

Gorkhali, Sanjay Prasad

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## Energy and economic welfare (cost-benefit analysis of micro-hydro systems in Nepal)

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**Sanjay Prasad Gorkhali**

**Energy and Economic Welfare**  
**(Cost-Benefit Analysis of Micro-Hydro Systems in Nepal)**

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Sanjay Prasad Gorkhali

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## **Abbreviations and Acronyms**

ACAP – Annapurna Conservation Area Project

ADB – Asian Development Bank

ADBN – Agricultural Development Bank of Nepal

CBA – Cost-Benefit Analysis

GDP – Gross Domestic Product

HMG/N – His Majesty's Government of Nepal

IG – Income Generating

IRR – Internal Rate of Return

KW – Kilowatt

MH – Micro-Hydro

MW – Megawatt

NEA – Nepal Electricity Authority

NPC – National Planning Commission

NPV – Net Present Value

RET – Rural Energy Technology

REDP – Rural Energy Development Program

Rs. – Rupees (Nepalese Currency) (1 Euro = Rs. 68, Jan 2002)

UNDP – United Nations Development Program

## 1 Introduction

Most of the people in Nepal live in rural areas and rely on agriculture for their main sources of income. They depend on traditional sources of energy such as fuel-wood and agriculture residue for their daily energy supply. On one hand, the lack of commercial sources of energy has limited the productivity of industrial activities. On the other hand, the excessive use of these energy sources has resulted in low agricultural productivity, deforestation and soil-erosion, which create imbalances in natural eco-system.

To enhance the economic welfare of people in the rural areas, it is necessary to increase agricultural productivity and to promote the development of rural enterprises. Both of these approaches depend highly on the accessibility of commercial sources of energy. To meet such demand, the utilization of energy from those renewable sources which are economically, environmentally and socially justifiable should be promoted.

As there is a high potential for the utilization of hydropower in the country and considering that the rural communities are isolated and scattered, micro-hydro (MH) systems serve as a viable alternative. The promotion of the MH system is expected not only to enhance people's welfare but also to positively impact social welfare through improvements in health and education. In terms of economic welfare, energy from MH systems is expected to be beneficial for both producers and consumers in rural economies via the opportunities to create links between them and the national economy.

From the preceding paragraphs, one might directly infer that the installation of MH systems can be an appropriate means to increase the economic welfare of people in the rural areas of Nepal. However, since the establishment of these MH systems require considerable resources, it is necessary to first evaluate the systems' economic desirability to gather its net welfare effect on the rural population.

Given the foregoing, this thesis has been prepared to assess the economic desirability of MH systems in Nepal. In this regard, research has been undertaken in three MH systems being operated in Nepal and used as the sample schemes. The financial analyses of all three systems show that only the privately-owned system is in a financially sound position. The other two community-owned systems are in weak financial conditions. Interestingly, the analysis shows that MH systems can be a highly effective means of increasing the economic welfare of people in the rural areas, even though it may be in a weak financial situation. However, bearing in mind the need to ensure the long-term sustainability of these MH systems in delivering services, the financial viability of a system therefore becomes a crucial consideration.

## 2 Research Problem

### 2.1 Country Background

Nepal is a small landlocked Himalayan kingdom wedged between two emerging economic powers in Asia, namely, China and India. With a total area of 147,181 square kilometres, Nepal boasts of diverse ecological zones, the lower terrain (Terai), the middle hills and the high mountains. The population of the country is more than 22 million, with an annual growth rate of 2.3%. With an annual GDP (at factor cost) of 5.1%, the per capita income of the country is US\$210.<sup>1</sup>

The World Bank notes that 'until the 1950s, Nepal had virtually no modern social services, infrastructure, cash economy or significant economic linkages to the rest of the world.'<sup>2</sup> To expedite the economic development of the country, His Majesty's Government of Nepal (HMG) began the adoption of a development plan in 1956. To date, eight periodic five-year plans have been implemented but only meager achievements have been observed. As a result, 42% of the population still live below the poverty line as of 1996.<sup>3</sup>

Almost 80% of the total population of the country live in rural areas, majority of whom depend on climate-based agriculture for their subsistence. Thus, most of the people living in rural areas are ravaged by poverty. The landlocked position and rugged topography with limited cropland (constituting 17% of the total land area) has been the major constraint in rural development. The annual growth rate of the agricultural sector is estimated to be only 3%.<sup>4</sup> In addition, lack of modern technology has limited the productivity of the rural-based population. With the relatively low growth rates in the agricultural sector and limited productivity of the rural industrial sector, matched by a high population growth rate, the economic situation continues to deteriorate. The deteriorating economy has resulted in incidents of social and political unrest erupting in the recent political violence staged by Maoist insurgents.<sup>5</sup>

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<sup>1</sup> Dahal, Madan K., Outward-Oriented Economic Nationalism: A Model for Development in Nepal, in: Dahal, Madan K. and Mund, Horst, (ed.), Social Economy and National Development, Lessons from Nepalese Experience, Nepal Foundation for Advanced Studies, 1996, Kathmandu, pp. 2.

<sup>2</sup> N.N., Country Assistance Strategy – Nepal (1999-2001), The World Bank, Washington DC, Kathmandu, pp. 2.

<sup>3</sup> N.N., The Ninth Plan (1997-2002), National Planning Commission, His Majesty's Government of Nepal, 1998, Kathmandu, pp. 1.

<sup>4</sup> Ibid, pp. 17.

<sup>5</sup> N.N., Country Assistance Strategy – Nepal (1999-2001), The World Bank, Washington DC, Kathmandu, pp. 2.

## 2.2 Energy Situation in Rural Areas

One of the major obstacles in the development of the rural areas in Nepal is the non-availability of commercial sources of energy. This has not only slowed down the rate of development of new technologies for increasing agricultural productivity but has also created excessive dependency on traditional sources of energy including fuel-wood and agricultural residues.

Owing to the lack of commercial energy sources, the productivity of the rural population remains modest. On one hand, considerable labor hours of human resources are spent in production activities, which could have been done with much less manpower if modern technologies were used. On the other hand, people especially women have to spend much of their working hours in collecting fuel-wood.

Fuel-wood is still the most important source of energy in Nepal. This source accounts for 73% of the total energy consumption in the country and is mainly consumed in rural areas. Overexploitation and the lack of proper management of fuel-wood has resulted in the high depletion of forests which has consequently led to soil erosion, and has thereby decreased the area of cultivatable land. The annual rate of deforestation is estimated to be 2.1%, which is a high figure for Nepal's fragile hill eco-system.<sup>6</sup> Other biomass sources, like agriculture residue and animal dung provide about 25% of energy requirements for domestic use.<sup>7</sup> The use of agricultural residue and animal dung as a source of energy has limited the supply of fertilizer for agricultural production.

## 2.3 Hydro Power - A Viable Option?

With more than 6,000 rivers and rivulets<sup>8</sup> crisscrossing the mountainous terrain of the country, Nepal has a considerable scope for accelerating economic growth by exploiting its huge potential in hydropower, which is estimated to be 43,000 Megawatts (MW). The nation possesses 2.3 % of the world's hydro resources,<sup>9</sup> which is an irony, considering that majority of Nepal's population still do not have access to commercial sources of energy, despite its high potential to generate hydropower. Only 13% of the total population has access to electricity, and of these, 3% live in rural areas.<sup>10</sup>

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<sup>6</sup> N.N., Community – Managed Rural Energy Development (Strategic and Operational Framework), REDP Publications 04/98, Rural Energy Development Program, 1998, Kathmandu, pp. 1.

<sup>7</sup> Ibid.

<sup>8</sup> Ibid, pp. 8-9.

<sup>9</sup> Dahal, Madan K., Outward-Oriented Economic Nationalism: A Model for Development in Nepal, in: Dahal, Madan K. and Mund, Horst, (ed.), Social Economy and National Development, Lessons from Nepalese Experience, Nepal Foundation for Advanced Studies, 1996, Kathmandu, pp. 2.

<sup>10</sup> N.N., Nepal Energy Sector Program Support Document, Main Report Danish International Development Assistance, Ministry of Foreign Affairs, 1998, without place, pp. 21.

Coal, petroleum product and electricity are the commercial sources of energy that are utilized in Nepal. As Nepal does not have any fossil fuel reserves of its own, the country has to spend a huge amount of foreign exchange reserves for the importation of fossil fuel. In addition, transportation problems arising from the geographical structure of the country tend to bar the people living in remote areas from even using petroleum products.

Empirical studies show that there is a high correlation between the use of energy and economic growth.<sup>11</sup> Thus, with the utilization of hydropower as source of energy, it is expected that Nepal can accelerate its pace towards economic growth. The energy derived through the use of hydropower has the potential to increase the economic welfare of the people via the channel of increasing productivity levels. This will also address the need to better manage the resources in the deteriorating environment by substituting fuel-wood with electricity for cooking, heating and lighting. In addition, the country can save foreign exchange reserves by reducing its dependency on imported petroleum products.

Recognizing the tremendous prospect for the development of hydropower, and considering that the rural communities are isolated and scattered, the government has postulated rural electrification at a larger scale as one of its major strategies to develop irrigation, agro-industries, and other cottage industries for alleviating poverty in the rural areas.<sup>12</sup>

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<sup>11</sup> Rosenberg, Nathan, Historical Relations Between Energy and Economic Growth, in: Stevens, Paul (ed.), The Economics of Energy Vol I, Edward Elgar Publishing Company Limited, 2000, Cheltenham, pp. 55.

<sup>12</sup> NN, The Ninth Plan (1997-2002), National Planning Commission, His Majesty's Government of Nepal, 1998, Kathmandu, pp. 1.

### 3 Role of Energy in Development

Energy has been an integral part of our life since the beginning of human civilization. In the early stages of human civilization, energy from the sun and biomass was used for cooking food. Over time, new sources of energy have been discovered for use of many societies. Today, the main sources of energy include biomass, coal, mineral oil, natural gas, hydro power, nuclear power, wind power, solar energy, geothermal/oceanic energy, etc. These are popularly known as the commercial sources of energy.

Simon Kuzents defined the economic growth of a country as “a long-term rise in capacity to supply increasingly diverse economic goods to its population. This growing capacity is based on advanced technology and the institutional and ideological adjustments that it demands.”<sup>13</sup> This definition emphasizes the importance of advanced technologies in propelling a country towards economic growth. The application of such advanced technologies is based on the availability of modern sources of energy.

Before the industrial revolution, the world largely depended on energy sources such as biomass, mainly fuel wood and water mills. The exploitation and development of commercial sources of energy was an important step in the industrial revolution experienced by other countries. The availability of these sources of energy was seen as being necessary for the industrialization of an economy. As an economy pushes towards industrialization, the energy need per unit of GDP increases steeply, before flattening out or even dropping during the post-industrialization phase, when a more service-based economy begins to emerge.<sup>14</sup>

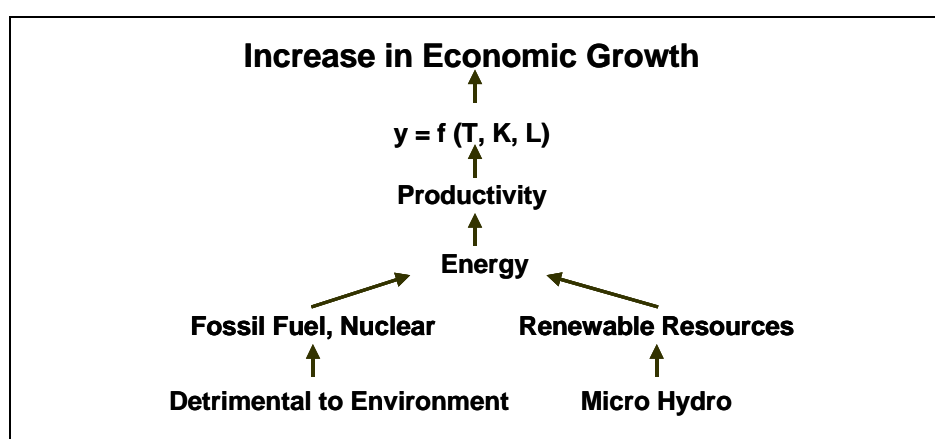


Figure 1: The Role of Micro-Hydro in Economic Growth

As shown in Figure 1, the implications of making use of MH systems on the sustainable economic growth in rural areas can be clarified with the use of the Neoclassical Growth

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<sup>13</sup> Lekhi RK, The Economics of Development and Planning, , Kalyani Publishers, 1999, Jalandhar, pp. 83/1.

<sup>14</sup> Farinell Ugo(ed), Energy as a Tool for Sustainable Development, The United Publications, 1999, New York, pp. XV.

Function,  $y = f(T, K, L)$ , where  $y$  stands for the Gross Domestic Product (GDP),  $T$  for technology,  $K$  for capital and  $L$  for labor. The function shows that the economic growth, i.e. a positive change in the GDP, can be achieved either through improved technology or through increase in the quantity and/or quality of labor or capital. Taking the factors labor and capital constant, growth can be realized by increasing productivity via technological progress, which can be supported by increasing the availability of energy. In this light, the empirical studies on the subject clearly show that energy is one of the means for increasing the level of productivity in a country.<sup>15</sup>

Apart from increasing production levels, energy is necessary to fulfill different consumptive needs of people. And amount of energy needs is influenced by level of income. People living under absolute poverty level are able to meet only their bare subsistence needs for food, clothing and shelter in order to maintain minimum level of survival.<sup>16</sup> Hence, they first try to satisfy their basic daily needs, i.e. food, clothing and shelter. The availability of these daily consumption needs is highly correlated with the supply of energy. Once these basic necessities are fulfilled, people will then seek other important services, such as health, education, and transportation services. These can then be efficiently supplied with the availability of energy.<sup>17</sup>

Significantly, the availability of energy also plays a pivotal role in alleviating poverty through employment generation effects. Commercial and industrial activities are important sources of employment. And the growth of these activities will increase the employment opportunities available to the population. However, once again, the growth of these sectors depends on the availability of adequate energy sources.

As shown in Figure 1, the economic growth of rural areas can be achieved by increasing productivity, labor or capital. Thus the introduction of modern technology through the usage of power generated from MH systems will increase the productivity of the rural people, and enable them to move away from poverty trap.

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<sup>15</sup> Rosenberg, Nathan, Historical Relations Between Energy and Economic Growth, in: Stevens, Paul (ed.), The Economics of Energy, Vol. I, Edward Elgar Publishing Company Limited, 2000, Cheltenham, pp. 55–69.

<sup>16</sup> Todaro, Micheal P. Economic Development, Addison Wesley Longman Limited, 1997, Essex, pp. 676.

<sup>17</sup> Farinell Ugo(ed), Energy as a Tool for Sustainable Development, The United Publications, 1999, New York, pp. XV.



## 4 Micro-Hydro Systems

A Micro-Hydro (MH) System is a system that generates energy up to 100 kilowatts (kW) through the utilization of water resources. The origin of MH systems can be traced back to the traditional water wheels which have been in use in Europe and Asia for some 2000 years mostly for milling grains.<sup>18</sup> Towards the end of the 18<sup>th</sup> century, efforts were made which led to the development of water turbines designed to generate mechanical power from water resources. It was later in the 1880s that hydro turbines were first introduced to generate electricity.<sup>19</sup>

### 4.1 Functioning of a Micro-Hydro System

In a hydropower system, power is generated through water pressure formed when the water is piped from an original level to another lower level.<sup>20</sup> For this purpose, water is diverted from a river through an intake, and passes through a canal to a forebay. From the forebay, it descends to the turbine through a penstock, a pressure pipe. The water flowing from the penstock rotates the runner of the turbine, and converts the water energy into mechanical and electrical energy.

In Nepal, both mechanical and electrical energy is produced through MH systems. The mechanical power from a MH system is mainly used for agro-processing such as for grinders used for grains, hullers for de-husking paddy, and oil expellers for producing oil. The electrical energy, on the other hand, is used for lighting and other household and industrial uses.

In the past three decades, Nepal has made significant progress in developing and utilizing its water resources for generating energy through MH systems. The promotion of the MH systems in the country emerged from the attempts to improve the functions of traditional water mills known as *Ghatta*. Though improvised generation of electricity by adding dynamos to the earlier-built *ghatta* were widely used, the first state-of-the-art MH system of 5kW was installed in 1962.<sup>21</sup>

The local manufacturing of water turbines since the 1960s and the popularity of Multi Purpose Power Units (MPPUs), an innovation made on the traditional *ghatta*, use a metal runner to increase efficiency and has since 1980 contributed to the growth of MH systems in Nepal. Later in 1984, the local manufacturing of induction generators led to the rapid growth in rural electrification mostly with the generators added on agro-processing units. The growth of rural electrification has been further facilitated by the favourable policies

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<sup>18</sup> Frankel, P. et. Al Micro Hydro Power, A guide for Development Worker, Intermediate Technology Publications Ltd., 1991, London, pp. 2.

<sup>19</sup> Ibid, pp. 10-11.

<sup>20</sup> Ibid. (see also Annex III for a schematic diagram of a MH system)

<sup>21</sup> N.N., Renewable Energy Perspective Plan of Nepal, 2000-2020: An Approach, Vol. – 2, Sectoral Report, Centre for Energy Studies, Institute of Engineering, Nepal, 2000, pp. 2.

implemented by the government in the 1980s. The de-licensing of all electricity installation below 100 kW in 1984 and the provision of subsidies for the establishment of MH systems in 1985 are among the policies that provided a favorable environment for the development of MH systems in rural and isolated communities.<sup>22</sup>

The average growth rate in the number of MH systems since 1985 has been around 14.7%.<sup>23</sup> Currently, there are 941 MH systems mostly with a capacity between 1 kW and 50 kW in about 59 of the 75 districts of the country.<sup>24</sup> The total installed capacity of these installations is about 4600 kW.<sup>25</sup> The electricity generated through the systems is mainly used for domestic lighting and limited industrial applications. In addition, it is estimated that there are 1200-1300 water turbines for agro-processing purposes, of which 20% have added on electricity generation for domestic lighting.<sup>26</sup> At present, only 0.83% of the total population have access to electricity generated through MH systems.<sup>27</sup>

#### **4.2 Policies Supporting the Installation of Micro-Hydro Systems**

Besides the existence of tremendous water resources and the isolation of rural communities, factors such as low capital investment requirements, short construction periods, simple operational requirements, manufacturing competencies of local manufacturers, favorable policies of government and the involvement of international development agencies have all contributed towards the progress in the development of MH systems in the country.<sup>28</sup>

In comparison to other hydropower systems, the capacity of MH systems is smaller and the technology demanded in order to run the system is less complicated. Hence, the construction period of a MH system is comparatively shorter and its operation and management is simpler.<sup>29</sup> As the system is based on the traditional water mill system, the local people can manage and operate it after only undergoing short trainings. With its simple construction, operation and maintenance procedures, the average cost per kilowatt of the

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<sup>22</sup> Bajracharya, Deepak and Singh, Kiran Man, Development of Micro-Hydro Systems in Nepal: Problems and Prospects, International Centre for Integrated Mountain Development, 1991, Kathmandu pp. 2.

<sup>23</sup> N.N., Renewable Energy Perspective Plan of Nepal, 2000-2020: An Approach, Vol. – 2, Sectoral Report, Centre for Energy Studies, Institute of Engineering, 2000, Nepal, pp. 2.

<sup>24</sup> N.N., Renewable Energy Perspective Plan of Nepal, 2000-2020: An Approach, Vol.-1, Main Report Centre for Energy Studies, Institute of Engineering, 2000, Nepal, pp.13.( A map depicting district wise micro hydro power generation in Nepal is attached in Annex II)

<sup>25</sup> Ibid.

<sup>26</sup> N.N., Nepal Energy Sector Program Support Document, Main Report, Danish International Development Assistance, Ministry of Foreign Affairs, 1998, without place, pp. 40.

<sup>27</sup> N.N., Renewable Energy Perspective Plan of Nepal, 2000-2020: An Approach, Vol. – 2, Sectoral Report, Centre for Energy Studies, Institute of Engineering, 2000, Nepal, pp.2.

<sup>28</sup> Ibid, pp. 13.

<sup>29</sup> N.N.Community – Managed Rural Energy Development (Strategic and Operational Framework), REDP Publications 04/98, Rural Energy Development Program, 1998, Kathmandu, pp. 10.

system is estimated at only Rs. 100,000 <sup>30</sup> per kW of installed capacity, which is below international figures.<sup>31</sup>

The government of Nepal has been emphasizing on the development of hydropower as a means for rural electrification since its fifth five-year plan (1975–1980). The policies for rural electrification including MH systems have been directed towards both the development of rural industries and household uses of electricity. As per the ninth plan (1997-2002), the government has targeted the provision of electricity to 8% of the rural population through the promotion of small and micro hydro systems to be attained by the year 2002.<sup>32</sup>

Since 1985, the government has been facilitating the development of MH systems by providing subsidies. Initially, the government provided a subsidy of 50-75% on the purchasing price of electrical components of MH systems for both private and community initiatives, which covered 13-20% of the total cost.<sup>33</sup> The investment cost of a MH system is very site-specific, and ranges from Rs. 100,000 to Rs. 200,000 per kW.<sup>34</sup> To make the subsidy policy even more effective, the government has come up with a new policy of providing a further subsidy of Rs. 55,000 per kW for the installation of less than 3 kW, and Rs. 70,000 per kW for MH systems generating electricity within the range of 3 to 100 kW.<sup>35</sup> For add-ons (adding generator for producing electricity in existing turbines), the government also provides Rs. 27,000 per kW. Furthermore, the government also offers provisions in terms of transportation subsidy, depending on the remoteness of the plant site. Likewise, investors are exempted from tax and royalty duties and are allowed to supply electricity and fix the tariff on their own. The Hydro Power Development Policy (1992) together with the Electricity Act (1992) and Water Resources Act (1992) have thus further facilitated the creation of a conducive environment for the development of MH systems.

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<sup>30</sup> Rs. is Nepalese currency. 1 Euro is equivalent to Rs. 68 (as of January 2002).

