Paper

Micro Hydro Power: A source of Sustainable Energy in Rural Communities: Economic and Environmental Perspectives.

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Abstract

Provision of energy is an important need of the human life. The environmental degradation caused by fossil- fuel based energy generation has led the governments and policy makers to switch to renewable and clean energy technologies. The present study aims to estimate the cost and benefit of Micro hydro power (MHP) projects in rural areas and also to show that Micro hydro power is environmentally sustainable and cost effective technology for energy generation. Primary data as well as secondary data is used. Two sets of data are used, one taken from WAPDA connected households and the other from MHP connected households in District Dir (upper) Khyber Pakhtunkhwa. The methodology used in the study is Descriptive Statistics, Financial and Economic analysis to estimate the results. Environmental analysis is used to estimate the emission reductions caused by Micro hydro power technology. Informal survey techniques are also used to highlight the main issues associated with community based MHP technology. 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 that gives higher rate of return to the investors. As an environmental contribution, the available MHP units in the area can reduce the Green House Gas (GHG) emissions by 6970.104 tons of CO_2eq per annum by replacing the use of fossil fuels. By registering the project with CDM, it can earn $1, 60312 per annum. Base on these results, the policy makers should devise a clear cut policy for rural areas based on the indigenous technology to initiate such projects. This will not only end the energy crisis but will also reduce the rural poverty.

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

1. INTRODUCTION

Provision of energy is an important need of human life. It is the life blood of all economic activities i.e. household, agricultural and industrial. Without access to sufficient energy the goal of economic and social development cannot be achieved.

In today's world due to increase in population and economic activities, the need for energy is increasing at a faster rate. More than 1.6 billion people 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. This feature of rural population does not allow economies of scale in the provision of electricity services. 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, 2007a).

Given this backdrop, Pakistan is also facing the issue of severe energy crisis. Not a single reason or factor can be identified to be a cause of the present energy crisis. There are so many factors that have intensified this issue. High cost and the low level of energy generation compared to demand are the main causes of the present energy crisis. 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 house hold 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 (Pakistan, 2013).

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 A, 2012). 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. 16% 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. 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 is faced with 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 a house hold appliance.

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 due to the availability of natural capital, 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).

A number of studies have been conducted to highlight the importance of Micro hydro power in rural communities. These studies also estimated the Financial and Economic analysis of Micro hydro power. Most of these studies were carried out in foreign countries (e.g. Reddy 1999, Woodruff 2007, Bailey and Robert Bass 2009 and Sarala 2009), there is little research on Micro hydro power in Pakistan. The Cost Benefit Analysis and Environmental Analysis is important because it will provide the public and the government to come up with a well designed policy of Micro hydro power development by identifying the weakness and strength of Micro hydro power technology. The main objectives of the present study are 1: To highlight the importance of Micro hydro power with special reference to Khyber Pakhtunkhwa. 2: To show that Micro hydro power is a cost effective and sustainable environment friendly source of energy for rural communities and 3: To identify the issues and problems in the way of Micro hydro power.

2. Data Discription

Mostly primary data is used for the study. Primary data was collected through questionnaires. For household data, two questionnaires were designed. One for MHP connected households and the other for non MHP connected households and the other for non MHP or WAPDA connected households. This was done to capture the difference in energy patterns and the corresponding expenditure on energy between the two categories of households. Questionnaire for the owners of power plant was also used to get the data of cost and energy output and also the issues faced by the MHP units. Informal survey techniques such as Key Informant Survey (KIS), Focused Group Discussion (FGD) and Expert Opinion (EO) are also used to get meaningful information.

[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).

2.1 Sampling Methodology

2.1.1 Selection of Households

The Ushairy valley which comprises different small villages and hamlets with scattered households has been selected for the study.

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 are very few in number. Therefore, they are 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.

2.1.2 Population and Sample Size

The total households having WAPDA connections are 2867 while MHP connected households are 2160 approximately in the area. A sample size of 100 households is selected from each population on the basis of confidence interval of 10 and confidence level of 90%.

