 ☐	9-13 hours	3 ☐	9-13 hours
4 ☐	> 13 hours	4 ☐	> 13 hours

C5. What is the average monthly electricity bill that you are paying for WAPDA electricity?

RS………………………………………………………………………….

C6.The connection charges/meter installation charges in Rs…………………………………….

C7. Load shedding is scheduled or unscheduled?

1 ☐ Scheduled 2 ☐ Unscheduled

C8. Are you satisfied with the present availability of WAPDA electricity?

4 ☐ Highly satisfied

5 ☐ Satisfied

6 ☐ Neutral

7 ☐ Dissatisfied

8 ☐ Highly dissatisfied

D: Household Economic Activities (Non users of MHP)

D1. Do you have any economic activity in your household?

3 ☐ Yes

4 ☐ No

D2. If yes, what type of activity?

4 ☐ Tailoring

5 ☐ Knitting

6 ☐ Food processing

4 ☐ Embroidery

5 ☐ Grain grinding

6 ☐ Others

D3. What electric appliances do you have in your household?

1 ☐ TV

2 ☐ Fridge

3 ☐ washing machine

4 ☐ Blenders

5 ☐ computers

6 ☐ others

D4. Are they functioning now? 1 ☐ yes 2 ☐ No

D5. What do you use as an alternative source of energy?

1 ☐ Manual energy

2 ☐ WAPDA electricity

3 ☐ Solar cells

4 ☐ UPS

5 ☐ Diesel generators

6 ☐ others

D6. What is the per month cost of using the given source of energy?----------------------------

D7. If electricity is used, for how many hours in a day do you use electricity of WAPDA in this activity?

1 ☐ 2-4 hours   3 ☐ 6-8 hours

2 ☐ 4-6 hours   4 ☐ >8 hours

D8. Income per month from this activity in RS…………………………………………..

D9. Do you experience any fluctuation in the voltage of WAPDA electricity while you are working?   1 ☐ Yes   2 ☐ No

D10. If yes, does it cause any damage to the machinery or appliances in the household?

1 ☐ Yes   2 ☐ No

D11. If yes, then how much it cost to repair it? ……………………………..in RS

E: ENVIRONMENT

Note. *The data of fire wood, kerosene oil, diesel, LPG, and other energy sources will be taken from households to estimate the use of fuels.*

E1. What is your main source of lighting?

4 ☐ WAPDA electricity   4 ☐ Solar cells

5 ☐ Kerosene oil   5 ☐ Generators

6 ☐ Car batteries   6 ☐ Others

E2. What is your primary fuel for cooking?

3 ☐ Fuel wood   4 ☐ Electricity

4 ☐ LPG   5 ☐ Kerosene oil

5 ☐ Dung cakes   6 ☐ others. Specify……………

E3. What is your primary fuel for space heating?

1 ☐ Fuel wood

2 ☐ LPG

3 ☐ WAPDA electricity

4 ☐ Others. Specify……………………….

E4. Quantity of fire wood and fuels used per month and their associated cost

#	*Fuels used*	*Unit*	*Price/unit*	*Total quantity*	*Expenditure*
1	Fuel wood	Kg			
2	Dung cakes	No			
3	Kerosene oil	Liters			
4	LPG	Kg			
5	Others, specify…………………				
Total					

E5. Do you use car batteries for lighting in your home?

3 ☐ Yes

4 ☐ No

E6. If yes, what is its purchased price?---------------------- Rs

E7. Do you use solar cells?

3 ☐ Yes

4 ☐ No

E8. If yes, what is its purchased price?------------------------Rs

Economic and Environmental perspectives of Micro Hydro Power: A case study of District Dir (upper) Khyber Pakhtoonkhwa.

Note: The information collected through this questionnaire will be kept confidential and will be used only for research purpose.

Questionnaire for Micro Hydro power plant:

Name of the village………

Union council……….

Tehsil………………………………………………………….District……………………………………………………………….

Date…………………………………………………………….Time………………………………………………………………….

Name of Enumerator……………………………

Signature………………………

Date ………………………………

Section A

Micro Hydro Power (MHP) Plant

Specification

A1: Electricity generation capacity of the power plant in (kW)…………………………………..

A2: Started operation in (year)…………………………………………………

A3: Ownership

1 ☐ Government

2 ☐ Community

3 ☐ Private

A4. Name of the organization who installed the plant…………………..

A5. Number of households connected to the plant………………………………………………

A6. Number of households not connected to the plant…………………………………………..

A7. Hours of electricity supplied to the households per day……………..From…………………To…………………………………

A8. Electricity bill collected from the households per month in Rs……………………………

A9. Electricity bill collected from shops and businesses per month in Rs……………………..

A10. Total bill collected in RS per Month…………………………Per annum………

Section B

Issues

B1. Name of operator/respondent……………………………………………………………………

B2. Age………………………………………………..years

B3. Education...

B4. Experience in operating of MHP……………………..Years…………………Months…………………..

B5. Do you have any technical skills for the operation of the plant?

1 ☐ Yes

2 ☐ No

B6. If yes, what type of skills?

1 ☐ Electrical
2 ☐ Mechanical
3 ☐ Plumbing
4 ☐ Others

B7. Have you acquired any technical training for the successful operation of MHP plant?

1 ☐ Yes
2 ☐ No

B8. If yes, duration of the training in years…………………………months …………………

B9. Who repair the plant in case of any fault?

1 ☐ Operator
2 ☐ owner-cum operator
3 ☐ Hire from the market

B10. Is there any shortage in the flow of water during any season of the year?

1 ☐ Yes 2 ☐ No

B11. If yes, is it in winter or summer?

1 ☐ Winter
2 ☐ Summer

B12. How much electricity is reduced in hours?

1 ☐ 2-3 hours
2 ☐ 4-5 hours
3 ☐ 6-7 hours
4 ☐ More than 7 hours

B13. Do the floods in summer affect the power plants?

1 ☐ Yes
2 ☐ No

B14. If yes, to what extent?

1 ☐ partially damage
2 ☐ Complete damage
3 ☐ Complete sweep

B15. Are there any institutional arrangements for reducing the risk associated with floods?

1 ☐ Yes
2 ☐ No

B16. If yes, what are those arrangements?

1 ☐ community involvement
2 ☐ Help from the government
3 ☐ Help from NGO's
4 ☐ Others, specify……………………………

B17. Are there any geological changes that affect these plants negatively?

1 ☐ Yes   2 ☐ No

B18. If yes, then state the nature of those changes.

1 ☐ land slides
2 ☐ Rock fall
3 ☐ Storm gully
4 ☐ Others

B19. Is any community member willing to offer his land free of cost to the community or government for the installation of MHP plant?

1 ☐ Yes
2 ☐ No

B20. If no, then on what terms and conditions he will be willing to offer?

1 ☐ Yearly lease
2 ☐ on monthly rent
3 ☐ Free electricity
4 ☐ other incentives

B21. Is there any transformer installed with the power plant?

1 ☐ Yes
2 ☐ No

B22. If no, then what is the reason behind that?

1 ☐ Due to unawareness
2 ☐ Lack of financing
3 ☐ Due to the negligence on the part of contractors/project executers.
4 ☐ Any other

Thank you