<sup>31</sup> Ibid.

<sup>32</sup> N.N., The Ninth Plan (1997-2002), National Planning Commission, His Majesty's Government of Nepal, 1998, Kathmandu, pp. 501-502.

<sup>33</sup> N.N., Community – Managed Rural Energy Development (Strategic and Operational Framework), REDP Publications 04/98, Rural Energy Development Program, 1998, Kathmandu, pp. 11.

<sup>34</sup> N.N., Renewable Energy Perspective Plan of Nepal, 2000-2020: An Approach, Vol-1, Main Report Centre for Energy Studies, Institute of Engineering, 2000, Nepal, pp. 13.

<sup>35</sup> N.N., Subsidy for Renewable Energy, His Majesty's Government of Nepal, Alternative Energy Promotion Centre, 2000, without place, pp. 2.

## 5 Rationale of Cost-Benefit Analysis (CBA)

According to Per-Olov Johansson, "societies must make choices on how to use their scarce resources of labor, capital, natural resources, and so on. At any point in time, the total amount of resources can be considered as fixed, implying that we are automatically faced with the fact that trade-offs must be made. If we ask for more of one thing, it usually means less of something else."<sup>36</sup> Thus, as the government's resources are limited, the development projects to be funded should be prioritized on the basis of their hierarchy in economic efficiency, given that the investment in one project means that resources are decreased and made less available for another. To ensure the economic efficiency of these scarce resources, only the project that yields maximum benefit to the society should be chosen.

### 5.1 Economic Analysis of Development Projects in Nepal

In the five decades of planned development, the government has given priority to various socio-economic sectors but has not been able to achieve the desired results. One of the major problems for not being able to do so is that the development projects are implemented without the conduct of proper economic analysis. The projects are initiated through foreign technical assistance, and by His Majesty's Government of Nepal (HMGN), non-governmental organizations (NGOs), District Development Committees (DDCs) and Village Development Committees (VDCs), only on the basis of a simple request letter made without any economic analysis, including a CBA.<sup>37</sup> Similarly, "the foreign aided new projects are forwarded without due information of actual performance, lack of comparative analysis of the project(s) and decision analysis. In the absence of prioritization of projects, too many projects are approved by the NPC."<sup>38</sup>

The present situation of development projects being implemented in the country implies that the limited resources are spent on projects without proper evaluation. The limited revenue sources and approval of 'too many projects' has not only led the government to excessively depend on foreign loans and grants but has also barred it from spending adequately on those projects that yield the maximum benefit to the society.

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<sup>36</sup> Johansson, Per-Olov, *An Introduction to Modern Welfare Economics*, Cambridge University Press, 1991, Cambridge University Press, p. 1.

<sup>37</sup> N.N., *Strengthening Project Screening System in National Planning Commission*, National Planning Commission and Nepal Administrative Staff College, February 1999, Kathmandu, pp. 10.

<sup>38</sup> *Ibid*, pp. 21.

## 5.2 Financial and Economic Analysis

### 5.2.1 Financial Analysis

A financial analysis is usually undertaken in order to evaluate the cost and benefit brought about by the project to a person or business.<sup>39</sup> According to the Asian Development Bank (ADB), "in financial appraisals (analyses), the tasks of identifying and valuing the project's benefits and costs collapse into one, since the benefits are given by the revenue receipts from the sale of the project outputs and the inputs are given by the costs (expenditure) of production. Market prices are therefore used as the unit of valuation. Projects are sustainable if their net benefits or positive effects endure as expected throughout the life of the project."<sup>40</sup>

### 5.2.2 Economic Analysis

An economic analysis is undertaken in order to assess the overall impact of projects on the economic welfare of the citizens of the country concerned. Thus, the scope of the economic analysis is larger than the financial analysis as it assesses a project in the context of the national economy.<sup>41</sup> According to the ADB, "for a project to be economically viable, it must be both financially sustainable and economically efficient. If a project is not financially sustainable, the economic benefit will not be realized. Financial analysis and economic analysis are therefore two sides of the same coin and complementary."<sup>42</sup>

When the result of the economic analysis indicates that a project is worthwhile for a society, but the financial analysis shows that it is not viable, it may be appropriate to provide subsidies for its promotion, assuming that projects which are not financially viable would not be able to attract private investors. The provision of subsidies may encourage private investors to eventually participate, as it will decrease the risk for them. On the other hand, if the project is financially viable, but its economic cost are judged too high, then it should probably not be promoted at all.<sup>43</sup>

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<sup>39</sup> Thompson, Paul and Handmer, John, *Economic Assessment of Disaster Mitigation, An Australian Guide*, Center for Resource and Environmental Studies, Australian National University and Flood Hazard Research Center, Middlesex University, 1996, without place, pp. 19.

<sup>40</sup> N.N., *Guidelines for the Economic Analysis of Projects*, Asian Development Bank, [http://www.adb.org/documents/guidelines/Eco\\_Analysis/financial\\_economic.asp](http://www.adb.org/documents/guidelines/Eco_Analysis/financial_economic.asp)

<sup>41</sup> Ibid.

<sup>42</sup> Ibid.

<sup>43</sup> Thompson, Paul and Handmer, John, *Economic Assessment of Disaster Mitigation, An Australian Guide*, Center for Resource and Environmental Studies, Australian National University and Flood Hazard Research Center, Middlesex University, 1996, without place, pp. 19.

## **6 Cost-Benefit Analysis of a Micro-Hydro System**

Given that the use of MH systems offers a viable option for providing electricity to populations in isolated and rural communities, the government has been trying to facilitate the growth of this sector. In this regard, the government has been providing subsidies to encourage private or community investment in this sector. Although the subsidy offered may attract the needed investments, considerable resources are further needed in order to achieve the desired results. As government resources are limited, the subsidies provided imply that the resource will not be available for other projects. In order to ensure that the resources spent on promoting the use of MH systems enable the government to meet development objectives in the rural areas, there is therefore a need to evaluate the relative economic efficiency of these systems.

Given the assumption that the net benefit of the society as a whole equals the sum of the benefits of individual members, the evaluation can be done by assessing the changes in the economic welfare of individuals (both producers and consumers) in the affected community. The changes in economic welfare can be measured as the benefit and cost brought about by the system in the community. Only when the benefit of a project exceeds its cost, then it is worth proceeding with. However, if the cost exceeds the benefit realized, it should be discarded.

### **6.1 Financial Analysis**

The financial analysis is conducted to assess the financial viability of MH systems. In the evaluation, both the cost incurred for establishment and operation of the system is compared with the revenues realized over the life of the system. Only when the revenue from the MH system exceed its cost, the system will be judged as financially viable.

#### *6.1.1 Financial Cost*

The cost incurred for the establishment of MH systems together with the cost of its operation for its entire life is taken as the financial cost.

##### *Capital Cost*

The establishment of MH systems require considerable initial or upfront investments. The investment is made to cover the cost of the different components of the system, i.e. termed as the capital cost. This consists of all the expenses for both equipments and services, from the planning phase until the commissioning of the system. The capital cost of the system generally includes the cost of conducting a feasibility study, the cost of design development,

the cost of weir, intake, canal, forebay, penstock pipe, turbine, generator, governor, powerhouse, distribution, etc.<sup>44</sup>

### *Operating and Maintenance Cost*

During the operational phase of a MH system, manpower is required in order to operate and maintain the system. The salaries of personnel needed for such activities, as well as all related personnel expenses, form part of the operating cost. Similarly, the cost incurred for regular maintenance of the system including its repair is taken as the maintenance cost.

### *6.1.2 Revenue*

The revenue realized from making use of MH systems is the amount received through the sales of both the mechanical and electrical energy generated by the system.

## **6.2 Economic Analysis**

Under the assumption that the sum of individual welfare gains equals the total net welfare of the society, the impact of MH systems on the welfare of each individual member of the society is assessed in the economic analysis. The individual's welfare is measured as the cost and benefit brought about by the system. In carrying out this analysis, all the cost and the benefit should be measured in terms of their monetary value.

### *6.2.1 Economic Cost*

The economic cost is the cost of establishing a MH system in a society. To calculate the economic cost, there is a need to define the boundary of the society for which the economic analysis is to be carried out. The capital cost as well as operating and maintenance cost will vary depending on the boundary of a society. For example, if labor and material for the establishment of a MH System is available within the society, then the cost incurred is not a cost to the society. It is a cost to the society only when they come from other society.

### *Capital Cost*

The MH systems in Nepal are generally financed through a mix of private, community investments, government subsidy and grants. For a community, their investment is

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<sup>44</sup> Frankel, P. et al., Micro-Hydro Power, a guide for development worker, Intermediate Technology Publication Ltd., 1991, London, pp. 13.

accounted as capital cost, when all of the equipment is manufactured and established by the people from other communities. If a part of the equipment is manufactured using local resources and established by the people of the same community in which the MH system is being established then the cost of that part would not be calculated in the total capital cost as the community neither gains nor loses with incurring such cost. Similarly, the subsidy and grant amount that is used in establishment of the MH system is not calculated as capital cost because the amount is not a cost for the particular community.

When the country as a whole is defined as a society for the analysis, then only that part of investment utilized for importing equipments for the system should be taken into account. If the equipment is produced and manufactured locally and established by the citizens of the country, then this cost does not form part of the economic cost for the country.

### *Operating and Maintenance Cost*

As in the case of capital cost, when a community is defined as a society, only if the operating and maintenance cost flows out from the community, they will be accounted as cost. If individuals of the same community undertake the operation and maintenance, then the community neither gains nor loses from the amount spent. Similarly, when the analysis is being done on a national level, then only the amount that flows out from the country should be taken into account.

### *External Cost*

External cost is the cost that incurs when the economic activity has an impact on someone other than the consumer or the producer. Environmental damage is one common type of external cost.<sup>45</sup> Although micro-hydro power is regarded as one of the most environmentally friendly methods of generating electricity, it is not totally without environmental problems.<sup>46</sup> Fish running into the turbine, water diversion affecting the irrigation system of farmers in the upstream, hazards of electrical supply to human beings and animals, surface mounted penstocks and transmission cables conflicting with the paths and tracts are some of the environmental problems that may be posed by the establishment of MH Systems.

### *6.2.2 Economic Benefit*

Individuals in a community can benefit from the establishment of a MH system in various ways. An individual can benefit from the energy generated from a MH system not only for

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<sup>45</sup> Chowdhury, Anis and Kirkpatrick, Colin, Development Policy and Planning, An introduction to models and techniques, Routledge, 1994, London and New York, pp. 114.

<sup>46</sup> Frankel, P. et al. Micro Hydro Power, a guide for development worker, Intermediate Technology Publication Ltd., 1991, London, pp. 15.



lighting purposes but more so for increasing his/her productivity. How a community and the nation as a whole can benefit from MH systems are discussed in more detail in the sections that follow.

#### *6.2.2.1 Benefit to a Community*

The potential benefit that individuals in a community can get with the establishment of MH systems can be summarized under the three major uses of electricity: (1) for industrial use, (2) for household use, and (3) for irrigation.

##### *Benefit from Industrial Uses*

With the establishment of MH systems, a rural village can propel its way towards economic growth through increased industrial productivity. Both mechanical and electrical energy generated through the system can be used for initiating industrial activities. Although only small-scale industries can be run through the energy generated from MH systems, it can still bring about considerable changes, affecting the welfare of people living in rural communities.

The MH-based energy can increase industrial productivity by either replacing traditional sources of energy or providing an opportunity to initiate new industrial activities. With mechanical and electrical energy, agro-processing units can be better operated, including grinders used for grains such as wheat and maize, hullers used for de-husking paddy to produce rice and oil expellers used for producing oil from mustard seeds. Apart from agro-processing, people in these areas are also enabled to operate sawmills in manufacturing furniture and other wood products, tailoring machines to produce garments and leather products, and refrigeration instruments for chilling milk. Similarly, small enterprises activities such as in cheese factories and bakeries can also be adequately supported.

Let us see how MH systems affect the welfare of people by taking the example of an agro-processing unit. Before having access to MH-based energy, people in rural areas of Nepal were grinding and milling grains using a manual process, locally known as *Dhiki Janto*, which requires a considerable amount of labor time. If people do not want to mill manually but want to get it done using machines, then they usually would have to walk a couple of hours to the mill where this service is being offered. However, for day-to-day household activities which require necessities like rice and wheat, walking for a couple of hours does not seem like an attractive option. Thus, in the absence of electricity, people opt to carry out the grinding and milling themselves and devote a considerable amount of labor hours fulfilling this function.

To illustrate further, we look at the case of making use of a huller. A huller can be operated through the energy generated from a MH system, and can be used for de-husking paddy in order to produce rice. How a farmer, as a producer of rice, can increase a producer's surplus

through the technological change can be explained with the use of a production function. The production function shows the maximum output the farmer can produce with a given amount of inputs.<sup>47</sup> The technological change, which the farmer has introduced in his production process, shifts the production function upward.

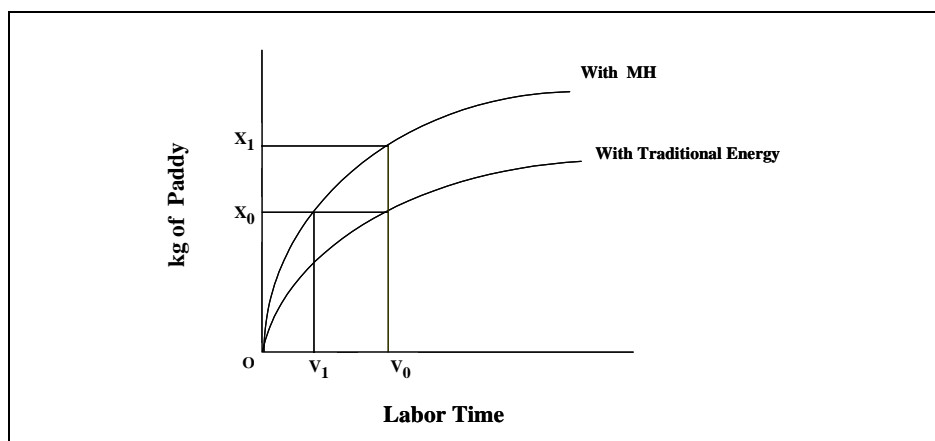


Figure 2: Saving of Labor Time

Figure 2 illustrates how a farmer, as a producer, can increase his surplus, by saving on labor time through introduction of an agro-processing unit. Before the introduction of electricity, a farmer used to mill quantity  $X_0$  of paddy at labor time  $V_0$ . With access to MH-based energy, the production function shifts upwards. The farmer can therefore mill the same quantity of paddy equivalent to  $X_0$  with labor time  $V_1$ . Moreover, a larger quantity of paddy  $X_1$  can be milled by the farmer with the same labor time  $V_0$ . Therefore, the introduction of technology through the use of modern energy increases the productivity of the farmer and therefore enhances his welfare.

#### *Benefit from Household Uses*

Households in rural areas can benefit from the use of electricity generated through MH systems in various ways. Households are able to use electricity for lighting, cooking, studying or for operating electronic gadgets such as radios and televisions. The benefit that a household derives from having access to electricity are described in more detail in the following sections, broadly grouped into two categories, namely, the benefit of lighting and the benefit of operating electronic gadgets.

<sup>47</sup> Samuelson, Paul A. and Nordhaus, William D. Economics, 15<sup>th</sup> edition, McGrawhill Inc, New York, 1995, pp. 103.

### *Benefit of Lighting*

The lighting that is made possible by the electricity generated through MH systems can bring with it dramatic changes in the lives of people. Without MH systems, people in rural areas have to live and carry out their activities either in the dark after daylight or would have to depend on lighting from kerosene lamps, should kerosene be available.

The kerosene lamp is widely used in rural areas where kerosene is available. However, the lamp provides low illumination and the fumes produced through the burning of kerosene can be hazardous to people's health. With its low illumination, school children of households that are dependent on kerosene lamps either have limited periods to study or may study longer, much to the detriment of their eye sight. In addition, the low illumination of kerosene lamps also means that people's activities during evening or after daylight are restricted and limited. The additional hours provided by having access to electricity-powered lighting means that people and households have more scope to engage in activities to generate income, children can study better and families are also more able to engage in social activities.

### *Saving on Household Expenditure on Lighting*

The figure below shows how a household may have better illumination at the same price or even at a lower price, through lighting produced by energy that is generated by a MH system.

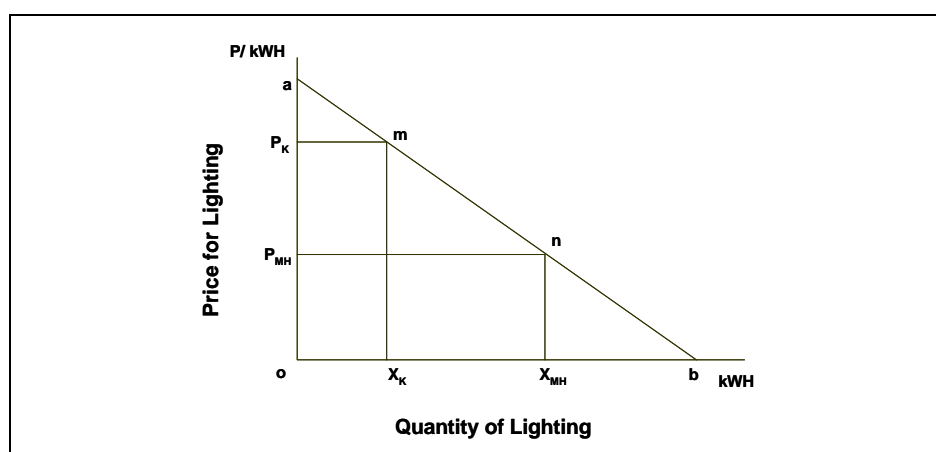


Figure 3: Saving on Expenses on Lighting

Let us suppose that  $ab$  is the demand curve showing what a consumer is willing to pay for lighting. On the basis of this demand curve, the consumer is willing to pay the price  $P_K$  for the quantity of lighting equivalent to  $X_K$ , generated through the burning of kerosene. With the electricity generated from the MH system, the consumer will have more quantity of light equivalent to  $X_{MH}$ . However, this additional quantity of light will cost the consumer the price  $P_{MH}$  only, which is less than the price paid for kerosene. Thus, given the decrease in the

price from  $P_k$  to  $P_{MH}$  and the increase in the quantity of lighting from  $X_k$  to  $X_{MH}$ , the consumer is able to realize an additional consumer surplus equivalent to  $P_k m n P_{MH}$ .

### *Benefit from Income Generating Activities*

People in rural areas are usually engaged in farming activities during daytime. Thus, without lighting generated through MH-based electricity, apart from farming, they do not have the capacity to engage in other income-generating (IG) activities. With access to electricity generated by MH systems, the extended time of lighting can be used to increase income by allowing households to engage in off-farm income generating activities. These may include carpet weaving, sweater knitting, traditional handicraft making, straw mat weaving etc.

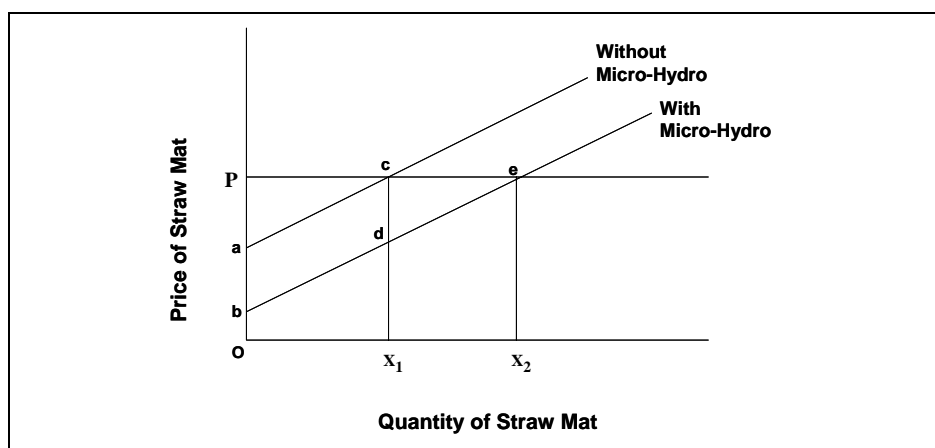


Figure 4: Benefit of Lighting in IG Activities

Using Figure 4 to illustrate, let us assume that members of a household weave straw mats when they have free time. Although the straw mats have a high demand in the market, during the farming season, their productivity is limited because their daytime is dedicated to farming activities. Without MH-based electricity, the household had limited time of exposure to light, during which period the production of a quantity of straw mats is equivalent to  $X_1$ . With this quantity, the household will get the turnover of  $OPcX_1$ . On the other hand, with access to lighting through MH-based electricity, the household will be able to go beyond this limit in its production capacity for straw mats, and thereby produce a quantity equivalent to  $X_2$ . As the additional supply of straw mats in the market is small in relation to its market quantity, the price of the product remains same. Thus, the household would be able to realize an additional turnover equivalent to  $X_1ceX_2$ . Given this turnover, the household's total producer's surplus will be equivalent to  $Peb$ , and the additional surplus achieved through the additional quantity of straw mats is equivalent to  $ced$ .

### *Benefit of Better Quality of Education and Health*

The deplorable situation of health and education in the rural areas has been regarded as one of the main obstacles in the rural development process. With lighting from MH-based electricity, children will have the opportunity to study under better illumination. This enables them to study for more hours after the passing of daylight. In addition, adult education initiatives will be more fruitful with access to electric lighting, as most adults residing in the villages are occupied with farming activities during the daytime.

Moreover, lighting produced by MH-based electricity will relieve people of the health hazards from the smoke created through the burning of kerosene lamps or other traditional sources of lighting. The availability of MH-based electricity will also make the medical treatments easier to carry out, either through better illumination provided or through the use of electronic medical equipment.

Via the improvements in the quality of education and health ushered in by people having access to MH-based electricity, the level of productivity of people in rural areas will also be positively influenced by improvements in their skills and knowledge. Thus, these improvements would lead to an increase in their welfare.