3. Methodology

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 stage, 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 stage, Environmental analysis is carried out to estimate the emission reductions that would have occurred in the absence of the MHP project.

3.1 Descriptive Analysis

First of all, the collected data was entered into Statistical Package for Social Scientists (SPSS). 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 SPSS. The information of household size, source of income and area of agricultural land etc were entered into SPSS. The other variables like main source 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. The use of fuel wood is also a part of the analysis.

3.2 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. We also estimate the 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 fixed per month bill on the total units consumed per month (kWh).

3.3 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

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 etc.

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 values of benefits in monetary terms were entered into the excel spread sheet. 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).

3.3 (a) Discount Rate

The discount rate is the interest rate charged to commercial banks and other depositary institutions on loans they receive from their Regional Reserve Bank.

The interest rate used in discounted cash flows (DCF) analysis to determine the present value of future cash flows is called 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 discount rate selected for the study is twelve percent (12%). It is also called the opportunity cost of capital.

3.3 (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%. For Economic analysis, the costs & benefits of financial analysis cash flows are multiplied by 90% to get economic costs and benefits. For Micro hydro power projects there are no CO_2 emissions from the project. Therefore, there is no environmental cost of carbon emissions. The standard conversion factor has been used by different projects for economic evaluation.

3.3 (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 interest rate, the project can be considered to be carried out (Kierulff, 2008).

$$\text{IRR} = \text{Lower Discount Rate (d1)} + \left[(\text{d2} - \text{d1}) \times \frac{\text{NPV1}}{\text{NPV1} - \text{NPV2}} \right] \ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

$$\begin{pmatrix} \text{d1} = \text{lower discount rate} \\ \text{d2} = \text{higher discount rate} \\ \text{NPV1} = \text{NPV at lower discount rate} \\ \text{NPV2} = \text{NPV at higher discount rate} \end{pmatrix}$$

3.3 (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 give us Financial Net Present value.

$$\mathbf{NPV} = \sum_{t=1}^{n} (Bt - Ct) \Big/ (1+i)^{t} \quad \text{……………………….. (2)}$$

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

3.3 (e) Benefit Cost Ratio

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).

$$\text{BCR} = \sum_{t=1}^{n} \frac{Bt}{(1+i)t} \Big/ \sum_{t=1}^{n} \frac{Ct}{(1+i)t} \quad \text{……………… (3)}$$

3.3 (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

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 (Dictionary, 2014).

3.4 Environmental Analysis

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.

3.4 (a). 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, nd).

Annual electricity generation (kWh/year) = plant Capacity (kW) × Plant Capacity Factor × 8760 hours[2]

Annual CO_2 Emissions (Tones of CO_2 eq) = Power Generation (kWh/year) × Emissions Factor (Tones of CO_2/ kWh).

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=tone of CO_2

An emission factor of 1.83 kg/kWh is used in this analysis.[3]

3.5 Informal Survey

This section shows qualitative analysis using Participatory Reflection and Action (PRA). Informal survey or qualitative survey is used as a supplement to the quantitative survey. The techniques used for this study includes Focused Group Discussion (FGD), Key Informant Survey (KIS) and Expert Opinion. Group Discussion is an open discussion with a formal agenda between ten or more members of the community about an issue. Key informant survey is a method through which information is taken with the help of key informants. Expert opinion is an informal technique that can be used for identification of issues and problems.

[2] Plant Capacity Factor= Average Demand/ Installed Capacity (Akella, Saini, & Sharma, 2009).

[3] 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, nd).

4. Results and Discussion

4.1 Descriptive Analysis

This part of the analysis shows the results and empirical findings that were obtained through SPSS. First we give the socio-economic information of the sample and then goes to further analysis.

Table 4.1 Main source of income

		Labor	agriculture	Govt service	Business	Remittances
MHP(household)	In %	39	31	17	10	3
Non –MHP(Household)	In %	34	21	18	17	10

The percentage of households in labor and government service is more or less the same. As MHP households are located in a comparatively remote and hilly area, therefore they are less accessible to the business and expatriate employment. The non- MHP's are comparatively better off in terms of business and overseas employment.