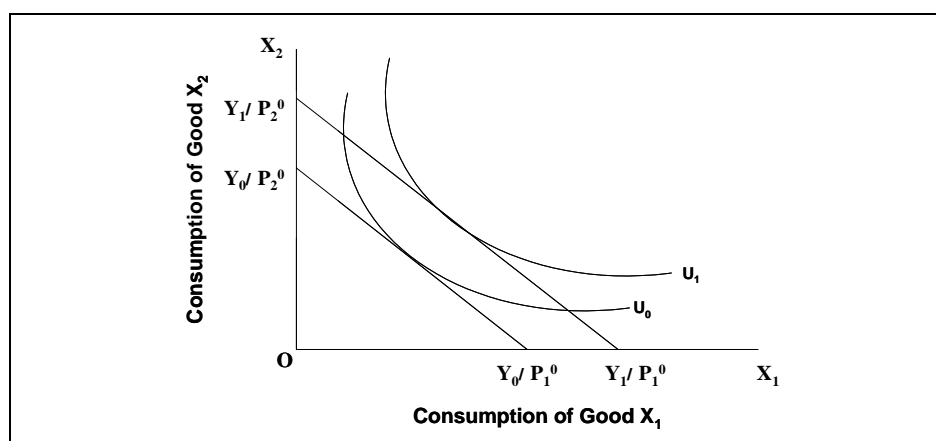


Figure 5: Benefit of Better Quality of Education and Health

Figure 5 shows how the welfare of people is increased through a rise in their level of productivity. Before having access to lighting through MH-based electricity, their level of productivity is limited, and therefore, they have low incomes. With low incomes, their household budget will be likewise limited, as depicted in the figure by the budget line  $Y_0/P_1^0$ . This budget line illustrates that people can consume either quantity  $Y_0/P_2^0$  of good  $X_2$  or quantity  $Y_0/P_1^0$  of good  $X_1$ . If they want to consume both goods, then they have to be satisfied with the combination of goods that corresponds with a point in the budget line  $Y_0/P_2^0$   $Y_0/P_1^0$ . As such, people will have the utility curve  $u_0$ . As enhanced productivity through access to electricity increases the income level of people, the resulting budget line shifts

upward. With a new budget line  $Y_1/P_2^0$   $Y_1/P_1^0$  the utility curve also shifts upward ( $U_1$ ), which is equivalent to the increase in the welfare of the people.

### *Benefit from Electronic Gadgets*

With access to electricity, people can now operate different electronic gadgets. As rural areas are generally isolated away from the cities, electronic gadgets such as radios, television, and internet facilities, etc, can serve as crucial means for people in these areas to have access to information. With the operation of such gadgets, people would be able to secure information from different corners of the world in their village, which may impact their knowledge base and skills. For example, if people are able to operate radios and television units, they will be able to get current information about markets relevant to their trade. This enables them to make better business decisions such as determining the competitive pricing of their products and equipments. Similarly, people in rural areas can also ease the burden of their daily household chores by using cheap electrical appliance for cooking. In doing so, people will be able to carry out their household activities using less labor time and make use of this saved labor time in other productive income-generating activities.

### *Benefit from Increased Interaction*

Having access to an extended period of lighting during the evening, people are afforded the opportunity to interact with one another, both within and outside their respective households for longer periods. This increased social interaction among the members of households or among community members may dwell on daily activities or the development of households or the community in general. The frequency of interaction will not only strengthen their inter-personal relations but also allow them to share information which may be useful in increasing their level of productivity.

### *Benefit from Irrigation*

In most of the rural areas of Nepal, people depend on climate-based agriculture due to the lack of adequate irrigation facilities. The dependence on rain as a source of water for crops has limited the level of agricultural productivity in rural areas. Given this situation, providing irrigation facilities via MH systems can assist households and communities in improving agricultural production, i.e. realizing increases in the number of harvests per year.

With the establishment of MH systems, farmers are better able to irrigate their land in two ways. First, they can make use of the electricity generated in order to run an electrical water pump. Second, water brought to run the turbine can be later used for the irrigation of farm land. The figure below shows how irrigation can bring changes in agricultural production, and hence produce an increase in the benefit realized among farmer-households.

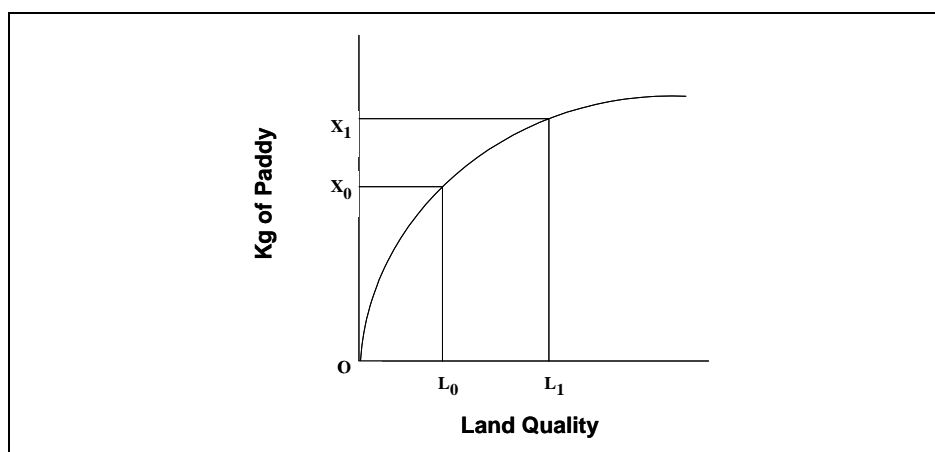


Figure 6: Increase in Agricultural Production

Let us suppose that given the absence of adequate irrigation facilities a quantity of paddy  $X_0$  can be produced with an input of a given size of land at land quality  $L_0$ . As land is the fixed factor of production, we cannot increase its area, but the quality of the land can be improved through irrigation. Thus, with irrigation, the quality of land can be changed from  $L_0$  to  $L_1$ , thereby shifting the production of paddy from  $X_0$  to  $X_1$ . This increase in the production of paddy then results in an increase in the welfare of farmers through an increase in their income.

#### 6.2.2.2 Benefit to a Country

MH systems, as a source of renewable energy, can act as a catalyst in rural development, which impacts the economic development of the country as a whole. An improvement in the welfare of the people in the community translates into an improvement in the welfare of the community as a whole. Similarly, an increase in the welfare of the community will lead to an increase in the welfare of the country as a whole. For example, an increase in the level of employment and income generated in the rural areas in the country will not only assist in alleviating poverty in the rural areas, but may also decrease the rate of unemployment registered in the country as a whole. Thus, an increase in productive activities in rural areas positively influences a country's prospect for economic growth. Moreover, the replacement of fuel-wood and kerosene as main sources of energy through the availability of MH-based electricity would be beneficial for the conservation of the environment, not to mention will allow a country to save on its foreign currency reserves needed to purchase such products from outside.

To calculate the benefit to the country as a whole, there is a need to take the shadow price of all cost and benefit into account. The shadow price is calculated to value the cost and benefit in real terms by avoiding any distortion in the market such as those produced by subsidies and tariffs. The use of the shadow price helps avoid the double accounting of any cost and benefit. For example, to calculate the savings made on household expenditure on

lighting, the cost of kerosene is compared with the cost of MH-based electricity. As the government provides a subsidy for kerosene, the benefit through saving in kerosene at the market price will not equal the real benefit to the country as a whole. On the one end, there is a cost for the government to provide a subsidy for kerosene. And on the other, the benefit is reduced, as the market price is not equivalent to the real price for the country. Therefore, in order to avoid this double accounting, the shadow price of the kerosene needs to be used in the calculations.

### **6.3 Aggregation of Cost and Benefit**

In the preceding sections, both the cost and benefit (revenue) relating to the financial and economic analysis have been discussed. As the future value of cost and revenue do not equal its present value, these should be analyzed using a discount rate. The choice of a discount rate is based on three economic and social arguments as forwarded by Dixon and Hufschmidt i.e. the opportunity cost of capital, the cost of borrowing money and the social time preference.<sup>48</sup>

Under the opportunity cost argument, the discount rate is taken as the market interest rate, since this reflects the minimum rate of return that a project should realize. To calculate the precise opportunity cost, the inflation rate should be deducted from the market interest rate. In terms of the cost of borrowing money, the discount rate is set at the interest rate charged for borrowings made in financing the project.

Under the social time preference argument, the discount rate varies, as the preference of the society for valuing the future value in comparison to the present value of cost and revenue might differ. For example, the preference for consumption at present vis-à-vis consumption in the future varies from society to society. Only when the discounted revenue exceeds the discounted cost over the lifetime of a MH system, will the system be deemed financially viable. Similarly, when the total benefit derived by a community exceed the total cost incurred, will the system be considered economically efficient.

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<sup>48</sup> Thompson, Paul and Handmer, John, Economic Assessment of Disaster Mitigation, An Australian Guide, Center for Resource and Environmental Studies, Australian National University and Flood Hazard Research Center, Middlesex University, 1996, without place, pp. 38.



## **7 Field Research**

### **7.1 Research Objective**

Given the tremendous potential for harnessing hydropower in Nepal, establishing MH systems can be seen as an effective strategy to provide electricity to scattered and isolated rural communities. The establishment of these systems requires considerable investment, and therefore justifies the need to evaluate the financial viability and economic desirability of these MH systems in order to ensure that the country's resources are utilized efficiently. The evaluation of these systems will enable the government to formulate adequate policies regarding the promotion of MH systems in particular and the development of rural areas in general.

Given this background, an empirical study was undertaken in Nepal from August - October 2001 in order to evaluate existing MH systems in place.

### **7.2 Research Methodology**

The empirical research was divided into two parts. In the first phase, secondary data regarding the development of MH systems in Nepal was collected from the various documentations and later verified through interviews made with representatives of organizations involved in the development of MH systems in Nepal. In the second phase, primary data was collected from existing MH systems.

#### *7.2.1 Secondary Data*

In order to get information on past activities, the present situation and the future prospects of MH systems within the context of rural areas in Nepal, a survey of related documentation, publications and literature was carried out. These were made available by the organizations engaged in the promotion of MH systems in the country. The empirical studies and other evaluation reports of the said organizations provided useful secondary data, which were then verified through interviews and meetings with representatives of these organizations, as well as via the workshops they organized.<sup>49</sup> The secondary data collected provided the background information for the collection of primary data.

#### *7.2.2 Primary Data*

In order to evaluate the financial viability and economic sustainability of the MH systems in general, there is a need to carry out an individual analysis of all the systems since the cost

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<sup>49</sup> The list of contact persons and representatives interviewed is given in the annex of this paper.

and benefit realized by each of the systems are affected by their site-specific conditions. This type of detailed analysis, however, requires time and resources, which this study faced as a constraint. Thus, considering the limitations and scope of this research, the collection of primary data, necessary for both the financial and economic analyses, was undertaken using only one MH system as a sample site. Additionally and to complement this analysis, primary data needed for the evaluation of the financial viability of two other MH systems was collected.

#### *7.2.2.1 Site Selection*

Given the predominance of MH systems with capacities less than 50kW in Nepal, those systems with varying capacities under 50 kW were selected for the research. The sites were also selected on the basis of three major models used for the establishment and management of MH Systems in Nepal<sup>50</sup>, with the chosen sites enumerated and described as follows:

<b>Name of MH System</b>	<b>Model</b>	<b>Power Output</b>
1. Daunekhola Micro-Hydro System	Donor, Local Bodies, Agency, Community Based Organization (CBO) Managed	12 kW
2. Angakhola Micro-Hydro System	Private Company Managed	5 kW
3. Tikhedhunga Micro-Hydro System:	Users Committee Managed	40 kW

Additional background information on these three systems will be provided separately in chapter 8.

#### *7.2.2.2 Interviews*

Prior to going to the field in order to collect primary data regarding the sample sites, interviews were made with the officials of support agencies i.e., the Rural Energy Development Program (REDP) in the case of Daunekhola MH System, and Annapurna Conservation Area Project (ACAP) in the case of Tikhedhunga MH System. The interviews

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<sup>50</sup> N.N., A Study on Rural Hill Potentials and Service Delivery System (Final Draft Report), SAPPROS-Nepal, 2001, Kathmandu, pp. 20.

were focused mainly on discussions concerning the project area and the initiatives of the respective organizations.

#### *7.2.2.3 Household Survey*

A household survey was carried out within the project site of the Daunekhola MH System (Pinthali, Kavrepalanchok district), which was established through the support of the REDP. A total of 40 households subscribing different amounts of electricity were chosen to form the sample out of a total population of 116 households. During the survey, members of these households were contacted and interviewed on the basis of a structured questionnaire, which consisted of questions regarding the economic changes brought about by the MH system.<sup>51</sup> In particular, the questions dealt with the changes in cost and benefit, specifically, the changes in prices, quantities, labor hours and income experienced by each respective household. Moreover, the households were also asked about the changes they have experienced in the areas of education, health and their access to information.

#### *Observation*

Benefit from having access to electricity in the three sites mentioned were observed by the researcher, which included observations made of the powerhouse, turbine, transmission and distribution systems. Visits to different households were also carried out in order to look into the lighting usage made by the respective beneficiaries.

#### *7.2.3 Limitation*

##### *Research Period*

As the period allotted for carrying out the research was approximately two months only, detailed research could not be done on all three MH systems. In Angakhola and Tikhedhunga, only the financial data were collected. However, in the case of Daunekhola, data covering 40 households were gathered.

##### *Primary Data*

Primary data regarding the changes in income level brought about by the changes in productivity, which further result from the changes experienced in education, health, access to information and increased interaction could not be measured using the sample under the Daunekhola MH system. The system was only established in 1998. And since recognizing the

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<sup>51</sup> A sample of Household Survey Questionnaire is attached in the annex.

impact brought about by the changes experienced in the sectors mentioned above requires a longer period of observation, the analysis has been made on the basis of early indications.

#### *Constraints in Data Collection*

Most of the collected data are on the basis of the data provided by the respondents. Thus the validity of the data hinges upon two main constraints found in the way the data was collected. i.e. recall or memory and hiding of information.

Most of the primary data collected through the structured questionnaire relied on recall or the memory of the respondents as they did not have recorded data. Thus, in the process of making the analysis, developing certain assumptions was called for. Moreover, it was also observed that there was a tendency on the part of certain respondents and interview partners to hide information for various reasons which could not be disclosed to the researcher.

## 8 Research Areas

### 8.1 Daunekhola Micro-Hydro System<sup>52</sup>

The Daunekhola MH System was installed in 1998 with the support given by the Rural Energy Development Program (REDP)<sup>53</sup>, a joint undertaking of the United Nations Development Program (UNDP) and His Majesty's Government of Nepal. There were altogether 116 households in the community in Pinthali making use of energy generated from the system with a power capacity of 12 kW. This MH system uses water from the nearby river Daune Khola.

The community members of Pinthali are homogeneous by ethnicity, most of them tracing their origins from the *Tamang* community. Agriculture is the main source of livelihood of its people and the community is likewise characterized by patterns of seasonal migration. A couple of years ago, in order to reach Pinthali, one had to walk for about six hours from the nearest urban area, Dhulikhel. During the conduct of the study, a highway was under construction passing through the foot of the hill. However, despite this development, people still have to walk about thirty minutes uphill in order to reach the community, which is located on the top of a hill.

There is a primary school within the community, but the nearest secondary school is located about an hour away by foot. Similarly, the community is characterized by an absence of any modern health treatment facility. There is neither a health post nor a shop that sells modern medicines. In terms of communications infrastructure, there are no telephone facilities in the area. However, people have access to radios. Recently, owing to their access to MH-based electricity, people in this community have started to acquire television units.

The MH system is owned by the Daunekhola Micro-Hydro Cooperative, which is organizationally structured to include an equitable participation of all households of the community. The MH system is managed and operated by the local people who are trained with the support of REDP. Energy generated from the MH system is mainly used for lighting purposes. All the households in the village are linked to the electricity source and maintain electricity subscriptions ranging from 25 to 150 Watts. For the use of electricity, subscribers pay tariffs on a flat rate, which is Rs 0.60 per watt of electricity used per month.<sup>54</sup> In terms of industrial use, there is a huller and oil expeller being run through mechanical and

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<sup>52</sup> The REDP refers to the scheme as the Daunekhola Micro Hydro Demonstration Scheme. The information is based on the different publications of REDP, personal observations and interviews made.

<sup>53</sup> The REDP has been in implementation since 1996. Its basic objective is to support and improve rural livelihoods and preserve the environment through the promotion of MH systems and other renewable energy technologies in the country. Given this objective, the Daunekhola MH system was developed as one of the demonstration schemes.

<sup>54</sup> As the meter for the consumption of electricity is expensive, most of the MH systems use only a controller which automatically cuts off the line if the user tries to use more electricity than what the customer has subscribed for.

electrical energy generated by the MH system. Both units are owned by the Cooperative and are leased to individuals for its operation. The Cooperative receives Rs 9,000 per year from leasing out the huller and Rs 25,000 from leasing out the oil expeller.

A grant from REDP is the major source of financing for the MH system. Apart from the equity participation of the District Development Committee, the Village Development Committee and the community members themselves, a subsidy is also provided by the government for the establishment of the MH system. The committee has also acquired a loan from the Agricultural Development Bank, which has already paid and settled since. The sources of financing and the amount for the establishment of the system is specified further on Table 1.

Table 1: Sources of Financing in Daunekhola MH System<sup>55</sup>

<i>Sources of Financing</i>	<i>Amount (in Rs.)</i>
Grant	
REDP	668,336
HMG Subsidy	199,150
Loan	
Bank Loan	189,686
Equity Participation	
DDC Equity	100,000
VDC Equity	100,000
Community Equity (cash)	79,500
Community Equity (labor and material)	144,837
<i>Total</i>	1,481,509

## 8.2 Tikhedhunga Micro-Hydro System<sup>56</sup>

The Tikhedhunga MH System is located in Tikhedhunga, along the Annapurna Circuit Trek, which is the popular trekking route for tourists visiting the country. The MH system was established in 1997 through the support from Annapurna Conservation Area Project (ACAP), which aims to reduce the stress on critical natural resources such as forests through wider use of electricity and other alternative energy sources. There are altogether 12 hotels and 90 households which have access to the electricity generated by this 40 kW plant. Water from Bhurungdi Khola is used by the MH system. Apart from the Tikhedhunga community, the electricity generated is also distributed to nearby communities such as Kamitole, Saber,

<sup>55</sup> N.N., Profile of Micro Hydro Schemes, Kavrepalanchok, District Development Committee, Rural Energy Development Section (DDC: REDS), Kavrepalanchok, 2000.

<sup>56</sup> This is based on the information provided by ACAP, personal observations and interviews made.

Hile and Sudame. Most of the people in the communities are depended on agriculture as their main source of livelihood.

The owner of the MH system is the Tikhedhunga Micro Hydro Users' Committee, which is composed of representatives of the different beneficiaries. A manager and an operator are hired by the committee for the management and operation of the system. The system is operated only from evening until the morning of the following day. The electricity generated is used mainly for lighting and the hotels with access also use it for boiling water. In terms of the electricity tariffs paid by the users, the hotels are charged Rs. 0.90 per watt per month, while the households are charged Rs 0.60 per watt per month.

The system is being financed through funds received from the British Embassy and ACAP. Similar to the former case, the user's committee received government subsidy as well as loans for the establishment of the system. The loan, however, has already been paid back. Over and above this, there is also a financial participation of the local communities. The sources of financing and the amount received for the establishment of the system is given in the table below.

Table 2: Sources of Financing in Tikhedhunga MH System

<i>Sources of Financing</i>	<i>Amount (in Rs.)</i>
Grant	
Donors	2,240,000
ACAP	292,835
Local+ADBN <sup>57</sup>	1,143,001
Loan	
ADBN	695,500
ACAP	606,486
Total	4,977,822

### 8.3 Angakhola Micro-Hydro System<sup>58</sup>

The Angakhola MH System is an add-on MH system established in 1992. It is a system that is privately owned and managed, and system has a capacity of 5 kW, providing electricity to 22 households residing in the community of Angakhola. Initially, agro-processing units including a huller, a grinder and an oil expeller were installed by the owner. Five years later, the owner instead installed a generator for producing electricity.

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<sup>57</sup> The local equity participation and the amount of subsidy from the government could not be distinguished as data provided by ACAP. However for analysis the local cost including labor has been calculated at Rs. 200,000, as told by a member of the User's Committee.

<sup>58</sup> This is based on personal observations and interviews made with the manager and the community members.

Angakhola is situated in the Pipal Danda Village. The communities are extended along the Pokhara-Sunauli highway, 26 km from Palpa. People in this area share a heterogeneous ethnic background. As Angakhola is also considered for its market place serving the nearby villages and travelers, almost all the households consuming electricity from the system are found along the highway, with shops that sell different products, mostly provisional goods and clothing/garments.

The mechanical and electrical energy generated from the MH system is being utilized by the different subscribers. During day time, the system is used for running a huller and oil expeller units, while in the evenings and wee hours in the morning, the electricity is sold to the different consumers. Charges for the use of the electricity are made on a flat rate basis, i.e. Re. 1 per watt per month. The plant is being managed by the owner himself. However, for operating the plant and the mill, a local operator is hired. As the manager himself is formally trained in repairing a MH system, there is no need to go to the repair center unless there are major problems in the system. To finance the system, the manager himself has invested Rs.70,000 which he obtained as a loan from the Agriculture Development Bank (ADB/N). He has also received subsidy from the government for the installation of the system. The financing structure for the electrical installation is given on the table below.

Table 3: Sources of Financing in Angakhola MH System<sup>59</sup>

<i>Sources of Financing</i>	<i>Amount (in Rs.)</i>
Subsidy from HMG/N	30,000
Loan from Bank	70,000
<i>Total</i>	100,000

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<sup>59</sup> As the MH system is add- on type, no investments were made apart from those having to deal with the electrical installation. Thus, total investments in this case will be calculated based on the cost of added components only.