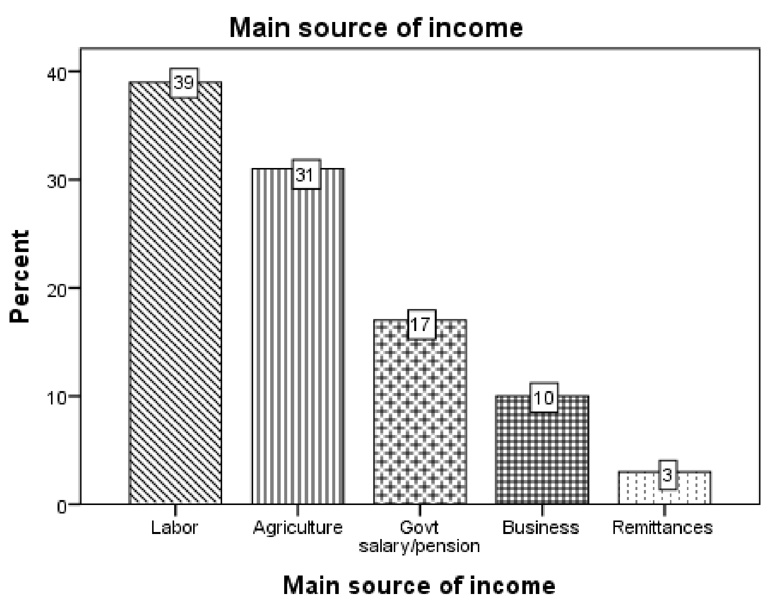

Figure1. Main source of income (MHP household)

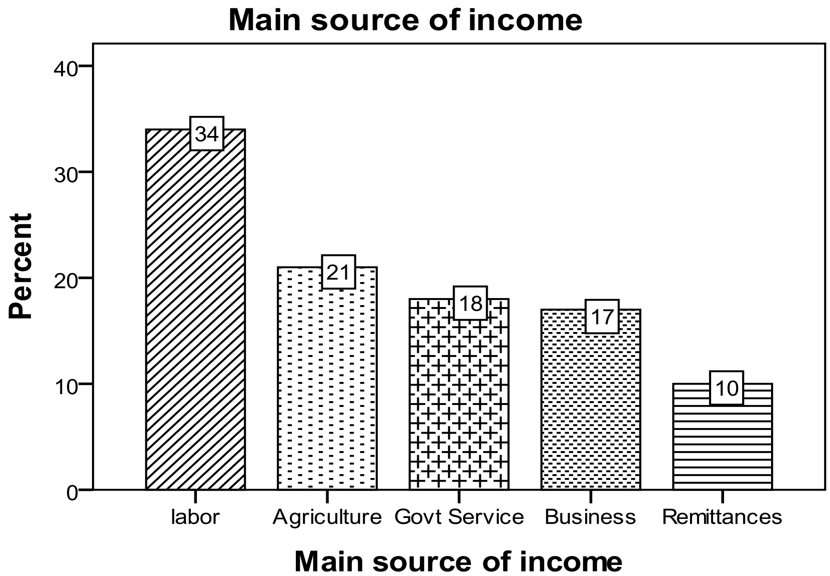

Figure2. Main source of income (Non-MHP household)

Table 4.2 Area of Agriculture land (in Acres)

MHP Households		Non–MHP Households	
Area in acres	%	Area in acres	%
0.1-2	60	Landless	25
2.1-4	21	0.1-1	43
4.1-6	11	1.1-2	21
6.1-12	8	2.1-5	11

Both MHP and non- MHP households are different with respect to ownership of agriculture land. MHP households have more agriculture land than the non-MHP households. The former rely more on agriculture than the latter one. This is also supported by the share of income sources.

4.1.1 Main source of lighting

Comparison is made between the two categories of households on the basis of energy source that is used by users and non users of MHP. The result of the study shows that the duration of light in the households of MHP users is greater than the duration of light in case of WAPDA electricity. Therefore non users' uses other alternatives like kerosene oil, LPG and DC chargeable lamps to meet their needs.

Table 4.3 Main source 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 %	4	2	0	0	9	85

Source: Field survey

Table 4.4 Duration of Light

	Duration of light	Household response in %
Non-MHP(WAPDA)	2-3 hours	95
MHP	8-12 hours	90
	13-17 hours	10

Source: Field Survey

The above table shows the electricity or duration of light available to both categories of households. The duration of light available to households using WAPDA electricity is 2-3 hours, while the duration of light available to the households using electricity from MHP is 8-12 hours. It means that about 20 hours load shedding is carried out in those areas by WAPDA. Results of the survey show that the households using WAPDA electricity actually pays more than their available power. However the MHP users pay less in exchange for the available electricity from the local power plants.

4.1.2 Monthly electricity bill and connection charges.

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 than the MHP households. Even though, the availability of light is more in case of MHP households. This shows that the consumers of MHP electricity are better up than the consumers of WAPDA electricity.

Table 4.5 Monthly electricity bill and connection charges (Rs.)

	Monthly bill			**Connection charges**		
	Min	Max	Mean	Min	Max	Mean
WAPDA	500	3000	920	5000	7000	6500
MHP	100	400	200	1000	7000	4000

Source: Field Survey

4.1.3 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. It 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.

Table 4.6 Use of fuel wood and other sources of energy

	Non users of MHP(WAPDA)			**MHP users**		
	Min	**Max**	**Mean**	**Min**	**Max**	**Mean**
Q. of fuel wood used per month in (Munds)	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) Rs	300	7000	1750	100	4150	532

Source: Field survey

4.1.4 Degree of satisfaction.

This part of the analysis deals with the people's perceptions about the electricity provided by WAPDA and MHP.

Table 4.7 Degree of satisfaction (Percent of household)

	WAPDA			MHP		
	Satisfied	**Dissatisfied**	**Highly dissatisfied**	**Satisfied**	**Dissatisfied**	**Highly satisfied**
In %	12	58	30	64	11	25

Source: Study Survey.

4.2. Comparative Cost Analysis

4.2.1. Micro Hydro Power

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[4]

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 fix tariff that the consumers pay for using MHP electricity = **Rs 200/ month,** therefore the energy price per unit= 200/150 kWh= **Rs 1.33/ kWh**

4.2.2. WAPDA Grid electricity

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

[4] 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.

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 (Pakistan, 2013).

1 unit= 1 kWh

Price per unit of WAPDA electricity for consumers using 100kWh- 200 kWh =Rs. 9

Per day consumption= 5 kWh

Monthly bill=150× 9= Rs 1350

Table 4.8 Energy price per unit (in Rs.)

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

Source: Study Survey

4.3 Financial and Economic Analysis

Table 4.9 Financial Analysis of Cash Flow of MHP Plant

(In 1000 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	233.28	98.28
12	2022	0	135	135	233.28	98.28
13	2023	0	135	135	233.28	98.28
14	2024	0	135	135	233.28	98.28
15	2025	0	135	135	233.28	98.28
16	2026	0	135	135	233.28	98.28
17	2027	0	135	135	233.28	98.28
18	2028	0	135	135	233.28	98.28
19	2029	0	135	135	233.28	98.28
20	2030	0	135	135	233.28	98.28
21	2031	0	135	135	233.28	98.28
22	2032	0	135	135	233.28	98.28
23	2033	0	135	135	233.28	98.28
24	2034	0	135	135	233.28	98.28
25	2035	0	135	135	233.28	98.28