## 9 Results

### 9.1 Financial Analysis

As noted in the earlier chapters, a financial analysis is conducted in order to assess the financial viability of a project on the basis of its cost and revenue. Thus, for the financial analysis of the MH systems, data pertaining to all the expenditures incurred for the establishment of the respective MH systems and their generated revenues are taken into consideration.

#### 9.1.1 Financial Cost

##### *Capital Cost*

For the calculation of the capital cost incurred by the MH systems, the cost incurred from the planning until the supplying of energy to the final users were collected. The capital cost for the three MH systems and their respective cost per kilowatt is enumerated as follows.

Table 4: Capital Cost of MH Systems

<i>MH System</i>	<i>Installed Capacity (in kW)</i>	<i>Total Cost (in Rs.)</i>	<i>Subsidy (in Rs.)</i>	<i>Grant (in Rs.)</i>	<i>Financial Cost (in Rs.)</i>	<i>Financial Cost per installed kW (in Rs.)</i>
Angakhola MH	5	100,000	30,000	0	70,000	14,000
Daunekhola MH	12	1,481,509	199,150	668,336	614,023	51,169
Tikhedhunga MH	40	4,977,822	943,000	2,532,835	1,501,987	37,549

The data on Table 4 clearly shows that the capital cost of the systems are higher for those with higher capacities, both in terms of the total cost (capital cost including subsidy) and the financial cost (capital cost excluding subsidy). We see a drastic change, however, between the financial cost per kilowatt reported under the Angakhola MH system and the other two MH systems. In contrast to the other two systems, the Angakhola MH System is considered an add-on only, and thus, only the cost of electrical installation has been accounted for the cost of this system, resulting in comparatively lower cost per installed kW.

The cost of MH systems vary, depending on the type of components installed. For example the quality of the canal can temporarily or permanently change the cost of the system. The cost also include the cost of transporting the different components of the system, and thus,

the distance from the main road to the actual site affects the overall cost of the setting-up the respective systems.

### *Operating and Maintenance Cost*

The annual operating and maintenance cost of the three MH systems are calculated on the basis of the annual salary of the manager and the operator of the systems, plus other maintenance cost as they are reported. In the case of the Angakhola MH System, only an operator and the owner manage the system. Salary expenses only include the salary of the operator, who is paid Rs. 1500 per month.<sup>60</sup> In the case of the Daunekhola MH System, the operator and the manager is the same person, whose salary has been reported at Rs 1,500 per month. Lastly, in the case of the Tikhedhunga MH System, a manager and two other operators are employed, each receiving Rs 2,200 per month. Other maintenance cost for each of the system have been calculated using a rate of 3% of total cost.<sup>61</sup> This assumption was made since the exact costs could not be provided.

Since the Daunekhola MH System and the Tikhedhunga MH System have already paid back their respective loans during the initial years of operation, the interest amount was no longer included in the computations. Hence this amount was considered as being part of the amount invested by the owners themselves. For the comparison the interest on loan of Angakhola has also been neglected.

Table 5: Annual Operating and Maintenance Cost

<i>MH System</i>	<i>Operating Cost (in Rs.)</i>	<i>Maintenance Cost (in Rs.)</i>	<i>Total (in Rs.)</i>
Angakhola MH	18,000	3,000	21,000
Daunekhola MH	36,000	44,445	80,445
Tikhedhunga MH	52,800	149,334	202,134

Consistent with the previous observations, the data on Table 5 also show that the annual operating cost, which include both the salary and maintenance cost of the respective MH systems, vary according to the capacity of the systems.

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<sup>60</sup> In computing the salary of the operator of the Angakhola MH System, only 50% of his total salary was used as he is employed to operate both the agro-processing units and the electrical installation.

<sup>61</sup> Frankel, P. et al. Micro Hydro Power, a guide for development worker, Intermediate Technology Publication Ltd., 1991, London, pp 15. – 'In practice it is down time (lost income due to an idle system) that costs more than the maintenance itself, and it is important to allow from two days to a week or so per year in total for this, depending on location, quality of equipment, calibre of skilled staff etc.'

### 9.1.2 Revenue

The revenue of a MH system is the amount received through the sales of energy generated by the system, which include both the mechanical and electrical energy. The annual financial returns of the three MH systems are reported as follows.

Table 6: Annual Revenue

<i>MH System</i>	<i>Return from Household Uses (in Rs.)</i>	<i>Return from Industrial Uses (in Rs.)</i>	<i>Total Revenue (in Rs.)</i>	<i>Return per installed kW (in Rs.)</i>
Angakhola MH <sup>62</sup>	36,000	0	36,000	7,200
Daunekhola MH <sup>63</sup>	45,720	29500	75,220	6,868
Tikhedhunga MH	334,800	0	334,800	8,370

Table 6 figures show that the total annual revenue is higher for systems with greater capacities. However, the revenue generated per installed kW varies according to the total capacity utilized and the tariffs charged. The revenue per installed kW is highest in Tikhedhunga, which is due to the high capacity utilization of this MH System for household uses during early mornings and evenings. However, as there are no day time uses for the system, only 63% of the total capacity of the system is being utilized.

In the case of the Angakhola MH System, which generates the second highest returns among the three MH systems, the personal use of the electricity by the owner was not included in the calculations. Moreover, as the electrical installation is an add-on only, day time uses of the system were also not taken into account because electricity is not produced during day time. It should be noted that even when the personal use is not taken into account, however, and the capacity utilization which excludes day time uses is kept at 60%, the return generated by this MH system still remains high, given the relatively high tariff rate of Re 1 per watt per month charged.

In case of the Daunekhola MH System, although the daytime use of this MH system is recognized in our computations, the return still remains low. Only about 53% of the total capacity is sold, covering both evening and morning capacity utilization, and the tariff rate

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<sup>62</sup> As Angakhola MH System is an add-on system only returns from the electrical installation has been taken into account. In addition, returns from the use of the electricity for the purpose of the manager himself are not taken into account. He uses the electricity himself both for household uses including lighting and IG activity, i.e. poultry farming.

<sup>63</sup> The return from industrial uses is calculated on the basis of amount received from huller and oil expeller. Therefore the cost of the huller and oil expeller has not been taken into consideration though the units are owned by the Cooperative itself.

remains low at Rs 0.60 per watt per month. Although this MH system is used during the daytime, the revenue generated is only Rs 0.20 per watt per month.<sup>64</sup>

### 9.1.3 Aggregation of Financial Cost and Revenue

For the evaluation of financial viability of the MH systems, the cost and revenue over their entire life should be aggregated under a common measure. Accordingly, the cost and revenue generated by the systems are discounted using the real interest rate in Nepal, which is pegged at 6% per annum. The real interest rate is calculated by subtracting the inflation rate of 10% per annum<sup>65</sup> from the market interest rate, which is 16%. The market interest rate is the rate charged by Agricultural Development Bank/ Nepal (ADB/N), which is a loan provider for the establishment of MH systems. After discounting the cost and revenue of each year using the discount rate, the resulting discounted cost are subtracted from the discounted revenue in order to arrive at the net present value (NPV).<sup>66</sup> The net present value of the systems are computed and shown as follows:

Table 7: Net Present Value

<i>MH System</i>	<i>At Net Financial Cost (in Rs.)</i>	<i>At Total Cost (in Rs.)</i>
Angakhola MH	75,683	45,683
Daunekhola MH	-489,951	-1,357,437
Tikhedhunga MH	-269, 911	-3,945,746

Table 7 shows that only the Angakhola MH System is financially viable among the three, with return generated higher than the cost incurred. The return is higher even when compared against the net financial cost as well as the total cost (cost of capital including subsidy). The other two systems have negative NPV, which implies that the investors are incurring losses with their respective investments in these MH systems.

## 9.2 Economic Analysis

As the scope of the economic analysis encompasses the welfare effect to all members of a society, the definition of cost and benefit as used in the analysis differs from that made

<sup>64</sup> As the consumption of energy for the agro-processing, i.e. huller and oil expeller could not be acquired, the return per watt has been calculated on the basis of total available capacity.

<sup>65</sup> N.N., Quarterly Economic Outlook, The World Bank, Kathmandu, July 1999. ([www.worldbank.org.np](http://www.worldbank.org.np))

<sup>66</sup> See annex for detail calculations.

under the financial analysis. The evaluation of efficiency can be assessed through changes in the welfare of the society on the basis of the cost and benefit brought about by the system to society. In this analysis, we assess the efficiency of the investments made in the Daunekhola MH System.

### *9.2.1 Cost and Benefit to the Community*

Under the assumption that the sum of the changes in individual welfare equals the changes realized by the society as a whole, a household survey was carried out in Pinthali in order to find out the changes in the welfare of individual households in the community, i.e the cost and benefit brought about by the Daunekhola MH System to household subscribers. The survey was made covering a total of 40 households, representing a total population of 116 households benefiting from the system.

#### *9.2.1.1 Economic Cost*

The economic cost is the sum of the cost brought about by the system to each individual member in a society. Thus, the economic cost includes the cost of an investment required for the establishment of the system as well as other cost borne by the individual members of the society. However, if a cost to an individual may be a benefit to another in the same society, such cost are ignored since the society neither gains nor loses from such cost. Thus, it is important to identify such cost and differentiate them from capital cost as well as other operating and maintenance cost in order to arrive at the real economic cost.

#### *Capital Cost*

In terms of the capital cost, only that which is spent on purchasing components from outside the community for the establishment of the Daunekhola MH System i.e. non-local cost is taken as the capital cost. In addition, as the community has received a subsidy and grant for the system, these amounts are further deducted from the capital in order to calculate the net capital cost to the community. Thus, the net capital cost to the community is calculated as follows,

$$\begin{aligned}\text{Net Capital Cost} &= \text{Total Cost} - \text{Local cost} - \text{Government Subsidy} - \text{REDP Assistance} \\ &= 1,481,509 - 144,837 - 199,150 - 688,336 \\ &= \text{Rs. } 449,186^{67}\end{aligned}$$

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<sup>67</sup> The Net Capital Cost equals the investment made by the community, and the local bodies, i.e. District Development Committee (DDC) and Village Development Committee (VDC). Although the amount received from the two local bodies DDC and VDC is not a cost to the community, it is included in the Net Capital Cost, as the amount has been invested as equity participation of DDC and VDC in the system.

### *Operating and Maintenance Cost*

Similar to capital cost, local cost are not included under the operating and maintenance cost. In the case of the Daunekhola MH System, both the manager and the operator are from the same community. Therefore, there are zero operating cost. The society as a whole does not gain nor lose from paying such an amount. The maintenance cost, on the other hand, is taken to be equivalent to 3% of the total cost of the system, to cover the costs related to repairing the system (i.e. materials purchased and technicians hired from outside). In summary, the total operating and maintenance cost for the system amounts to Rs. 44,445.

### *External Cost*

There is an underlying assumption that any project will incur at least some amount of external cost. These may include the cost of the disturbance in the natural ecology through the construction of the canal and diverting water from the river, the obstruction created by the construction including the penstock, or the potential hazards from electricity transmission and distribution. However, in the case of the Daunekhola MH system, this cost is assumed to be negligible.

#### *9.2.1.2 Economic Benefit*

The net benefit to all individuals in a society brought about by the MH system is considered as the economic benefit of the system as a whole. The net benefit to an individual can be measured through the aggregation of all the benefit and the other cost incurred, apart from the cost of the system. The net benefit brought about by the Daunekhola MH System is calculated on the basis of industrial, household and other uses.

#### *Benefit from Industrial Uses*

In considering the industrial uses of the Daunekhola MH System, a huller and an oil expeller is being operated through the use of energy generated from the system. These two agro-processing units have been installed by the MH Cooperative, making use of the energy generated by MH systems during day time. The service rendered by these units carries both cost and benefit to individuals in the community. Figure 7, depicts how the agro-processing units established after the setting-up of the MH system affect the individuals in the community.

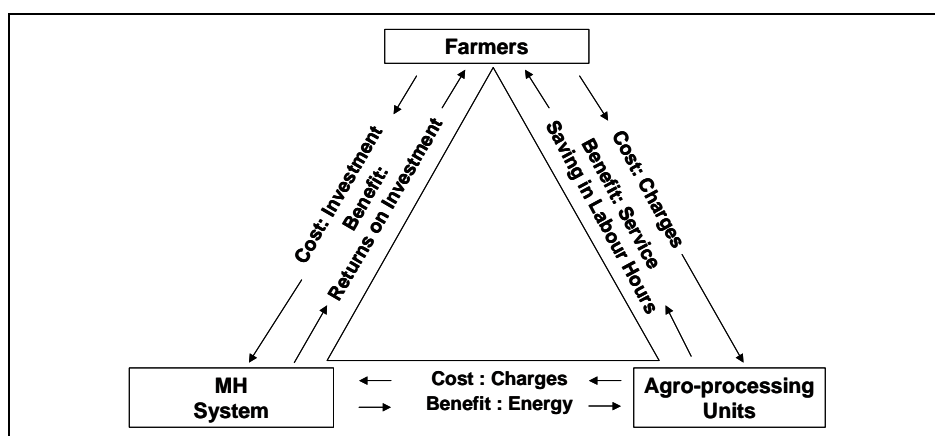


Figure 7: Cost and Benefit of Agro-processing Units

The farmers (individuals) in the community realize benefit from the agro-processing units in terms of the service rendered for de-husking paddy and producing oil. Given this, the individuals are able to save on labor time, but need to pay certain charges for the service rendered. For persons running the agro-processing units, the cost includes the cost of acquiring or purchasing the unit itself and their benefit is equivalent to the fees or charges they received for the service provided by the unit. The return generated by the MH system is equivalent to the amount charged for the energy supplied for these agro-processing units. This return is a benefit realized for all individuals in the community, equivalent to the return on the investment they made in setting up the system.

### *Benefit to the Farmers*

In calculating the net benefit to the farmers brought about by the agro-processing units operated through the MH-based energy, the cost and benefit for the previous agro-processing unit used is compared with the present method. The cost and benefit brought about by Huller and Oil Expeller are summarized in the table that follows.

Table 8: Cost and Benefit of Agro-processing Units

<i>Huller (Paddy)</i>		<i>Oil Expeller (Mustard)</i>	
<i>Time Saved per Kg.</i>	<i>Charge per Kg.</i>	<i>Time Saved per Kg.</i>	<i>Charge per Kg.</i>
<i>(in mins.)</i>	<i>(in Kg.)</i>	<i>(in mins.)</i>	<i>(in Rs.)</i>
23.53	0.05	51	3

### *Huller*

Before establishing the huller, almost all the people in Pinthali produce rice from paddy through a traditional process known as *Dhiki*. With the installation of the huller after the establishment of the MH system, individual farmers have been able to decrease their labor time for de-husking one kilogram (kg.) of paddy by 23.53 minutes. In order to use the huller for de-husking, they have to pay 0.05 kg of paddy for each kg they de-husk.<sup>68</sup> As the market rate of paddy is Rs.16 per kg, the cost of time saved, i.e. for every 23.53 minutes for each kg of paddy, is equivalent to Rs 0.80. The people, especially the women, will be freed from the burden of having to use the traditional process *Dhiki*. The saved labor time can be used either in agricultural production or other income-generating activities.

### *Oil Expeller*

Without the MH system, the farmers in the community used to produce oil from mustard seeds using either of two practices. One is the traditional method in village known as *Kohl*, which requires a tremendous amount of labor time. If they opted not to do it manually, people had to walk for at least half an hour to reach to the nearest expeller in order to carry out the production, which requires both time and money. With the expeller available in the village, the farmers can save 51 minutes of their labor time per kg of mustard, with a cost of Rs 3.<sup>69</sup>

### *Benefit for the Operators*

With the establishment of the MH system, an opportunity for employment has been created for two persons needed in operating the agro-processing units. In terms of the cost, the operators have to pay Rs. 20,500 per year for the oil expeller and Rs. 9,000 per year for the huller. The benefit they get in return is the revenue in lieu of service rendered to the farmers in the community. As the exact returns made from the units were not recorded, the operators do not have the total amount of earnings per year. However, the operator of the huller estimated that he earns about 5 kg of paddy per day.

The market rate for 5 kg of the paddy is equivalent to Rs. 80. Similarly, the operator of the oil expeller estimates that the expeller is used to produce oil from 21 kg of mustard seeds daily. Given this estimate, he therefore earns approximately Rs. 168 daily. Thus, in summary, the operator of huller earns approximately Rs. 24,000 per year and the operator

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<sup>68</sup> The amount has been calculated on the basis of average labor time saved and average cost as reported by the respondents. During the survey, two persons did not reply to the question regarding savings in labor time and another four did not reply to the changes in cost.

<sup>69</sup> Only very few people seem to be producing oil from mustard. During the survey, 30 of the respondents did not make any comment regarding the changes in costs and benefits brought about by the oil expeller. However, the average has been calculated on the basis of the total number of respondents.



of oil expeller approximately earns Rs. 50,400 per year, based on the assumption that the mill is run for 300 days a year. The annual net benefit that the operator of huller receives is Rs. 13,000, while the operator of the oil expeller realizes a net benefit equivalent to Rs. 29,900 per year.

### *Benefit from the MH System*

The benefit from the MH system is an earning through the sale of energy generated. The net benefit of the MH system in terms of its industrial use is the amount paid by the operators of the two agro-processing units, which equals Rs.29,500.<sup>70</sup> There is no additional cost for the MH system for providing the energy during day time as the operator of the oil expeller and the operator of the MH system is the same person.

### *Net Benefit from Industrial Uses*

The net benefit from the industrial uses made of the Daunekhola MH System equals the net benefit to the individuals in the community. As farmers, operators and other individuals who have invested in the MH systems are all members of the society, their total net benefit from the industrial uses made of the system is equivalent to the benefit to the society as a whole. Thus,

#### Net Benefit from Industrial Uses

- = Net Benefit from Agro – Processing Units
- = Net Benefit to the farmers + Net Benefit to the Operators of Agro-processing Units + Net Benefit to the Investors
- = (Savings on Labor Time – Cost to the Farmers) + (Cost to the Farmers – Cost of Energy) + (Cost of Energy)
- = Savings on Labor time

### *Benefit from Household Uses*

The households in Pinthali benefit from the electricity generated by the Daunekhola MH System in two ways, namely through lighting and through the operation of electronic gadgets. Their cost for getting the benefit is the electricity tariff that they have to pay for.

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<sup>70</sup> Although the Cooperative is the owner of both agro-processing units, the amount that the operators pay has been assumed as the charge paid for the usage of the energy. Thus, the return on investment of the agro-processing units is not incorporated into this computation.

### *Benefit from Lighting*

Given the electricity generated by the MH system, the individual households benefit through replacement of previous sources of lighting by electricity. When the cost for electrifications is lower than previous sources, the household is able to save on their expenses for lighting. With better illumination through the availability of MH-based electricity, the welfare of the people is improved through the possibility of being able to initiate new income-generating activities. In addition, the individuals in the community can benefit from the increase in their productivity level through better education and health levels. Along with the increase in productive activities, individuals can also benefit through improvements in agricultural production.

### *Savings on Household Expenditure for Lighting*

Before the establishment of the MH system, the beneficiary households in Pinthali, used to depend on wick kerosene lamps for lighting their houses and flashlights when conducting activities outside their houses. Thus, the cost of lighting for the community without the MH system is equivalent to the cost of purchasing kerosene and batteries. The cost of lighting with and without the MH system is given in the following table.

Table 9: Annual Savings on Lighting

<i>Expenses on sources of Energy</i>	<i>Amount (in Rs.)</i>
A. Without MH System	
Kerosene	37,440
Battery	19,680
<i>Total</i>	57,120
B. With MH System	
Kerosene	11,640
Battery	7,920
Electricity	13,464
<i>Total</i>	33,024
<i>Savings (A-B)</i>	24,096

On Table 9, it can be seen that the electricity generated by the system has decreased the expenses of the 40 households surveyed. The changes in expenses incurred, show that the community realizes a net benefit equivalent to Rs. 24,096 per year with the MH system. On

the basis of the amount saved, it can be derived that the total savings of the community approximates Rs. 69,878 per year.<sup>71</sup>

### *Benefit from Income-Generating Activities*

The individuals in the community are using the light produced through the MH-based electricity for more hours than what a regular kerosene lamp can accommodate. The extended hours of lighting has provided opportunities for individuals in the community to increase their income by initiating a number of other income-generating (IG) activities.

Apart from the two operators of the huller and the oil expeller, five households who are among the 40 respondents of the survey were found benefiting from the electric lighting via the initiation of new IG activities. Among them, two are using the extended hours of lighting for *Thanka* painting.<sup>72</sup> Both of these households reported that the quantity of the paintings they produced used to be limited since kerosene lamps provided very low illumination for this purpose.

The other two beneficiaries are households with the grocery stores. The owners reported that they now can maintain longer open-shop hours for their stores and therefore have more business than usual. However, of these two, only one store indicated an increase in income generated. Table 10 provides a more detailed account of these beneficiaries, including their names, the type of activities and their estimated yearly increase in benefit.

Table 10: Benefit from IG Activities

<i>S.No.</i>	<i>Name</i>	<i>Type of Business</i>	<i>Increase in Benefit per year (Amount in Rs.)</i>
1	Bahadur Singh	Tea Shop/ Grocery	7200
2	Thulo Babu	Grocery Store	0
3	Bajra Dhoj	Thanka Writing	36,000
4	Sukbir Lama	Thanka Writing	36,000
		<i>Total</i>	79,200

On the basis of results pertaining to the benefit derived from IG activities as shown on Table 10, the total amount of earnings made from IG activities of all households in the community can be estimated at Rs. 229,680.<sup>73</sup>

<sup>71</sup> The total amount of savings is calculated by taking the average saving per household from the savings of 40 households. This is then multiplied by the total number of households in the community, i.e. 116.

<sup>72</sup> *Thanka* is the traditional painting, which is highly demanded by tourists visiting Nepal.