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 1000 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	121.5	121.5	233.28	111.78
12	2022	0	121.5	121.5	233.28	111.78
13	2023	0	121.5	121.5	233.28	111.78
14	2024	0	121.5	121.5	233.28	111.78
15	2025	0	121.5	121.5	233.28	111.78
16	2026	0	121.5	121.5	233.28	111.78
17	2027	0	121.5	121.5	233.28	111.78
18	2028	0	121.5	121.5	233.28	111.78
19	2029	0	121.5	121.5	233.28	111.78
20	2030	0	121.5	121.5	233.28	111.78
21	2031	0	121.5	121.5	233.28	111.78
22	2032	0	121.5	121.5	233.28	111.78
23	2033	0	121.5	121.5	233.28	111.78
24	2034	0	121.5	121.5	233.28	111.78
25	2035	0	121.5	121.5	233.28	111.78

Net Present Value **459.16**

Benefit Cost Ratio **1.36**

Inter Rate of Return **27%**

Payback Period **3.6 Years**

Source: Study Survey

The study shows the results of Financial and Economic Analysis in detail in Table 4.9 and 4.10. 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. The final results of Financial and Economic analysis are summarized in Table 4.11.

Table 4.11: IRR, NPV, BCR and Pay Back Period (PBP) of MHP Project at 12% Discount Rate

Description	Financial Analysis	Economic Analysis
IRR	24 %	27 %
NPV	350.1	459.16
BCR	1.25	1.36
Pay Back Period (PBP)	5 Years	3.6 Years

Source: Study Survey

4.3.1 Internal Rate of Return (IRR)

Internal Rate of Return is the discount rate at which NPV is equal to zero. If IRR is greater than the discount rate the project is acceptable. In our 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.

We 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, we 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.

4.3.2 Net Present Value

According to this criterion if the Net Present Value (NPV) is positive or greater than zero, the project will be worth to undertake. The greater the NPV, the higher will be the possibility of acceptance of the project. In this case the Financial NPV is 350 which is greater than zero. The Economic NPV is 459 which is also positive and hence the project is feasible and worth to undertake.

4.3.3 Benefit Cost Ratio (BCR)

If BCR of the project is greater than one, we accept the project. If it is less than one, we reject the project. In the given table the BCR in financial analysis is 1.25 and in the Economic analysis, it is 1.26 which are both greater than one. Therefore, we can conclude that according to this criterion, the Micro hydro power project is viable and worthy to be undertaken.

4.3.4 Pay Back Period

Pay Back Period is the length of time required to recover the cost of an investment. 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 4.12: Sensitivity Analysis of Cash Flow of MHP

(In1000Rs.)

	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	233.28	98.28
12	2022	0	135	135	233.28	98.28
13	2023	0	135	135	233.28	98.28
14	2024	0	135	135	233.28	98.28
15	2025	0	135	135	233.28	98.28
16	2026	0	135	135	233.28	98.28
17	2027	0	135	135	233.28	98.28
18	2028	0	135	135	233.28	98.28
19	2029	0	135	135	233.28	98.28
20	2030	0	135	135	233.28	98.28
21	2031	0	135	135	233.28	98.28
22	2032	0	135	135	233.28	98.28
23	2033	0	135	135	233.28	98.28
24	2034	0	135	135	233.28	98.28
25	2035	0	135	135	233.28	98.28

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

Source: study survey

4.4 Sensitivity Analysis

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. The capital cost is increased by 10%, 20% and 30%. It is estimated using the same procedure and tools that are used in financial and economic analysis. The same 12 % discount rate is used for the analysis. The results are given in the tables given below.

Table 4.13: 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

Table 4.14: Sensitivity Analysis with 20 % Increase in Capital Cost

Description	Financial Analysis	Economic Analysis
IRR	21.4%	22%
NPV	309	311
BCR	1.5	1.4
PBP	6 years	6 years

Source: study result

Table: 4.15: Sensitivity Analysis with 30 % Increase in Capital Cost

Description	Financial Analysis	Economic Analysis
IRR	19.4%	20%
NPV	290	293
BCR	1.2	1.3
PBP	6.7 years	6.5 years

Source: study result

The above table shows the results of sensitivity analysis of the project when capital cost is increased by 10%, 20% and 30% respectively. The result shows that IRR, NPV, BCR and PBP, all are sensitive to the changes in capital cost.

4.5 Environmental Analysis

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.

Our 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.

4.5.1 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. Majority of the households have no access to any source of electricity in the area under consideration. However, there is a growing trend in the use of diesel fuel for electricity generation by households and public institutions in the area.

The area has also the most precious and rare forest resources which are being used by the local people in an unsustainable way for cooking and heating. If high powered mini and micro hydro power projects are established, it will even 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 area under study serves as an important catchment area for river Indus. 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.

4.5.2 Emission Reductions

This part describes that how the anthropogenic GHG emissions by sources are reduced below those that would have occurred in the absence of the project activity. 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. Moreover, due to 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.

Total cumulative installed capacity of MHP plants=1058 kW

Operating for 10 hours per day=1058kw*10 hours=10580 kWh/day

Per month: 10580kwh*30=317400 kWh

Per annum: 317400kwh*12=3808800kWh

Thus the total electricity generation from the plants will be 3808800 kWh per annum.

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

3808800kWh*1.38 kg CO_2 eq/kWh=6970104 kg CO_2/1000= **6970.104 tones CO_2eq / annum.**

4.5.3 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. 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 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 (Christensen, Duncan, & Phillips, 2012), the given project if registered with CDM will earn $160312 per annum.

4.6 Result of the survey of MHP plants.

All the 35 Micro hydro power plants were taken as a sample for the study. This survey included the cost of civil works and electro mechanical works of the power plant. This was covered in the Financial and Economic analysis of the MHP project. The remaining part of the survey relate to the main issues about the installation and maintenance of MHP plants.

4.6.1 Main Issues.

1. Unskilled Operators

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.

2. Low Education level

Majority of them are illiterate. They have no technical skills. The given table summarizes the information.

Table 4.16: **Education level and skills of the operators in percent**

S#	Education / Skill		%
1	Education	Illiterate	54
		Middle	11
		Inter	8
		Graduation	2
2	Skill	-----	8
3	Technical training	---	2

Source: study survey

3. Reduction in Water Flow

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.

4. Risk of Floods

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.

5. 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. 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.

6. 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.

7. 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 three to four children had been electrocuted in the past according to the information shared by the community members.

8. 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.

9. 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.

10. 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.

4.7 Results of Informal survey

In this part of the analysis we informally obtain information from the people and key figures of the area to confirm the results we obtained in the formal survey.

4.7.1 Review of Findings from Focused Group Discussions

Participants were asked to discuss the following statements.

- The community based MHP units are more efficient than the Government one.
- Community members/ Government organization should be the decision makers.
- There should be strict rules and regulations for the operation and distribution of electricity generated by Micro hydro power plant.
- There is an apparent discrimination in the collection of bills by charging the same plate rate.

Key Findings

- All the participants agreed on the point that the project based MHP units or the government one is more efficient than the private one. 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 demanded 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.
- Regarding the issue of the same flat rate collected from the households irrespective of the electricity units they consume, they said that they will look into it and decide to adjust the rate in future. First, the project had promised to install meters to every household but later on they could not provide it due to unknown reasons.

Regarding other issues associated with the project, a committee member said "*the needed spare parts related to electro mechanical components are not provided to us. It is necessary because in case of any fault, it should be available with the operator and can repair the fault. We have no capacity to arrange it for ourselves, we are poor" (*committee chairman, Usharai).

4.7.2 Key Informant Survey

4.7.2. A. Business man, village Usharai

A local business man was selected as the first key informant. He has a lot of information about the people perceptions and other issues associated with the Micro hydro power projects. Narrating the story of the project construction, he told that there was a dispute on the selection of project site among the members of two villages. Later on, due to the availability of land, the project was decided to be constructed in our village. In the dispute, about seven electric Poles were forcibly taken by the other village members, who claimed that their village should also be connected to the plant. He was asked to share his experience and the problems faced by the community, he informed that:

"Due to the shortages of electric poles, we have installed some wooden poles to supply electricity from the power plant to the houses. During rain and snow fall in winter, these poles become wet and fell which causes disconnection of electricity supply to the houses. We have extended the electric wires in trees which is dangerous. The government should provide us these."