<sup>73</sup> The total amount of savings is calculated by taking the average savings per household from the savings of 40 households, and then multiplying it by the total number of households in the community i.e. 116.

## *Benefit of Better Quality of Education and Health*

### *Education*

The better quality of illumination produced by the lighting with MH-based electricity can change the quality of education in the village. However, as it is difficult to measure the impact of the lighting on education within the short period, data regarding the trend in the changes in study hours of children in the evening, with and without the MH system, was collected during the survey. The survey shows that the study hours of children have changed with the availability of lighting through electrification.

Among the 40 households surveyed, 37 admitted that their children study for longer periods compared to before. The additional average number of hours of study in the evening made, after the access to MH-based electricity, is one hour 30 minutes per child per household. The changes in study hours can be taken as an indication of the changes in productivity of people in the future.

### *Health*

Changes in the quality of health brought about by better illumination are also difficult to evaluate within a short period. Nevertheless, with the change from using kerosene to electricity, people avoid exposure to the fumes produced through the burning of kerosene. Similarly, children do not have to strain their eyes when studying in the evening. These changes can be regarded as an indication of an improved health situation than before, which may point further to the rise in the level of productivity of the people, based on the assumption that people can work more if they are healthier.

### *Benefit from Increased Interaction*

With the extended hours of lighting, it becomes more convenient and therefore possible for people to meet even after the passing of daylight. During the conduct of the survey, respondents reported that they are able to meet one another more frequently than before. However, the meeting of people cannot be quantified in monetary terms, as it does not have a direct impact on the economic welfare of the people. Nevertheless, it is important to mention that the people in the community expressed that the extended period of lighting has provided them more opportunities to interact with one another, both within and outside the village.

### *Benefit from Electronic Gadgets*

As the electric power subscribed to the individuals in the community ranges from 25 watts to 150 watts only, they are only able to use the electricity for operating radios and television units. Although the operation of a radio and a television does not have a direct impact on

the economic welfare of the people, having the access to information as may be brought about by the operation of these two appliances, can help increase their level of productivity. For example, people listen to different programs aired on the radio, which provide them with information on current events, skills and entertainment. However, it was not possible to quantify the increase in productivity through the access to information within a short period. In the community, about 73% of the individuals listen to the radio, out of which 73% used to listen to the radio even before having access to MH-based electricity. With the introduction of MH-based electricity, these people are able to save on expenses made on batteries needed to operate radios. Although the introduction of MH-based electricity created an opportunity to operate television sets in the village, only six out of the 40 respondents reported watching television on a regular basis.

### *Net Benefit from Household Uses*

The net benefit from household uses is equivalent to the sum of the net benefits to the individuals in the community. This is illustrated further using the figure that follows.

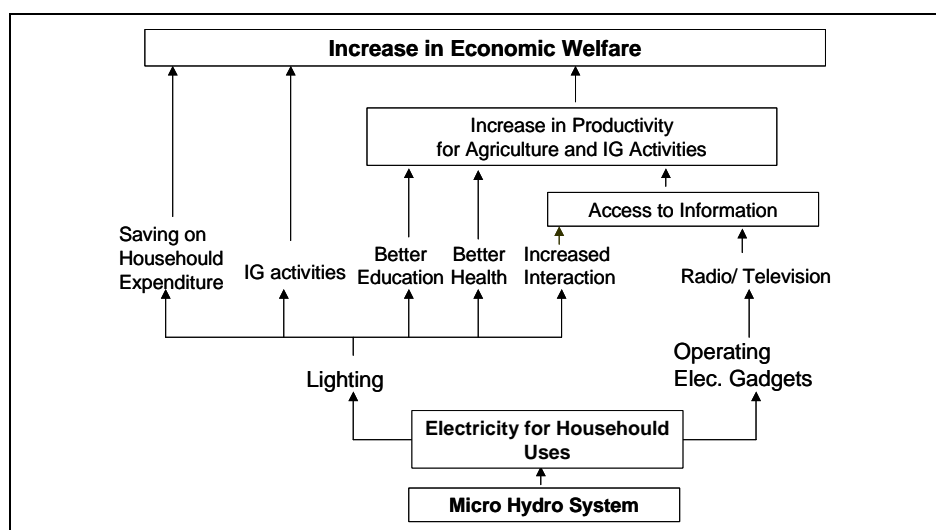


Figure 8: Benefit from Household Uses

In Figure 8, it can be seen that the individuals benefit from MH systems via lighting as well as through the operation of electronic gadgets. The direct benefit of lighting through MH-based electricity includes savings on household expenditure on lighting and the earnings from income-generating activities. The other benefit from lighting through MH-based electricity includes improved education and health quality, as well as the increased interaction among the people. All of the benefit contributes towards increasing productivity in agriculture as well as IG activities. Similarly, the households in Pinthali further benefit by having the opportunity to operate radios and television units. Access to the market information through radio and television is also expected to contribute in productive activities. The cost for the individuals is equivalent to the tariff they have to pay for using

electricity. But as the charge paid is a return on the investment made on the MH systems, the electricity tariff is not a cost to the community. Given this assumption,

#### Net Benefit from Household Uses

$$\begin{aligned}
 &= \text{Net Benefit to Individuals} + \text{Net Benefit to the MH System} \\
 &= (\text{Net Benefit from Lighting} + \text{Net Benefit from Electronic Gadgets}) + \text{Net Benefit to the MH System} \\
 &= (\text{Saving on Household Expenses on Lighting} + \text{Benefits from IG Activities} + \text{Benefits from Better Quality of Education and Health} + \text{Benefit from Increased Interaction}) + \\
 &\quad (\text{Benefit from Radio and Television: access to information} - \text{Electricity Cost}) + \\
 &\quad (\text{Electricity Cost: paid by the individuals for electricity}) \\
 &= 69,878 + 229,680 + \text{Increase in Productivity (IP)} - \text{Electricity Cost} + \text{Electricity Cost} \\
 &= \text{Rs. } 299,558 + \text{Increase in Productivity}
 \end{aligned}$$

#### *Benefit from Irrigation*

Although the Daunekhola MH system does not impact directly on irrigation, the water used in the turbine of the system is later used for irrigation purposes. The use of the water flowing from the tailrace of the MH system has made it possible to irrigate land in the community, which results in an increase in agricultural production. The area of the land irrigated, with and without the MH system, is given in the following table.

Table 11: Changes in Quality of Land

<i>Irrigated Land</i>		<i>Non Irrigated Land</i>	
<i>Without MH (in Ropanis)</i>	<i>With MH (in Ropanis)</i>	<i>Without MH (in Ropanis)</i>	<i>With MH (in Ropanis)</i>
233	363.5	227.5	97

Without the MH system, the surveyed households had 460.5 *Ropanies* of land, out of which 50% were irrigated.<sup>74</sup> After the establishment of MH system, the total quantity of irrigated land has increased to about 79%. With an increase in the area of irrigated land by 29%, equivalent to 130.5 *Ropanies* of land, the households have been able to increase their production of different crops. This increase in the production of crops is outlined on the table that follows, along with the crops' market value.

<sup>74</sup> One hectare equals to 20 Ropanies of land.

Table 12: Changes in Agricultural Production

<i>Crops</i>	<i>Changes in Production Quantity (in Kg.)</i>	<i>Market Value Per Kg. (in Rs.)</i>	<i>Total Increase ( in Rs.)</i>
Paddy	3,400	16.00	54,400
Wheat	3,073	10.29	31,616
Maize	4,896	11.76	57,576
Mustard	575	17.86	10,270
Garlic	18,900	25.00	472,500
		<i>Grand Total</i>	626,362

Through the benefit of irrigation, the surveyed households have increased the production of different types of crops amounting Rs. 626,362 (at total market value). Extrapolating this finding, all the 116 households of the community would therefore have an increase in agricultural production estimated at Rs. 1,816,451.

### Net Benefit from Other Uses

Although the individuals of the community are able to benefit from the irrigation and increase their level of agricultural productivity, there are other factors which might affect this supposed increase in agricultural production. Thus, to assess the net benefit from irrigation, the net benefit from agricultural production needs to be calculated. The increase in agricultural production through the establishment of the MH system is depicted in the figure below.

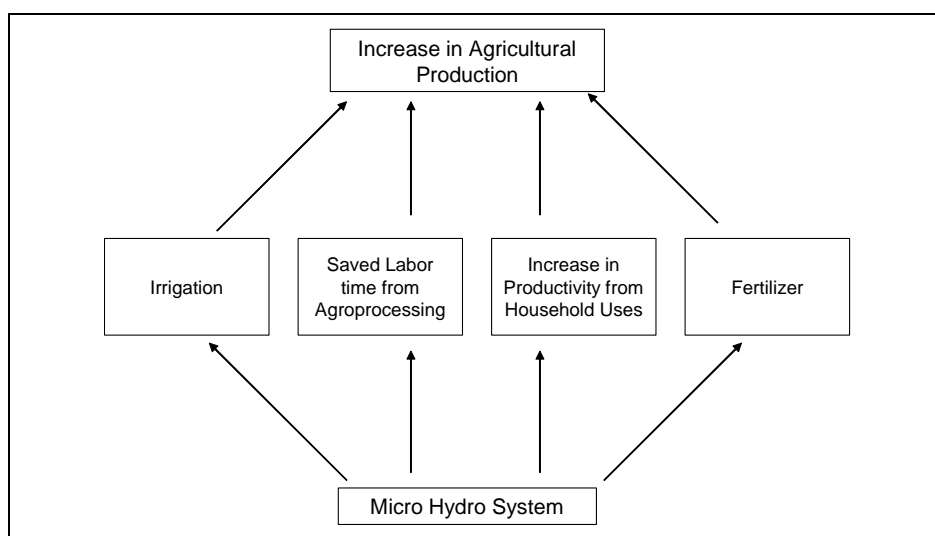


Figure 9: Benefit from Irrigation

Figure 9 shows that the individuals in the society have been able to benefit from the MH systems, through an increase in agricultural production. However, the individuals also have to bear the cost of fertilizer in doing so. Thus,

#### Benefit from Other Uses

$$\begin{aligned}
 &= \text{Agricultural Production} - \text{Cost for Irrigation} - \text{Productivity} - \text{Labor Time} - \text{Cost of fertilizer} \\
 &= \text{Rs. } 1,816,451 - 0 - \text{Productivity Increase} - \text{Labor Time} - \text{Rs. } 68,165 \\
 &= \text{Rs. } 1,748,286 - \text{Productivity Increase} - \text{Labor time}
 \end{aligned}$$

#### 9.2.1.3 Aggregation of Cost and Benefit

An aggregation of the cost and benefit to the community brought about by the Daunekhola system provides the following annual cash outflow:

Initial Cash Outlay = Rs. 449,186

Annual Cash Flow (from year 1 – 15)

$$\begin{aligned}
 &= \text{Annual Net Benefit} - \text{Annual Net Cost} \\
 &= \text{Benefit from Industrial Uses} + \text{Benefit from Household Uses} + \text{Benefit from Other Uses (Agricultural Production)} - \text{Annual Maintenance Cost} \\
 &= (\text{Saving on Labour time}) + (\text{Rs } 299,558 + \text{Productivity}) + (\text{Rs. } 1,748,286 - \text{productivity} - \text{Labour time}) - \text{Rs. } 44,445 \\
 &= \text{Rs } 299,558 + \text{Rs. } 1,748,286 - \text{Rs. } 44,445^{75} \\
 &= \text{Rs } 2,003,399
 \end{aligned}$$

On the basis of calculations made above, the community is able to realize annual earnings of Rs. 2,003,399 over the lifetime of the MH system, with an initial investment of Rs. 449,186. To access the net benefit over the period, the cost and the benefit should be aggregated under a common measure. This can be done by making use of a social discount rate. The social discount rate depends on the social time preference, which was difficult to ascertain during the research period. Thus the real market rate as calculated under the financial analysis was adopted. The aggregated benefit and cost over the life time of the Daunekhola MH System is equivalent to Rs. 19,008,321 at net present value.

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<sup>75</sup> In the above calculation, it is assumed that the labor time saved from industrial uses of the MH system has been used for agricultural production. Similarly, the increase in productivity level brought about by the benefits of lighting, better quality of education and health as well as increased interaction and access to information through the operation of radio and television has been reflected in the changes in agricultural production.



### *9.2.2 Cost and Benefit to the Country*

Under the assumption that the sum of the individual welfare equals the welfare of the society as a whole, the benefit to the community brought about by the MH system is the benefit delivered to the country. However, the assessment of cost and benefit brought about by the system to the society needs further adjustment to derive actual cost and benefit to the country as other societies of the same country may be effected by the same MH system. The cost incurred by other societies due to the establishment of MH system must be reduced from aggregated cost and benefit derived should be added.

#### *9.2.2.1 Economic Cost*

The local cost of the community is not considered the economic cost for the country, as the community is an integral part of the country. Additionally, the non-local cost incurred by the community which forms part of its economic cost may not be considered the economic cost for the country. As non-local cost is the cost incurred for purchasing equipment outside the community and the cost associated with hiring people from outside, it only makes sense that this forms part of the economic cost for the community of Pinthali. However, from the country's perspective, as the manufacturers and technicians originate from Nepal, who are capable of manufacturing and establishing the MH systems, this non-local cost for the community would then be a transfer cost to the country. Nonetheless, as it is difficult to trace the origin of all raw materials and components used in the system and as the resources invested and made available for the establishment of the system also means that there are less available resources for other projects, all of the cost incurred in the system's establishment has to be taken as the economic cost to the country. Moreover, the grant amount is also taken as part of the economic cost to the country, under the assumption that this amount could have been used by the country for other projects and purposes, had it not been used in the establishment of the Daunekhola MH System.

The only cost excluded from computing the economic cost to the country is the one associated with the operation and management of the system, since people in the community (and within the country) are able to carry out these functions themselves.

#### *9.2.2.2 Economic Benefit*

In a similar light, the benefit brought about by the MH system to the community is also considered the benefit to the country. However, some adjustments need to be made in order to arrive at the net economic benefit to the country brought about by the MH system.

Again, as the market prices of the goods and commodities do not reflect the real price, the shadow price of the goods other than those locally produced and consumed need to be taken into consideration. For one, the electricity generated replaced the consumption of kerosene in the community. Since the government provides subsidy for kerosene, its shadow

price must be used in the calculations in order to avoid double-accounting. The replacement of kerosene enables the country to save on subsidies on kerosene as well, which means that the benefit to be realized by the country would be reduced if the market price of kerosene is taken into account.

On the other hand, the benefit to a community may be considered cost to others. For example the use of an agro-processing unit within a village may reduce the income of the owner of an agro-processing unit established outside the community. However, in the case of Pinthali, it is assumed that the operator of the agro-processing unit within the village derives the same benefit that the agro-processing unit outside the village used to get. Thus, the resources of the country remains unchanged as it is merely transferred from one community to another, in this case. This may be further justified by the increment in agricultural productivity which would not only benefit the community but would also fare well with the country's economic growth. In addition, the country would also be able to curb rural-urban migration and incidents of social unrest through the additional employment generated within the community. However, it should be noted that such benefit is not specifically part of the calculations contained in this study since it is after-effects which is difficult to evaluate and capture in monetary terms.

#### *9.2.2.3 Aggregation of Cost and Benefit*

The aggregation of the cost and benefit to the country brought about by the MH system provides the following results:

Initial Cash Outlay = Rs. 1,481,509

Annual Cash Flow (Year 1 – 15)

$$\begin{aligned} &= \text{Annual Benefit to Community} + \text{Subsidy in saved Kerosene in the community} \\ &= 299,558 + 1,748,286 + (\text{annual saving of kerosene} \times \text{subsidy per liter}) \\ &= 2,047,844 + (3,741 \times 3.5) \\ &= \text{Rs. } 2,060,938 \end{aligned}$$

As seen from the computations above, the country also derives more benefit from the investment made in the Daunekhola MH System. Therefore, such an investment can be considered efficient. The net present value of this benefit to the country is equivalent to Rs. 10,006,159.

## 10 Discussions

### 10.1 Financial Analysis

The results of the financial analysis (contained in chapter 9 of this study) lead to the conclusion that apart from the Angakhola MH system, all other MH systems are in a weak financial condition. When the total cost is taken into account, (assuming the absence of any form of subsidy), even the Angakhola MH system is deemed to be in a similarly weak financial situation. Considering that the long term sustainability of the MH systems is hinged upon their financial situation, efforts should be made to improve the financial condition of these systems.

#### 10.1.1 Financial Situation of the Micro-Hydro Systems

The financial situation of the three MH systems covered in this study is discussed in more detail below, with emphasis put on their cumulative net financial cost and revenue.

##### *Angakhola Micro-Hydro System*

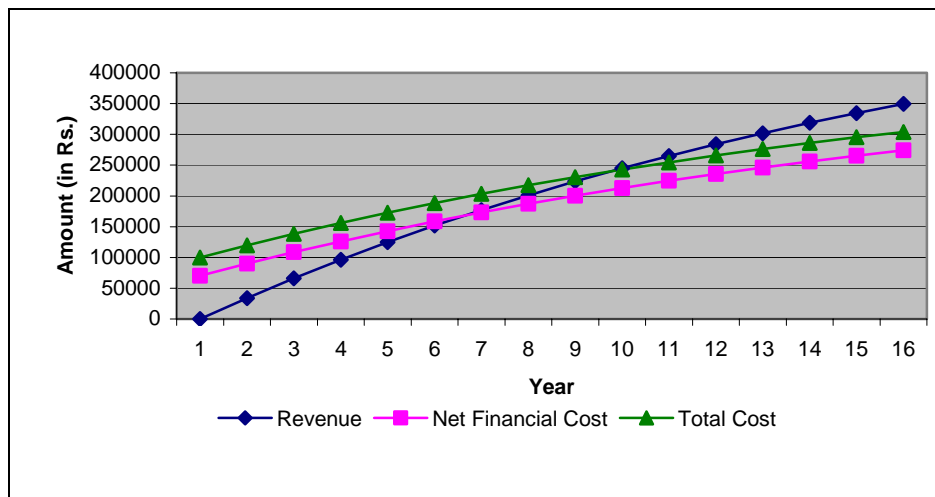


Figure 10: Cost and Revenue of the Angakhola MH System

Figure 10 shows that the Angakhola MH System is able to earn enough revenue to meet the total amount of financial cost and net capital cost on its sixth year of operation. The total cost is recovered only on the ninth year.

### *Daunekhola Micro-Hydro System*

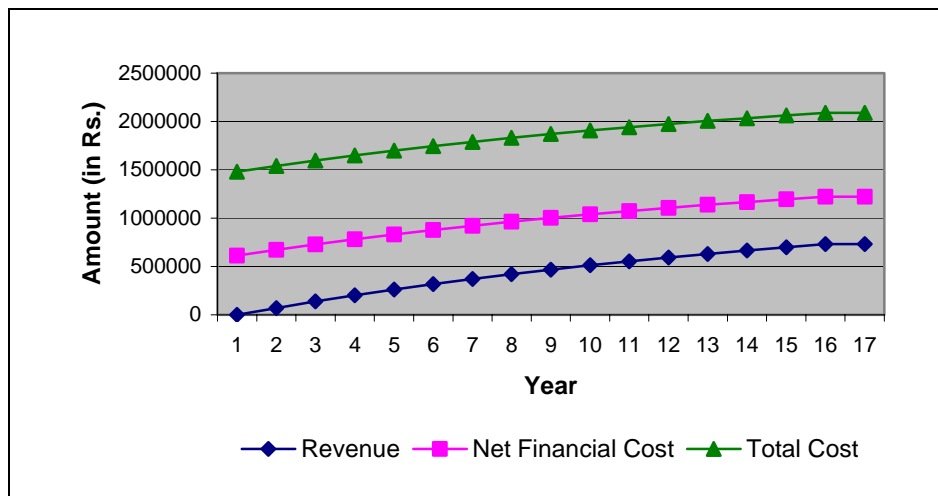


Figure 11: Cost and Revenue of the Daunekhola MH System

The financial situation of the Daunekhola MH System, on the other hand, is presented in Figure 11. As the figure depicts, the system financially runs very weak throughout its entire lifetime. The revenue from the system is not enough to meet even the net financial cost throughout the life of the system. The difference between the total net financial cost and the total revenue at the end of the fifteenth year is Rs. 489,952. In other words, the investor/s in this system would lose the equivalent of this amount by the end of the life of MH system, should everything be kept the same. The difference between the revenue generated and the total cost, equivalent to Rs.1,357,438, proves that the system is highly dependent on subsidies and grants.

### *Tikhedhunga Micro Hydro System*

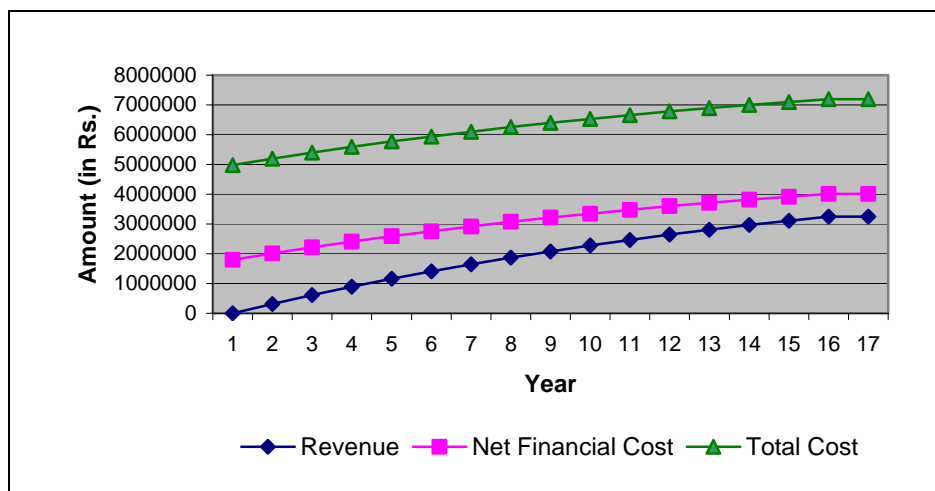


Figure 12: Cost and Revenue of the Tikhedhunga MH System

Lastly, in Figure 12, a similar pattern in the weak financial standing of the Tikhedhunga MH System is depicted. If the present situation continues to exist, the revenue collected will never be enough to meet the net financial cost of the system throughout its lifetime. The net loss in investments at the end of the lifetime of the system is estimated at Rs. 762,764. Similar to the situation of the Daunekhola MH System, the system also depends on subsidies and grants, which is represented in the figure by the area pertaining to the difference between total cost and revenue (estimated at Rs. 3,945,747).