4.7.2 B. Member Village Committee

A member of village committee was selected a key informant. He was also a member of project committee during project construction. He was satisfied with the MHP project. But he made his own community members to be responsible for the issues. He said that community members are not cooperating with the committee. His views are given in his own words.

"We advise and even warn the consumers not to use water heaters and 100 watt bulbs but still they are using it. The government has provided us this facility free of cost, now it is up to the people to maintain it or not."

He further said:

"The common people don't care about the facilities provided by the government. We need to change the people's perceptions".

These were the views expressed by the member of village committee who concluded that the ownership of MHP plants must be determined to make it successful and sustainable.

4.7.2 C. Ex- Councilor UC Tarpatar

An Ex- councilor of UC Tarpatar, was also selected for interview as a key informant. He was selected from the category of households that had no MHP connections. This was done so that we can also examine and explore the reason that why they were not provided with MHP electricity. He said that:

"We are in dire need of Micro hydro power project so that we can also get cheap and reliable electricity. WAPDA electricity is just nominal and is available only for two or three hours. Bills are more as compared to the availability of electricity. The meter reader just pays a visit to the area and takes estimated readings without properly checking the meters. We are not connected to MHP plant located in the village. Our houses are situated far away from the power plant and cannot afford the cost of wire."

4.7.2. D. School Teacher, village Almas

A local school teacher was also selected for the survey. As he has been involved in many surveys that were conducted for government departments, therefore he had much information about the households and the benefits and problems associated with the MHP power plants. About the benefits of the MHP projects he said.

"Previously, we used kerosene oil, candles and generators for lighting and operating home appliances. But now, we are using the electricity generated from Micro hydro power plant which is cheap and last through the whole night. Earlier, about 5% of the people were using petroleum generators but now its use is reduced. With nominal charges of Rs 250, we use light throughout night while the WAPDA electricity last for only two or three hours. For these two or three hours of electricity, we pay Rs 600 to Rs 700 per month."

In response to the question that whether the people cooperate with the management and take care of the projects, he said.

"Our people have low awareness level. When they use any thing that belongs to government, they use it carelessly without feeling that it is their own. For the successful operation of the plant, public awareness and honesty is must. The local political leaders etc are not sincere and honest, they only think about their pockets. They deceive the government and even their own people."

The above results from informal survey shows, Micro hydro power technology brings a positive change in the lives of common people. The greatest benefit the people get from it is home lighting. Before these projects, people were using kerosene oil and generators in their homes. Now they are using electricity of MHP plants. Despite these benefits, there are also some issues that have an adverse impact on the sustainability of these plants. These are, for example lack of interest from the community members to cooperate with the village committees and the use of high load appliances that causes MHP plants to trap. If these issues are addressed before launching any project, it will be successful and sustainable in the long run.

4.7.3 Expert opinion

4.7.3 A. 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.

4.7.3 B. Field Engineer (Civil) SRSP, Dist Dir (U)

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.

5. Conclusion and Policy Recommendations

5.1 Conclusion

The present study has four main parts. The first part is based on descriptive analysis which shows the socio economic information like the main source of income, area of agriculture land and the main source of lighting etc. The results indicate that the main source of lighting for MHP households is the electricity generated from the MHP plant. While for WAPDA users the main source of lighting is kerosene oil, generators and mostly DC chargeable lamps. Moreover, the MHP connected households are better up in terms of the monthly electricity bill and the expenditure made on other sources of energy. Thus the MHP households get a saving due to low expenditure on the use of energy items. This consumer surplus may be used for the consumption of other household items resulting into their welfare improvement.