#### *10.1.2 Improvements in the Financial Situation of the Micro-Hydro Systems*

Improvements in the financial condition of the MH systems can be made either by decreasing the cost incurred or by increasing the revenue generated enough to cover cost.

#### *Capital Cost*

In all three MH systems, the initial investment made to cover capital cost is very high. And because people in rural areas are characterized by very low disposable incomes, the establishment of MH systems therefore demands that government play a role in their financing via the provision of subsidies and grants. In the case of the Angakhola MH System, a government subsidy is being provided, equivalent to 30% of the total capital cost. The other two MH systems have also received subsidies and grants. The subsidy and grant component accounts for 59% of the total capital cost of the Daunekhola MH System. In the case of the Tikhedhunga MH System, this proportion even rises to as much as 70% of the total cost. However, even with these high proportions of subsidies and grants received for

the establishment of the Daunekhola and the Tikhedhunga MH System, these systems have not still been able to achieve financial soundness. In order to enable the MH systems to be in financially sound positions, reducing the capital cost can be an attractive alternative. However, such a reduction in the cost might also result in the lowering of their quality, which may in the end lead to higher maintenance cost.

#### *Annual Operating and Maintenance Cost*

The cost of operating a MH system is low as local manpower are hired to operate and manage the systems. As the capacity of the systems is highly influenced by regular maintenance, there is a need of annual maintenance expenses which is estimated flatly at 3% of the total capital cost. Although the system may not require such high maintenance cost in its initial years of operation, these will however be needed as the system gets older, owing to its regular wear and tear, which cannot be avoided.

#### *Tariff*

Since the capital cost as well as the operating and maintenance cost cannot be avoided, other alternatives for improving the financial situation of the MH systems need to be explored, such as through increase in the revenue generated by the system. This can be easily done by increasing the tariff rates charged.

The tariff is charged on the basis of the watts sold per month by all the three systems. At present, the electricity tariff of the Angakhola MH System is Re. 1 per watt per month, and Rs 0.60 for the Daunekhola MH System, while the Tikhedhunga MH System charges Rs 0.90 from its hotel-subscribers and 0.60 for its individual household subscribers. The higher tariff rate charged by the Angakhola MH system makes it possible for it to be in a financially better position than the other two systems. In the case of the Daunekhola and the Tikhedhunga MH systems, considering that the owner and the consumer of the electricity produced are same, there seems to be no incentive to charge a tariff rate high enough to cover cost. Although the low tariff rate implies that equitable access to electricity is ensured for all members of the society, the low tariff contributes to the weak financial position of the MH systems.

Assuming that the capacity utilization remains same, in order for the Daunekhola MH System to have a positive net present value that is enough to meet its net financial cost, Rs. 1.53 per watt per month needs to be its effective electricity tariff. On the other hand, in the case of the Tikhedhunga MH system, tariffs need to be raised to Rs 1.08 per watt per month. However, in order to recover the total cost by the end of lifetime of the respective systems, tariff rates should be raised to at least Rs. 3.14 and Rs. 2.26 by the Daunekhola and the Tikhedhunga MH Systems respectively.

### *Load factor*

Increasing the tariff rate may not be a suitable and attractive option to explore in enabling the MH systems to achieve a financially sound position. The other alternative is to increase the capacity utilization of the systems, which is referred to as the load factor. The financial viability of the MH systems depends highly on its load factor. As the systems are able to generate energy during the night and day, their capacity should be utilized at the maximum level.

### *Angakhola Micro-Hydro System*

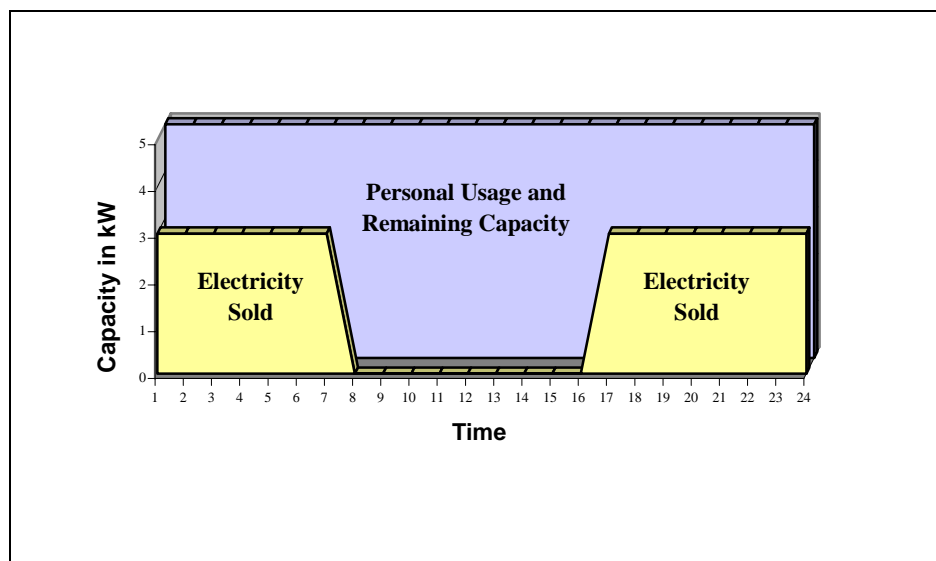


Figure 13: Load Factor of the Angakhola MH System

In the case of the Angakhola MH System, only the electrical component is considered in the analysis made and that the personal use derived by the manager is not included in the calculations. Hence the exact actual load factor of the plant cannot be determined. However, as shown in Figure 13, apart from the electricity sold outside, the rest of its capacity either remains idle or is utilized personally. The system is considered financially viable although the personal use made by the owner is not accounted in calculating the revenues generated by the system.

## Daunekhola Micro-Hydro System

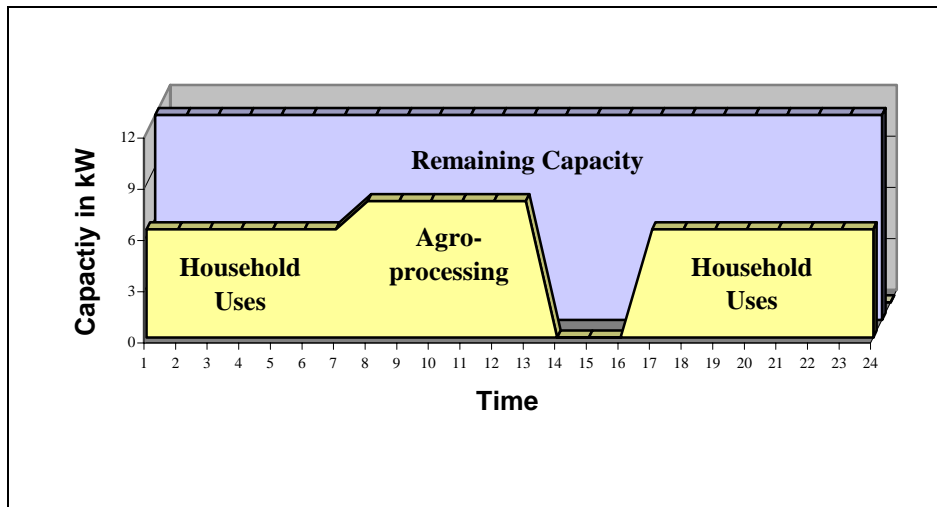


Figure 14: Load Factor of the Daunekhola MH System

In Figure 14, we show how the energy generated by the Daunekhola MH System is used by both households in the mornings and evenings, and for industrial purposes during the daytime.<sup>76</sup> The present electricity demand in the community is only 6,350 watts per hour, which is only about 53% of the total capacity of the system. With the present tariff rate given for household uses, even if the load of the evening and morning is increased to the total capacity of the system the revenue generated will still not be enough to positively affect its financial condition. Thus, either the daytime capacity utilization of the MH system should be increased, or the tariff rates should be raised if the present capacity utilization remains same. As of the year this study was conducted, the annual revenue from the daytime use of the system is estimated at Rs. 29,500, which translates into Rs. 0.20 per watt per month for the total capacity of the system.

In order to achieve the financial viability of the system, efforts must be made to increase the capacity utilization and tariff rates gradually, if the charges made for both household and industrial use cannot be dramatically increased. For example, during the remaining life of the MH system, if the load provided for the household use of the electricity increases by 10% annually until it reaches a utilization of 94% of the capacity (by the 9<sup>th</sup> year), and the tariff rate also increases by 5% annually until the end of the life of the system, revenue derived from industrial use should have also been increased by 7.8% annually in order to make the system financially viable. However, if the total cost considered is taken as the capital cost, then the MH system should be able to earn more revenues. Correspondingly, the MH system should increase the tariff for industrial uses by 24% annually in order to

<sup>76</sup> As the exact information of the capacity utilization for the daytime use of the energy generated through the MH system was not available, estimations contained herein follow the information personally provided by the relevant resource persons.



arrive at a positive net present value, with household use and tariff rates being increased by as much as 10% per annum.

### Tikhedhunga Micro-Hydro System

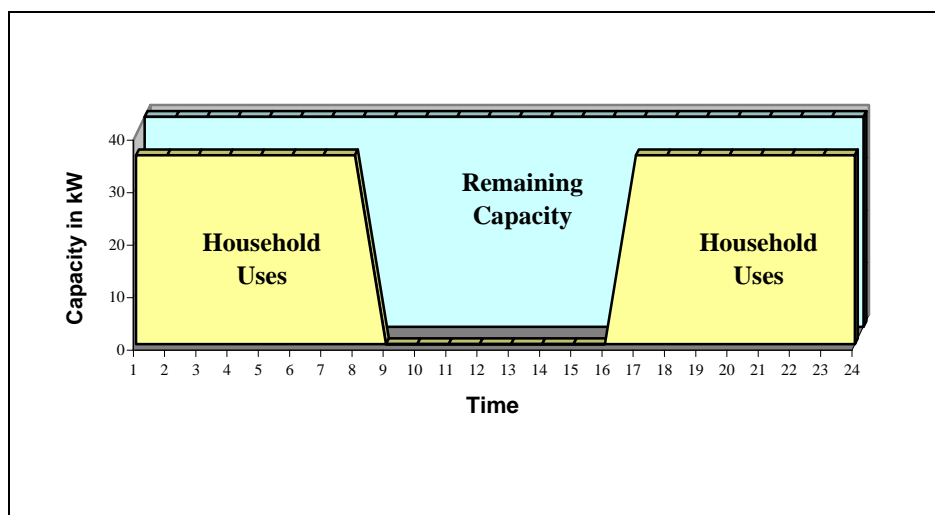


Figure 15: Load Factor of the Tikhedhunga MH System

In the case of the Tikhedhunga MH System, 90% of the total capacity of the system is dedicated for household uses during both the evenings and mornings. As the system does not have any industrial use, i.e. daytime use, the system remains idle for six hours (taking two hours as a time of rest for the system). Thus, if the existing tariff charged for household uses cannot be increased, efforts should be made to make use of the daytime capacity of the system in other productive areas. If the total day time capacity of the system were to be used, additional revenues equivalent to Rs. 0.33 per watt per month will enable the system to reach a positive NPV against its total financial cost by the end of its lifetime. If the total cost is taken as the capital cost, then the MH system should be able to earn even more revenues. The MH system should charge a tariff rate of Rs 0.83 per watt per month for industrial uses if the tariff rate for household uses increases by 10% per annum at the existing capacity utilization.

## 10.2 Economic Analysis

The economic analysis made in Chapter 9.2 covering the Daunekhola MH System shows that the system is able to increase the economic welfare of the society in various ways. The figure below illustrates how the MH system has increased the economic welfare of the individuals in the community.

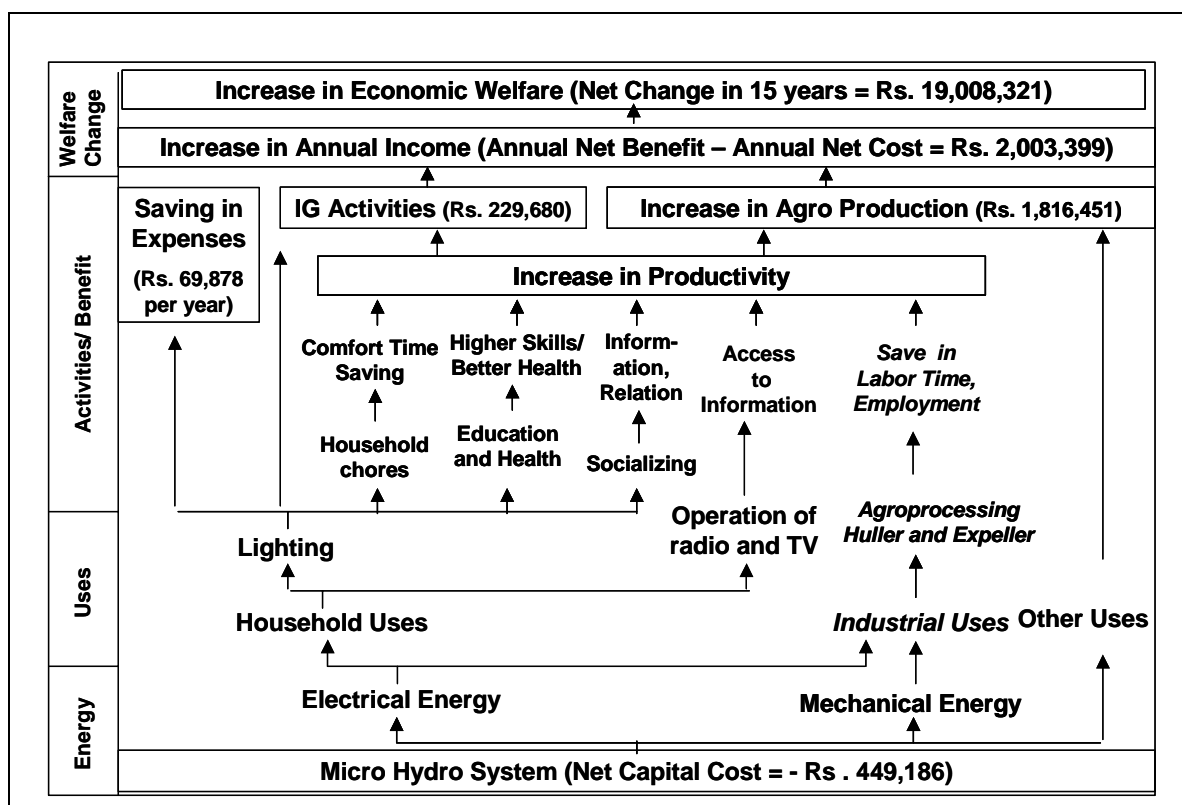


Figure 16: Benefit from the Daunekhola MH System

The Figure 16 demonstrates the individuals in the community are able to derive both direct and indirect benefit from the Daunekhola MH System in increasing their economic welfare. Through savings on household expenses made in lighting and through income generation made possible with the lighting from MH-based electricity, the community directly benefits from the MH system. On the other hand, the individuals in the community are able to realize indirect benefit through household uses made of electrical and mechanical energy generated by the MH system. With the lighting through electrification, households experience positive change in their quality of health and education, comfort in carrying out their household chores and the capacity to have increased interaction among members of the community. Moreover, the access to information through radio and television is also an added benefit to the population. These numerous benefits, in the end, are expected to lead to even further increase in the level of productivity among the individuals affected. Similarly, in terms of industrial uses, the individuals in the community are able to save on their labor time, which can be diverted into other productive activities. With increased industrial activity, employment opportunities have also been created in the village for two persons.

Over and above the mentioned benefit, the individuals in the community are also able to carry out irrigation through the water used in the MH System. This increased irrigation capacity together with the saved labor time from agro-processing, along with the increased level of productivity among the individuals, is reflected in an increase in agricultural production. The benefit when aggregated is very high compared to the cost involved in the

establishment of the system. Even when the total capital cost is taken as the cost to the community, the benefit still remain very high vis-à-vis the cost incurred.

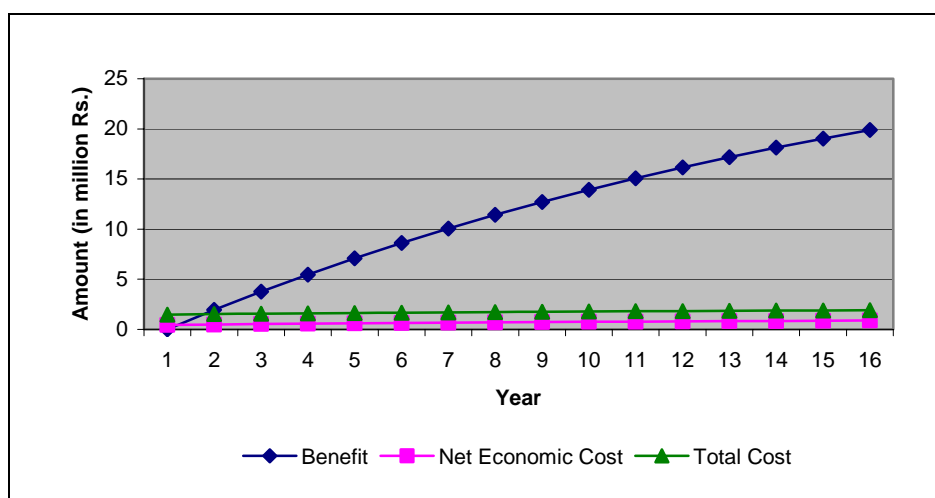


Figure 17: Economic Cost and Benefit of the Daunekhola MH System

The Figure 17 illustrates how the benefit surpass the cost within the first year of the establishment of the system. And if the present situation continues, then the benefit realized rises even at a higher rate than the cost involved. The total present value of the benefit against the net economic cost approximates Rs. 19,008,321. This is 57 times higher than the cost. This, therefore, leads to the conclusion that the welfare of the community has improved immensely even at the price they had to invest for the establishment of the MH system.

## 11 Conclusions

The case of the Daunekhola MH System helps illustrate that MH systems can be considered as a renewable source of energy and an effective tool in promoting the economic development of rural areas in Nepal, given its role in increasing the economic welfare of people via agricultural as well industrial productivity.

The Daunekhola MH System has brought about enormous changes in the economic welfare of people in Pinthali. The people in this community have been able to benefit from the system through the household and industrial use of the energy generated from the system. Significantly, an increase in agricultural productivity was also realized through irrigation made possible by the water flowing out from the system. Thus, in comparison to the cost incurred for the system's establishment, the community realizes a higher benefit.

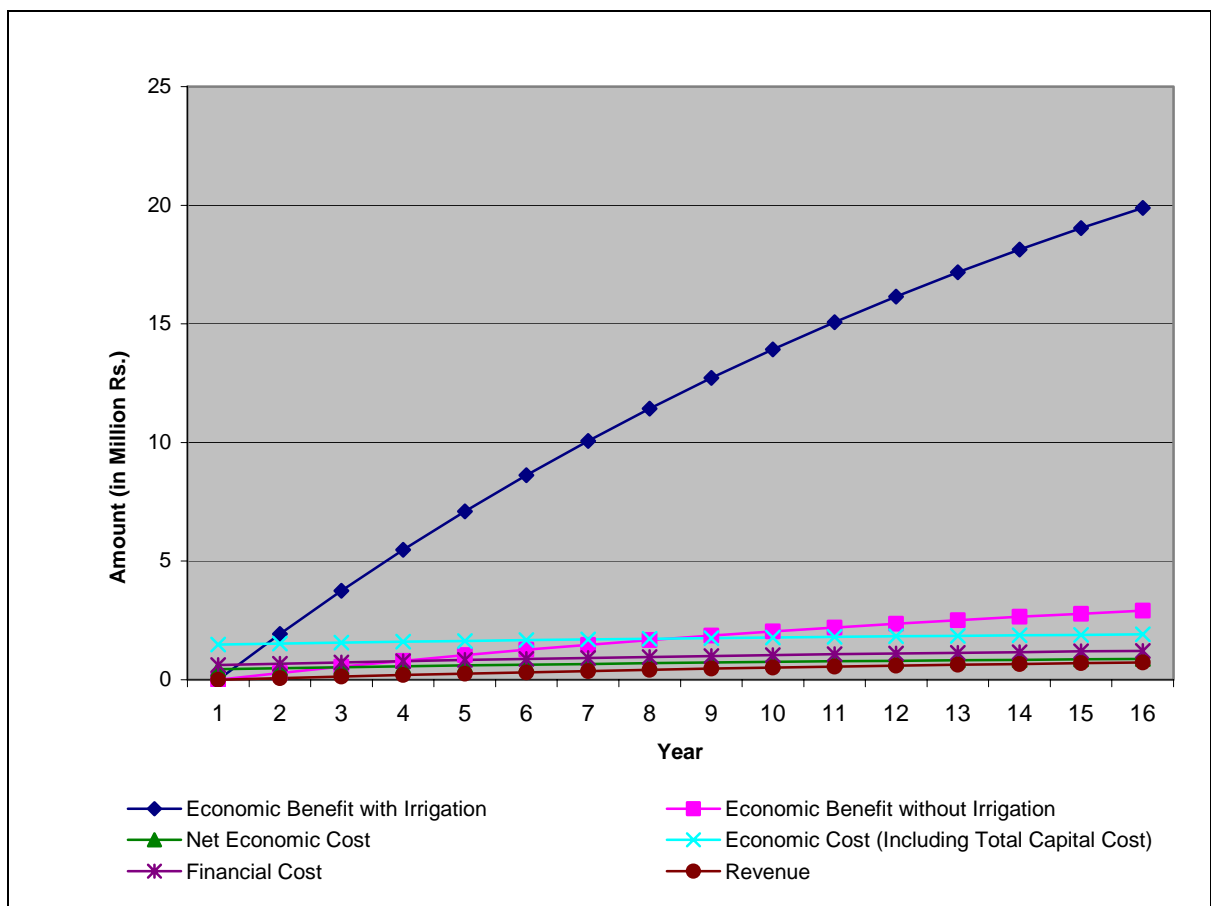


Figure 18: Cost, Return and Benefit of the Daunekhola MH System

The figure above shows that the benefit to the community outweighs the net economic cost to the community within the first year of the establishment of MH system. In the same year, these benefit also surpass the economic cost (which include the total capital cost).

As the cost and benefit of the various systems are site-specific, it is important not to immediately derive the conclusion that all MH systems are able to facilitate irrigation in the areas where they are being operated. Nevertheless, if the increase in agricultural production in Pinthali is not taken into account in the computation of the benefit derived from the MH system, as illustrated in the figure above, the community is still able to derive higher benefit compared to the net economic cost. However, the benefit excluding this increase in agricultural production would be less than the cost of the system when the total capital cost is considered.

As demonstrated in Figure 18, although the community is able to receive a high economic benefit from the establishment of the system, the system itself operates with a weak financial condition. And as the financial viability of the system is indispensable in consideration of its long term sustainability, efforts should be made towards the improvement of the system. The present situation is such that the system is established with a capacity higher than the energy supply being demanded. The high capital cost to be incurred with the establishment of a system with high capacity than what is being demanded contributes to such a situation.

As has been shown, improvements in the financial situation of the various systems can be achieved by increasing tariff rates or the load factor of the respective system. Under the assumption that the rise in income level will result in an increase in the budget of a consumer, and therefore enable him/her to pay more for the electricity supplied, the tariff can be increased to address the financial viability issue. However, the increment in the tariff rate must also mean that there is an increase in the economic welfare experienced by the people consuming the electricity. Otherwise, the increase in tariff rates may result in the decrease in the consumption of the electricity, which in the end leads to a lower total revenue. The other alternative in this case would be to increase the load factor. As the energy generated from the system is still not fully utilized, efforts should be made towards increasing energy consumption. In this respect, the remaining capacity of the system can be utilized for other commercial purposes such as the establishment of agro-based cottage industries in areas where there is a high agricultural yield.

Due to the low income level of the people in Pinthali, they were not themselves able to invest in the establishment of a MH system. Without the MH system, people were not able to harness the potential to increase their economic welfare. However, with the financial support from outside agencies and institutions, specifically through the subsidy extended by the government and a grant fund from the REDP/ UNDP, the MH system was established. This has enabled the community to realize an increase in their economic welfare.

In the case of the Tikhedhunga MH System, although water used in the system cannot be used for irrigating farm lands, the community nonetheless benefits from better illumination with lighting brought about by MH-based electricity. However, as in the case of the Daunekhola MH System, this system is also in a weak financial situation. As the daytime capacity of the system remains unused, efforts should be made towards using the capacity

for other commercial purposes. When the energy generated from the system is used for such purposes, it will not only enhance the welfare of the user but will also result in higher revenues generated by the system without having to increase the tariff rate charged for household uses. In contrast, the Angakhola MH System is in a sound financial position. As the beneficiary community is located along the highway and are engaged in commercial activities, they are able to pay a higher tariff rate for the use of the system.

As an increase in the economic welfare of the community also enhances the economic welfare of the country as a whole, the results of this study show that the investment from the government in the form of the subsidy extended for the establishment of the systems can be regarded as an effective way of making use of the country's resources. Taking the case of the Daunekhola MH System, the subsidy and grant amount has enabled an enormous increase in the economic welfare of the people. In the case of the Tikhedhunga MH System, it benefits the promotion of tourism apart from contributing to the welfare of the local people.

In terms of the benefit to the country, MH systems provide energy not only for lighting but also for industrial purposes. And an increase in the level of industrial productivity creates opportunities for employment in the rural communities. In addition, operating the MH system itself creates employment opportunities in the local community. Similarly, as most of the equipment needed for MH systems may be locally manufactured, the promotion of MH systems may result in additional employment generated for the people within the country. Furthermore, as electricity generated from the MH system replaces kerosene as a source of energy for lighting, the country is able to save the amount of subsidy provided for kerosene, not to mention the savings also made on hard earned foreign currency reserves being used to import kerosene. In terms of its environmental soundness, replacing kerosene with MH-based energy also helps in the control of carbon emissions.

Although the MH system can bring about benefit to rural communities as concluded in this study, it is important to note that the cost and benefit of different MH systems are site-specific, especially considering how the rural communities in Nepal can be diverse in socio-economic, geographic and ethnic terms. Thus, undertaking the cost-benefit analysis of individual MH systems is necessary in order to ensure the efficiency of the investments made in each one of them.

## 12 Recommendations

A micro hydro system as a source of renewable energy can bring about positive changes in the livelihoods of people in rural areas. The system serves as a viable option for the socio-economic development of backward and isolated rural communities when the integration of both the household and industrial uses of the system is ensured. As the micro hydro system has the capacity to increase the economic welfare of the people through such uses, the system should be promoted as one of the means to alleviate poverty in the rural areas. This is especially meaningful given that there is a high potential for harnessing hydropower in the country and most of the rural communities are isolated and scattered.

The rural communities are unable to realize this potential of enhanced economic welfare given their inability to afford the costs associated with the establishment of the system. Therefore, subsidies provided in this respect can help enable people and communities to realize this potential, and help the government in encouraging investments in MH systems from private sources as well as from communities in order to implement rural electrification policies.

Because the capital required can be substantial in amount, it becomes necessary to ensure that these resources spent are economically justifiable. Given that the country's resources are limited, this high initial investment necessitates that thorough analyses of the systems must be undertaken in order to ensure the maximum efficiency of the resources invested. As mentioned earlier, an analysis of every system is necessary as the cost and benefit of the systems are site-specific.

In ensuring the efficient utilization of the resources invested in the systems, it is necessary not only to account for the economic desirability of the system but also consider their financial viability. Taking into account the financial situation of the communities who own and operate the different MH systems, the long-term sustainability of the systems is put in question even in the presence of subsidies and grants. This means that if revenue generated from the system is to be greater than the cost involved, a thorough demand analysis should be undertaken before the establishment of the respective systems. High upfront cost required for the establishment of MH systems that have higher capacities than what is demanded by their respective markets will only lead to the higher costs in the long term.

The capacity of a MH system should be optimally utilized. Thus, the industrial uses of the energy generated should also be promoted, making use of the daytime capacity of the systems established. This can be done by implementing various skills development trainings and technical assistance in the development of market mechanisms for produced goods. The productive uses of energy generated by MH systems help in ensuring the financial viability of the system itself as well as increase in the economic welfare of the users.

When a MH system can be used only for lighting purposes, the cost and benefit of other renewable energy sources such as solar photovoltaic energy should be taken into account. This kind of analysis will provide a least-cost alternative for providing lighting to the rural

and isolated communities. MH systems have less external effects, and thus, the replacement of kerosene as a source of energy for lighting, contributes in efforts aimed at decreasing carbon emissions. However, due to the low purchasing power of most of those belonging to the rural population, a continued dependence on kerosene may still be observed, since this can be purchased in small units and can be used in quantities and frequencies as required. Thus, in order to replace kerosene as a source of energy for lighting other cost effective energy sources need to be considered and promoted. In the case of MH systems, the energy generated must be utilized in such a way that rural industrial productivity is increased and thereby enable people to afford the use of such energy source. This includes the need to explore how even those people from the lower-income segment are able to realize the benefits from MH-based energy use.

Given that the energy generated from MH systems is less used for cooking purposes, the systems have a very minimal effect in decreasing the consumption of fuel-wood in rural areas. In this case, other viable renewable energy sources such as biogas should be promoted in line with the policy of decreasing the incidence of deforestation in the country. In such a case promotion of improved cook stove can be taken as an alternative to make considerable impact in decreasing the existing fuel-wood consumption pattern.



### 13 Bibliography

- Bajracharya, Deepak and Singh, Kiran Man, Development of Micro-Hydro Systems in Nepal: Problems and Prospects, International Center for Integrated Mountain Development, 1991, Kathmandu
- Chowdhury, Anis and Kirkpatrick, Colin, Development Policy and Planning, An introduction to models and techniques, Routledge, 1994, London and New York.
- Dahal, Madan K., Outward-Oriented Economic Nationalism: A Model for Development in Nepal, in: Dahal, Madan K. and Mund, Horst, (ed.), Social Economy and National Development, Lessons from Nepalese Experience, Nepal Foundation for Advanced Studies, 1996, Kathmandu.
- Frankel, P. et. al., Micro-Hydro Power, A guide for Development Worker, Intermediate Technology Publications Ltd., 1991, London.
- Farinell Ugo(ed), Energy as a Tool for Sustainable Development, The United Publications, 1999, New York.
- Johanesson, Per-Olov, An Introduction to Modern Welfare Economics, Cambridge University Press, 1991, Cambridge.
- Lekhi RK, The Economics of Development and Planning, Kalyani Publishers, 1999, Jalandhar.
- N.N., Country Assistance Strategy – Nepal (1999 - 2001), The World Bank, Washington DC, Kathmandu.
- N.N., Community – Managed Rural Energy Development (Strategic and Operational Framework), REDP Publications 04/98, Rural Energy Development Program, 1998, Kathmandu.
- N.N., Guidelines for the Economic Analysis of Projects, Asian Development Bank, [http://www.adb.org/Documents/Guidelines/Eco\\_Analysis/financial\\_economic.asp](http://www.adb.org/Documents/Guidelines/Eco_Analysis/financial_economic.asp).
- N.N., Nepal Energy Sector Program Support Document, Main Report Danish International Development Assistance, Ministry of Foreign Affairs, 1998, without place.
- N.N., Profile of Micro Hydro Schemes, Kavrepalanchok, District Development Committee, Rural Energy Development Section (DDC:REDS), 2000, Kavrepalanchok.
- N.N., Quarterly Economic Outlook, The World Bank, Kathmandu, July 1999 <http://www.worldbank.org.np>.
- N.N., Renewable Energy Perspective Plan of Nepal, 2000-2020: An Approach, Vol.-1, Main Report, Centre for Energy Studies, Institute of Engineering, 2000, Nepal.
- N.N., Renewable Energy Perspective Plan of Nepal, 2000-2020: An Approach, Vol.- 2, Sectoral Report, Centre for Energy Studies, Institute of Engineering, 2000, Nepal
- N.N., Subsidy for Renewable Energy, His Majesty's Government of Nepal, Alternative Energy Promotion Centre, 2000, without place.
- N.N., Strengthening Project Screening System in National Planning Commission, National Planning Commission and Nepal Administrative Staff College, February 1999, Kathmandu.
- N.N., A Study on Rural Hill Potentials and Service Delivery System (Final Draft Report), SAPPROS-Nepal, 2001, Kathmandu.

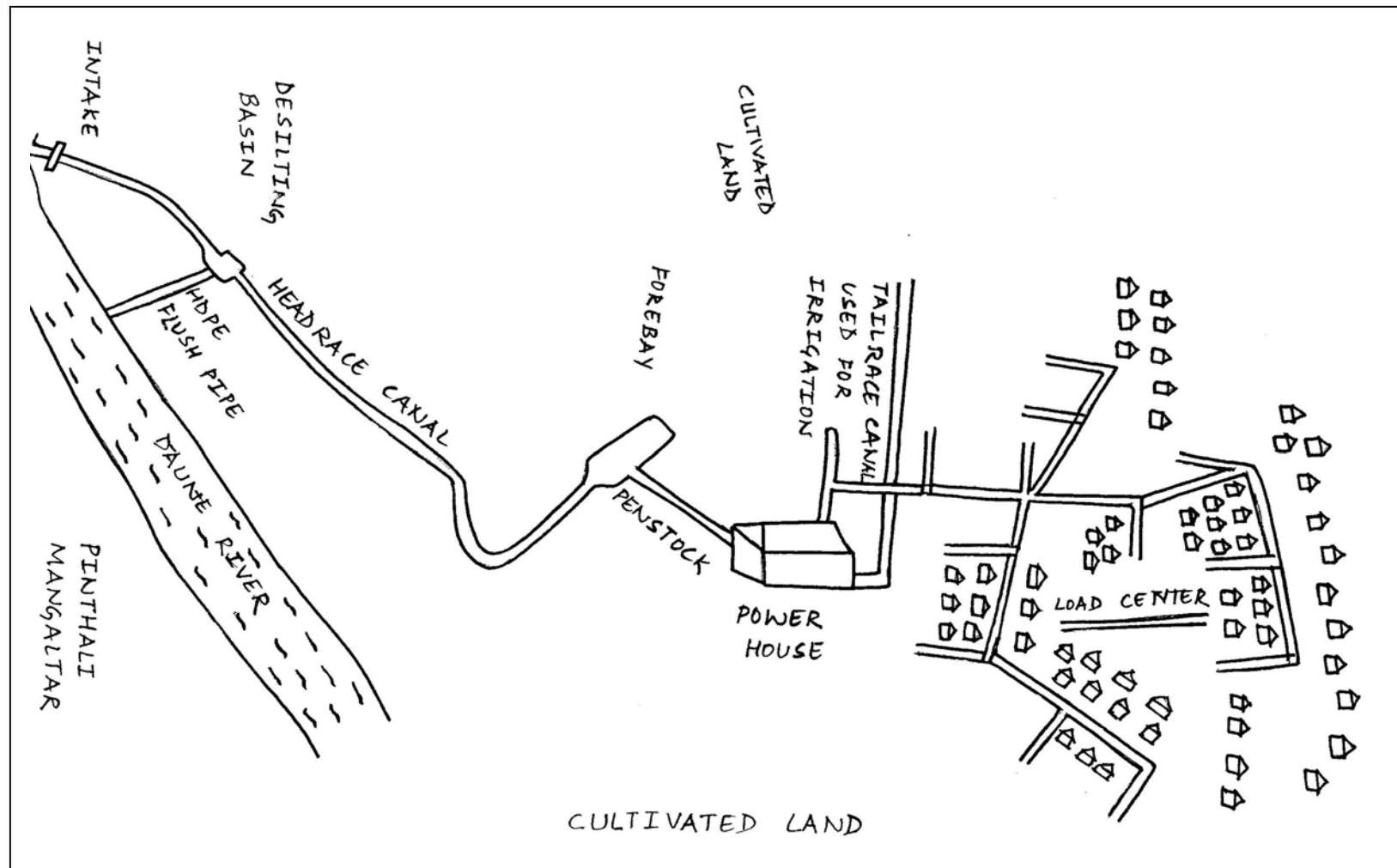
- N.N., The Ninth Plan (1997 –2002), National Planning Commission, His Majesty's Government of Nepal, 1998, Kathmandu.
- Rosenberg, Nathan, Historical Relations Between Energy and Economic Growth, in: Stevens, Paul (ed.), The Economics of Energy, Vol. I, Edward Elgar Publishing Company Limited, 2000, Cheltenham.
- Samuelson, Paul A. and Nordhaus, William D., Economics, 15<sup>th</sup> edition, McGrawhill Inc, 1995, New York.
- Thompson, Paul and Handmer, John, Economic Assessment of Disaster Management, An Australian Guide, Center for Resource and Environmental Studies, Australian National University and Flood Hazard Research Center, Middlesex University, 1996, without place.
- Todaro, Micheal P., Economic Development, Addison Wesley Longman Limited, 1997, Essex.

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Annex – VII	Economic Analysis
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Annex – I

Schematic Diagram of Daunekhola Micro-Hydro System



Source: District Development Committee: Rural Energy Development Program, Kavre

ANNEX - II

**Micro-Hydro System Profile - Questionnaire**

1. Name of the Micro Hydro System:

2. Location:

3. Owner: Private Community

4. Distance from the Nearest Motorable Road:

5. Date of Commencement:

6. Installed Capacity:

7. Water Source:

8. Beneficiary Communities:

9. Capital Cost:

9.1 Total Cost of Scheme (in Rs.):

9.2 Source of Financing and Amount:

Sources	Amount (in Rs.)
ADB Loan	
HMG Grant	
Equity	
Other Sources	

10. Operating and Maintenance Cost:

	No. of People Employed	Name	Qualification	Salary per Month (in Rs.)
Operator				
Manager				
Other Persons/ Purpose				

10.1 Maintenance Cost (in Rs.):

10.2 Other Costs (in Rs.):

11. Revenue:

11.1 Total Number of Household Served:

11.2 Type of End Uses:

11.3 Use of MH System:

	Time (Start – End)	Type of End- uses	Quantity of Energy Subscribed	Tariff Rate (in Rs.)	Total Amount per month (in Rs.)
Household Uses					
Industrial Uses					

12. Problems faced in Operation and Management of the System:

# Annex - III

## Micro-Hydro Systems - Profile

1.	Name	Angakhola MH System (Paudel Turbine)	Daunekhola MH System	Tikhedhunga MH System
2.	Location	Angakhola, Pipal Danda VDC Palpa	Pinthali, Mangaltar VDC, Kavrepalanchok	Tikhedhunga, Dangsing VDC, Kaski
3.	Owner	Private	Community	Community
4.	Distance from Roadhead	On the Highway	8 Hours from Dhulikhel	3 hours from Nayapul
5.	Year of Commencement	1992	1998	1997
6.	Installed Capacity	5 kW	12 kW	40 kW
7.	Water Source	Angakhola	Daunekhola	Burungdikhola
8.	Beneficiary Communities	Angakhola	Pinthali	Tikhedunga, Sudame, Saber, Kami Tole, Hiele,
9.	Capital Cost			
9.1	Total Cost of Scheme (in Rs.)	100,000 (electrical Installation)	1,481,508	49,77,822
9.2	Source of Financing and Amount (in Rs.)			
	Equity	10,000	79,500 (+144,836 labor and material)	1,143,001 (Subsidy and Investment)
	HMG Subsidy	30,000	199,150	NA (Included in equity)

	Loan	60,000	189,686	695,500 (all paid)
	Other Sources			
			668,336 (REDP/ UNDP)	2,240,000 (British Embassy)
			100,000 (DDC – Equity)	2,92,835 (ACAP)
			100,00 (VDC – Equity)	606,486 (ACAP Loan)
<b>10.</b>	<b>Operating and Maintenance Cost:</b>			
	<b>Operator</b>			
	No. of People Employed	1	1	2
	Name	Top Bahadur Burubhute	Nem Raj Lama	Ram Prasad Sherchan, Raj Man Gurung
	Qualification	General Training	General Training	General Training
	Cost per Month (in Rs.)	Rs. 3000 for all the systems	Rs. 1500	Rs. 4400, @ Rs. 2200 each
	<b>Manager</b>			
	Nos. of People Employed	Self	Operator and Manager (Same Person)	1
	Name	Yadav Paudel		Jaya Bahadur Gurung
	Qualification	N.A.		N.A.
	Cost per Month (in Rs.)	N.A.		Rs 2200



	<b>Other Persons/ Purpose</b>			
	Nos. of People Employed	No	No	No
	Maintenance Cost	N.A.	No major problem	No major problem
	Other Costs			
<b>11.</b>	<b>Revenue:</b>			
<b>11.1</b>	<b>Total Number of Household Served</b>	22	116	90 Households 12 Hotels
<b>11.2</b>	<b>Type of End Uses</b>	Lighting and Radio by the consumers	Lighting, Radio, T.V., Huller, Oil Expeller	Lighting, Rice Cooker, Radio
<b>11.3</b>	<b>Usage of MH System:</b>			
	<b>Household Use: (Evening – Morning)</b>			
	Time (Start – End)	4:30 – 6:30, 17:30 – 22:00	18:00 – 7:30 (next day)	18:30 – 10:00 (next day)
	Type of End-uses	Lighting and Radio	Lighting	Lighting, Rice Cooker, Refrigerator
	Quantity of Energy Subscribed	3 kW + personal use	6.35 kW	36 kW
	Tariff Rate (in Rs.)	Household Re. 1 per watt per month	Household Rs. 0.60 per watt per month	Household Rs. 0.60, Hotels Rs. 0.90 per watt per month
	Total Amount per month (in Rs.)	3000 (return from personal use not included)	3,810	27,900

	<b>Industrial Use (Day)</b>			
	Time (Start – End)	Electrical Installation only for electricity	7:30 – 1:00	None
	Type of End-uses		Huller and Oil Expeller	
	Quantity of Energy Subscribed		N.A.	
	Tariff Rate (in Rs.)		N.A.	
	Total Amount per month (in Rs.)		29,500 per year flat rate	
<b>12.</b>	<b>Problems faced</b>	Water shortage in dry season, no other major problem	Sometime problem in canal	Water shortage in dry season, no other major problems

**N.A: Data Not Available**

Annex - IV  
**Household Survey - Questionnaire<sup>1</sup>**

**A. Background Information**

1. Name: 2. Age:
3. Education: 4. Profession:
5. Village: 6. Ward No.:
7. How many people are there in your family?
8. Since when did your family have the access to electricity?
9. How many watts of electricity do you use?
10. How much do you have to pay as monthly tariff for electricity? (in Rs.)