The second part estimate the comparative cost of MHP electricity and WAPDA electricity to the consumers. The result shows that per unit cost of MHP electricity is less than the WAPDA electricity. The unit capital cost of MHP is Rs. 13333/kW. While per unit energy price is Rs. 1.33. On the other hand per unit cost of WAPDA electricity is Rs. 12 while for consumers it is Rs. 9 (for consumers using 100- 200 kWh). Based on this analysis, MHP electricity is far cheaper than WAPDA electricity.

The third part deals with the Financial and Economic analysis of Micro hydro power project. This part shows that whether the Micro hydro power is a profitable and viable investment and to show whether the project is viable with respect to the whole economy and society. For this purpose Cost Benefit Analysis is carried out. The analysis shows that it is both financially and economically viable. The project can give more benefits to the society through multiplier effect by increasing the income, improving health and education of the communities.

The fourth part deals with environmental analysis. As the micro hydro power is environment friendly technology, causing no GHG emissions, therefore it is environmentally sustainable. The analysis estimated the total emissions that will be reduced by the project. This reduction is 6970104 tones of CO_2 eq / annum. This reduction in CO_2 will earn Certified Emission Reductions (CERs) through CDM which is also a benefit from the project. Setting the price of one tone of CO_2 as $23, the total value of the CERs will be $160312 per annum.[5]

The study also uses informal survey techniques. The analysis shows that there are also some issues associated with the MHP plants and community members. These are dispute on the land proposed for the project, the misuse of hydro power (the public good nature of the power plant), and low capacity to meet the additional demand, scattered houses and the lack of awareness among the community members. Moreover, the MHP projects are not given on merit basis but political interference and personal influence determine the site for MHP projects. However for successful and sustainable use of the plants, the cooperation of community members is vital. If these problems are solved, the Micro hydro power will be a success story in the future to come.

5.2 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.
- 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.

[5] 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 (Christensen et al., 2012).

- 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.
- Local workshops should be established in order to provide repairing services at local level.
- To improve the efficiency and sustainability of the Micro hydro power plants, awareness workshops should be arranged for the community members, so that they can use the energy in a sustainable manner by avoiding misuse and losses.

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APPENDIX-A

Table1. Micro Hydro Power plants operating at Ushairy, District Dir (upper)

S#	Name of village	No of MHP'S	Electricity generation capacity (KW)	Started operation	Organization who installed	No of beneficiaries (HH)
1	Samkote	1Gov+2priv=3	50+30+20=100kw	2009	SRSP	180
2	Batal	1Gov+2priv=3	60+20+20=100kw	2008	SRSP	160
3	Nashnamal	1Gov+1priv=2	30+50=80kw	2009	UNICEF	140
4	Danele	2priv	25+25=50kw	2007	Community	70
5	Gur koi	2Gov	30+40=45kw	2009	UNICEF	100
6	Shomai	2priv+1Gov=3	20+15+50=85kw	2009	UNICEF	150
7	Jabai	2priv	20+20=40kw	2008	Community	90
8	Usharai Proper	1Gov	24+24=48kw	2013	ACTED(Japan funded)	110
9	Usharai	1priv	30kw	2010	Private	60
10	Usharai	1priv	25kw	2010	Private	70
11	Tarpatar	1Gov	40kw	2012	RAHA	120
12	Amrete	1priv	20kw	2009	Community	50
//	//	1priv	20kw	2008	//	40
//	//	1	20kw	2008	//	50
//	//	1	20kw	2009	//	50
//	//	1	20kw	2009	//	55
//	//	1 Gov	20kw	2009	SRSP	60
13	Barkand	3 priv	15+20+25=60kw	2007	community	200
14	Almas	1Gov+2priv=3	25+25+40=90kw	2011	MNA Funds	170
15	Choran	1privt	15kw	2008	private	25
16	Kalkote	2privt	40+25=65kw	2003	private	170
17	Nagasar	2privt	15+30=25kw	2004	private	60
Total		**35 units**	**1058 kW =1.058 MW**			**2160**

Source: Field survey.