**B. Household Energy Consumption**

11. What are the sources, usage and cost of energy that is required in your house?

Energy Source		Usage	Requirement Per Month	Cost
Fuel-wood	Without MH System			
	With MH System			
Agricultural Residue	Without MH System			
	With MH System			
Kerosene	Without MH System			
	With MH System			

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<sup>1</sup> This form has been translated from Nepali to English by the Author

Battery	Without MH System			
	With MH System			
Electricity	Without MH System			
	With MH System			
Other	Without MH System			
	With MH System			

### C. Agriculture

#### 12. Agricultural Production

Crop	Production Quantity	
	Without MH System	With MH System
Paddy		
Wheat		
Maize		
Mustard		

#### 13. How many ropani of land do you have? (in Ropani)

With Irrigation		Without Irrigation	
Without MH System (in Ropani)	With MH System (in Ropani)	Without MH System (in Ropani)	With MH System (in Ropani)

14. Expenditure in Agriculture

	Requirement per Year		Total Expenditure	
	Without MH System	With MH System	Without MH System	With MH System
Fertilizer				
Seeds				
Tools				
Labor				
Irrigation				
Others				

15. What process do you use for agro-processing with and without access to MH based energy in your village?

Type of Crop		Technology	Place	Time	Cost
	Without MH System				
	With MH System				
	Without MH System				
	With MH System				
	Without MH System				
	With MH System				
	Without MH System				
	With MH System				

	Without MH System				
	With MH System				

#### D. Other Source of Income

16. Apart from agriculture what are the other sources of income of your family?

General Store

Tea Shop

Joint(General Store and Tea Shop)

Cottage Industry

Labor inside the village

Labor outside the village

Others (please specify)

17. Does the activity mentioned above require any source of energy directly?

Yes

No

18. What amount of energy do you require?

Type of Energy Used	Requirement per day		Cost	
	Without MH System	With MH System	Without MH System	With MH System
Manual <sup>1</sup>				
Fuel-wood				
Kerosene				
Electricity				
Others				

<sup>1</sup>How many people are involved , if people from outside are involved what is the wage rate?

19. How much income does the family earn per month with the activity?

	Without MH System	With MH System
Turnover (in Rs.)		
Cost (in Rs.)		
Income (in Rs.)		

## **E. Education, Health and Access to Information**

### **Education Level**

20. The available educational level in the village:

21. How many hours does your children study?

Without Lighting (in Hours):

With Lighting (in Hours):

### **Health Treatment Facility**

22. Which type of medical facility do you have in the village?

Traditional System

Health Post

Medical Store

### **Access to Information**

23. Is there telephone service in the village?

Yes

No

24. Do you listen to radio before access to MH based electricity?

Yes

No

25. Do you listen to radio now?

Yes

No

26. If yes, which programs do you listen in the radio?

News related

Skill oriented

Entertainment

Others

27. Do you watch Television?

Yes

No

28. If yes, which programs do you watch in television?

News related

Skill oriented

Entertainment

Others



# ANNEX - V Household Survey - Results

## A. General Information

S. N.	Name	Age	Edu- ca- tion <sup>1</sup>	Prof- ession	Village	Ward No.	No. of Family Mem- bers	Electri- city Con- nection (Date)	Electri- city Expense per month (in Rs.)
1	Chadra Dhoj Tamang	26	2	Agri.	Pinthali	7	11	1998	45
2	Chain Sung Lama	24	5	Bus.	Pinthali	7	9	1998	45
3	Maila Tamang	28	2	Agri.	Pinthali	7	2	1998	30
4	Swayam Buddha	29	2	Agri.	Pinthali	9	5	1998	30
5	Chayangba Rani	80	1	Agri.	Pinthali	7	2	1998	15
6	Kanchi Lama	65	1	Agri.	Pinthali	9	5	1998	30
7	Uttar Kumar Lama	36	2	Agri.	Pinthali	9	6	1998	30
8	Resham Bdr. Lama	40	2	Agri.	Pinthali	7	7	1998	30
9	Kadhga Bdr. Lama	71	1	Agri.	Pinthali	7	7	1998	75
10	Dawa Lama	35	1	Agri.	Pinthali	9	6	1998	30
11	Chatur Lama	30	2	Agri.	Pinthali	7	7	1998	15
12	Kainla Lama	30	1	Agri.	Pinthali	9	5	1998	45
13	Hari Bahadur Lama	28	5	Agri.	Pinthali	9	9	1998	30
14	Choishang Lama	40	1	Agri.	Pinthali	7	11	1998	30
15	Thulo Babu Lama	51	1	Agri.	Pinthali	9	8	1998	30
16	Dhirendra Lama	22	5	Agri.	Pinthali	9	5	1998	45
17	Sang Tenjin Lama	52	1	Agri.	Pinthali	7	7	1998	30
18	Krishna Kumar Lama	30	5	Agri.	Pinthali	9	4	1998	30
19	Sarki Singh Lama	56	2	Agri.	Pinthali	9	7	1998	30
20	Sukbir Lama	40	2	Agri.	Pinthali	9	10	1998	45
21	Nyama Lama	40	2	Agri.	Pinthali	9	5	1998	30
22	Thulo Kancha	38	2	Agri.	Pinthali	7	6	1998	30
23	Surya Bahadur Tamang	40	2	Agri.	Pinthali	7	7	1998	30
24	Maya Lama	56	1	Agri.	Pinthali	9	6	1998	30
25	Bahadur Singh II	60	1	Agri.	Pinthali	9	5	1998	30
26	Chewang Lama	40	1	Agri.	Pinthali	9	4	1998	15
27	Chandra Singh Lama	30	2	Agri.	Pinthali	9	7	1998	30
28	Sano Maya Lama	40	2	Agri.	Pinthali	7	6	1998	30
29	Gunja Man Lama	65	1	Agri.	Pinthali	9	6	1998	30
30	Sainli Lama	55	1	Agri.	Pinthali	7	4	1998	30
31	Dhan Norbu Lama	60	1	Agri.	Pinthali	7	7	1998	30
32	Wangju Lama	46	2	Agri.	Pinthali	7	9	1998	45
33	Dawa Lama	58	1	Agri.	Pinthali	9	10	1998	30
34	Min Kumar Lama	40	1	Agri.	Pinthali	9	4	1998	30
35	Chyangpa Lama	33	1	Agri.	Pinthali	9	6	1998	30
36	Karna Bahadur Lama	7	1	Agri.	Pinthali	7	10	1998	30
37	Sainla Lama	35	1	Agri.	Pinthali	7	6	1998	30
38	Chakra Bahadur Lama	70	1	Agri.	Pinthali	9	7	1998	45
39	Singh Bahadur Lama	57	1	Agri.	Pinthali	7	5	1998	30
40	Maila Lama	46	2	Agri.	Pinthali	9	10	1998	30

<sup>1</sup>**Education:** 1. Illiterate    2. Literate    3. Primary School  
4. Secondary School   5. Higher Secondary School   6. University

## B. Household Energy Consumption<sup>1</sup>

S. N.	Kerosene Consumption				Battery Consumption				Electricity		Saving in Energy Expenses
	With out MH	With MH	Savings		With out MH	With MH	Savings		Sub-scribed	Total expenses	
	liter per month	liter per month	liter per month	(in Rs.) @ Rs20 per lt.	in pairs per month	in pairs per month	in pairs per month	(in Rs.) @ Rs20 per pair	in watts per month	in Rs. per month	in Rs. Per Month
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(D+H-J)
			(A-B)	(DX20)			(E-F)	(GX20)		(IX0.6)	
1	4	1	3	60	4	2	2	40	75	45	55
2	7	3	4	80	8	4	4	80	75	45	115
3	4	2.5	1.5	30	4	2	2	40	50	30	40
4	4	1	3	60	3	3	0	0	50	30	30
5	2	0.5	1.5	30	0	0	0	0	25	15	15
6	2	1	1	20	0	0	0	0	30	18	2
7	3	0.5	2.5	50	4	2	2	40	25	15	75
8	4	2	2	40	2	2	0	0	50	30	10
9	4	2	2	40	0	0	0	0	100	60	-20
10	8	4	4	80	0	0	0	0	30	18	62
11	2	0.5	1.5	30	0	0	0	0	25	15	15
12	4	2	2	40	4	1	3	60	75	45	55
13	2	0.5	1.5	30	8	2	6	120	25	15	135
14	4	1	3	60	2	0	2	40	25	15	85
15	5	2	3	60	0	0	0	0	30	18	42
16	4	1	3	60	5	2	3	60	25	15	105
17	4	1	3	60	0	0	0	0	30	18	42
18	4	1	3	60	0	0	0	0	50	30	30
19	2	0.5	1.5	30	2	0.5	1.5	30	25	15	45
20	4	0.5	3.5	70	2	0.5	1.5	30	25	15	85
21	4	2	2	40	2	1	1	20	50	30	30
22	3	0.5	2.5	50	2	1	1	20	50	30	40
23	4	0.5	3.5	70	6	1	5	100	50	30	140
24	6	2	4	80	8	4	4	80	50	30	130
25	2	0.5	1.5	30	0	0	0	0	50	30	0
26	4	2	2	40	0	0	0	0	25	15	25
27	3	0.5	2.5	50	4	1	3	60	50	30	80
28	3	0.5	2.5	50	0	0	0	0	50	30	20
29	2	0.5	1.5	30	0	0	0	0	50	30	0
30	5	0.5	4.5	90	1	0.5	0.5	10	50	30	70
31	4	2	2	40	0	0	0	0	50	30	10
32	5	1	4	80	5	2	3	60	75	45	95
33	4	1	3	60	0	0	0	0	50	30	30
34	5	2	3	60	0	0	0	0	50	30	30
35	8	2	6	120	0	0	0	0	50	30	90
36	4	0.5	3.5	70	1	0.5	0.5	10	50	30	50
37	2	0.5	1.5	30	0	0	0	0	50	30	0
38	4	1	3	60	0	0	0	0	75	45	15
39	3	1	2	40	0	0	0	0	50	30	10
40	4	0.5	3.5	70	5	1	4	80	50	30	120
T	156	48.5	107.5	2150	82	33	49	980	1870	1122	2008
AT	1872	582	1290	25800	984	396	588	11760	22440	13464	24096

T - Total AT- Annual Total

<sup>1</sup>Calculation of fuelwood and agricultural residue has been avoided as these sources of energy are used for cooking and the electricity generated from Micro-Hydro is not used for cooking.

## C. Agriculture

### Agricultural Production<sup>1</sup>

S. N.	Paddy			Wheat			Maize			Mustard			Garlic		
	With-out MH	With MH	In-crease	With out MH	With MH	In-crease	With out MH	With MH	In-crease	With out MH	With MH	In-crease	With out MH	With MH	In-crease
	Production Quantity (in Kgs)			Production Quantity (in Kgs)			Production Quantity (in Kgs)			Production Quantity (in Kgs)			Production Quantity (in Kgs)		
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
			B-A			E-F			H-G			K-J			N-M
1		350	350		68	68	680	680	0		28	28		500	500
2		100	100		680	680		136	136			0		250	250
3		150	150		59.5	59.5	442	442	0	18.2	18.2	0	750	750	0
4	450	450	0	68	204	136	544	544	0			0		250	250
5			0			0	612	612	0			0			0
6	350	300	-50			0	1360	1360	0			0		625	625
7	350	750	400	68	136	68	544	816	272	28	116	88		750	750
8	750	1500	750		136	136	952	952	0			0		1000	1000
9	1500	1750	250			0	1360	1360	0			0	3000	3250	250
10	150	150	0			0	884	884	0			0		875	875
11		150	150		680	680	204	408	204			0		625	625
12	200	450	250		204	204	2040	2040	0			0		875	875
13	250	600	350			0		884	884		29	29	375	875	500
14	750	1250	500	24.5	35	10.5	340	340	0			0		175	175
15	1350	1350	0		68	68			0			0		625	625
16	1250	1500	250	204	340	136	340	476	136		174	174		750	750
17	650	750	100		340	340	2380	2380	0			0	125	350	225
18	150	150	0		63	63	680	680	0			0		375	375
19	800	800	0			0	1088	1088	0			0	500	1000	500
20	700	1000	300	204	340	136	1020	1700	680		116	116		1000	1000
21		350	350	34	34	0	1564	1564	0	128	128	0	500	1000	500
22	400	300	-100	68	68	0	680	1020	340			0		1250	1250
23			0			0	476	884	408			0		750	750
24	200	2250	2050	52.5	136	83.5	1360	1360	0		28	28	75	1000	925
25			0		136	136		1156	1156	8.4	8.4	0	250	750	500
26	200	200	0			0	1020	1360	340			0		375	375
27	2500	2500	0	476	476	0	1700	1700	0		28	28		1750	1750
28		100	100	35	35	0	544	544	0		42	42		1000	1000
29		350	350			0	204	204	0			0		500	500
30			0	68	136	68	476	816	340			0		575	575
31	1250	1250	0			0	4080	4080	0			0		625	625
32	1000	1250	250	136	340	204	1020	1700	680		42	42		1500	1500
33	500	500	0			0	3400	3400	0			0		625	625
34	100	100	0		14	14	680	1360	680			0		250	250
35	600	600	0		68	68	1700	2720	1020			0		875	875
36		500	500	175	105	-70	680	408	-272			0		875	875
37		250	250			0	680	680	0			0		625	625
38	1000	1000	0		340	340	680	1700	1020	116	116	0	2500	3000	500
39	150	150	0		56	56	1700	1700	0			0	175	875	700
40	550	550	0			0	680	1224	544			0		1500	1500
	17400	20800	3400	1302	4375	3073	27574	32470	4896	299	874	575	5575	24475	18900

<sup>1</sup> Only major crops have been taken into account

Land Holding				Agricultural Expenses <sup>1</sup>			
S. N.	Total Area	Irrigated		Non Irrigated		Expenses on Fertilizer	
		Without MH	With MH	Without MH	With MH	Without MH	With MH
	(in Ropani)	(in Ropani)	(in Ropani)	(in Ropani)	(in Ropani)	(in Rs.)	(in Rs.)
1	7	0	7	7	0	500	1700
2	3	0	3	3	0	250	1000
3	11	0	4	11	7		1350
4	7	2	5	5	2	800	2100
5	6	1	3	5	3	120	600
6	12	10	10	2	2	1200	3700
7	3.5	0	3.5	3.5	0	900	4800
8	10	0	10	10	0	1500	3000
9	31	25	31	6	0	6000	7500
10	15	5	10	10	5	1600	2700
11	3.5	0	3.5	3.5	0	200	1200
12	8	4	4	4	4	800	4800
13	16	0	9	16	7		5000
14	4	0	4	4	0	500	1500
15	50	25	25	25	25	450	900
16	10	7	10	3	0	1600	4200
17	15	15	15	0	0	700	2200
18	4	4	4	0	0	200	700
19	15	0	8	15	7	2200	2800
20	15	3	15	12	0	2000	6000
21	8	0	8	8	0	1125	2560
22	6	3	3	3	3	800	3000
23	4	0	4	4	0	800	2400
24	4	1	4	3	0	2500	4800
25	2	0	2	2	0	1700	2200
26	7	0	5	7	2	350	1200
27	11	0	11	11	0	4000	6000
28	7	2	4	5	3	400	1800
29	3	2	3	1	0	1200	4200
30	3.5	0	3.5	3.5	0	800	3000
31	35	35	35	0	0	1900	3300
32	14	14	14	0	0	800	1200
33	14	14	9	0	5	1200	2200
34	4	4	4	0	0	1050	2200
35	24	12	12	12	12	650	2850
36	7	3	7	4	0	800	4200
37	8	0	4	8	4	1600	2400
38	30	30	30	0	0		
39	16	10	10	6	6	1300	2400
40	7	2	7	5	0	800	3000
Total	460.5	233	363.5	227.5	97	44495	112660

<sup>1</sup> As the other expenses for agricultural production such as tools and seeds are negligible it is not accounted.

## Changes in Agroprocessing - I

S.N.	Huller							
	Paddy							
	Technology		Place		Time (for 2.5 kg)		Cost (per 50 kg)	
					(in mins.)		(in kg.)	
	With-out MH	With MH	With-out MH	With MH	With-out MH	With MH	With-out MH	With MH
1	A	B	C	D	60	5		2.5
2	A	B	C	D	120	8		2.5
3	A	B	C	D	60	1		2.5
4	A	B	C	D	90	10		2.5
5								
6	A	B	C	D	30	3		2.5
7	A	B	C	D	60	5		2.5
8	A	B	C	D	60	4		2.5
9	A	B	C	D	60	5		2.5
10	A	B	C	D	30	5		2.5
11	A	B	C	D	60	5		2.5
12	A	B	C	D	45	10		
13	E	B	E	D	120	10	2.5	2.5
14	A	B	C	D	60	5		2.5
15	A	B	C	D	60	10		2.5
16	A	B	C	D	60	5		2.5
17	A	B	C	D	30	5		2.5
18	A	B	C	D	60	5		2.5
19	A	B	C	D	50	1.5		2.5
20	A	B	C	D	45	5		2.5
21	A	B	C	D	90	5	2.5	2.5
22	A	B	C	D	60	10		2.5
23								
24	B	B	E	D	60	7		2.5
25	A	B	C	D	60	5		2.5
26	A	B	C	D	60	3		2.5
27	A	B	C	D	60	10		2.5
28	A	B	C	D	45	10		2.5
29	A	B	C	D	60	10		2.5
30	A	B	C	D	60	10		2.5
31	A	B	C	D	60	1.5		2.5
32	A	B	C	D	120	5		2.5
33	A	B	C	D	60	10		2.5
34	A	B	C	D	60	10		2.5
35	A	B	C	D	60	10		2.5
36	A	B	C	D	90	5		2.5
37	A	B	C	D	60	5		2.5
38	A	B	C	D	60	10		2.5
39	A	B	C	D	15	3		2.5
40	A	B	C	D	60	5		2.5
<b>Total</b>					2360	242	5	92.5

<b>Place:</b> A. Dhiki Janto C. House	B. Mill D. In village
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## Changes in Agroprocessing - II

S.N.	Oil Expeller							
	Mustard							
	Technology		Place		Time (per 2.8 kg)		Cost (per 2.8 kg)	
					(in Mins.)		(in Rs.)	
	With-out MH	With MH	With-out MH	With MH	With-out MH	With MH	With-out MH	With MH
1	G	B	D	D	120	10		8
2	G	B	D	D	180	8		8
3		B		D		15		8
4								
5								
6								
7								
8	G	B	D	D	150	15		8
9	G	B	D	D	170	15		8
10								
11								
12								
13								
14	G	B	D	D	180	15		8
15								
16	G	B	D	D	180	15		8
17								
18								
19								
20	G	B	D	D	100	15		8
21								
22								
23								
24								
25								
26								
27	G	B	D	D	180	15		8
28								
29								
30								
31								
32	G	B	D	D	150	15		8
33								
34								
35								
36								
37								
38								
39								
40								
<b>Total</b>					1410	138	0	80

<b>Place</b>	A. Dhiki Janto	B. Mill	C. House
	D. In Village	E. Outside Village	F. Kole

### D. Other Source of Income (apart from Agriculture)

S.N.	Source	Need Electricity	End-Use	Energy Amount Required (in kW)	Increase in Income per Year (Amount in Rs.)
1					
2	Joint	Not Directly	Lighting	75 watts both for household and business	7200
3					
4	Labour Outside	No			
5					
6					
7					
8					
9					
10					
11					
12					
13	Nursery	No			
14					
15	Grocery Store	Not Directly	Lighting	50 watts both for household and business	0
16	Thanka Painting	Not Directly	Lighting	75 watts both for household and business	48000
17					
18					
19					
20	Thanka Painting	Not Directly	Lighting	75 watts both for household and business	48000
21	Labour Outside	No			
22	Labour Outside	No			
23					
24					
25					
26					
27	DDC Vice Ch.	No			
28					
29					
30					
31	Labour Outside	No			
32					
33					
34					
35					
36					
37					
38					
39					
40	Labour Outside	No			
<b>Total</b>					<b>103200</b>

## E. Educational, Health and Access to Information

S.N.	Education (Study Hours)		Health	Listen Radio				Watch Television		
	Without MH	With MH	Treat- ment Facility	Without MH	With MH	Hours per day	Program	Watch Tele vision	Hours per day	Which Program
	(in hours per day)									
1	1	4	1	yes	yes	3	a,b,c	yes	1.5	c
2	1	2	1	yes	yes	4	a,b,c	yes	1	a,b,c
3	1	2	1	yes	yes	1.5	a	No		
4	0.5	3	1	yes	yes	3	a,b,c	no		
5			1	no	no			no		
6	3	1	1	no	no			no		
7	1	3	1	yes	yes	1	a, c	no		
8	2	3	1	yes	yes	3	c	no		
9	3	6	1	yes	yes	10	a, c	yes	2	a, c
10	1	3	1	no	no			no		
11	1	3	1	no	no			no		
12	1	3	1	yes	yes	3	a, b	no		
13	0.5	3	1	yes	yes	3	a, b, c	yes	2	a, b, c
14	0.5	2	1	yes	yes	2	a,	no		
15	1	3	1	yes	yes	5	a, b,c	no		
16	1	2	1	yes	yes	4	a, c	no		
17	1	3	1	no	no			no		
18	1	3	1	no	no			no		
19	0.5	2	1	yes	yes	1	a, b, c	no		
20	2	4	1	yes	yes	3	a, c	no		
21	1	2	1	yes	yes	2	a, b, c	no		
22	0.5	2	1	no	yes	2	a, c	no		
23	1	3	1	yes	yes	3	a, b, c	no		
24	1	2	1	yes	yes	1	a	yes	1	a, b
25	1	2	1	no	yes	2	a	no		
26	3	1	1	no				no		
27	1	3	1	yes	yes	3	a, c	yes	4	a, b, c
28	0.5	2.3	1	no				no		
29	1	3	1	no	no			no		
30	1	2.3	1	no				no		
31	1	1	1	no				no		
32	0.5	2	1	yes	yes	3 hrs	a, c	no		
33	1	3	1	no				no		
34	1	3	1	no				no		
35	1	3	1	yes	yes	3 hrs	a, b	no		
36	0.5	1.5	1	no				no		
37	1	3	1	no				no		
38	1	1.5	1	no	no			no		
39	0.5	2	1	no	no			no		
40	1	3	1	yes	yes	2 hrs	a, c	no		

**Treatment Center**  
 1. Traditional System  
 2. Medical Shop  
 3. Health Post

**Radio & TV Program**  
 a. News  
 b. Skill based information  
 c. Entertainment  
 d. Others



## Annex - VI

### Financial Analysis

#### Summary Sheet of Financial Data

##### Sources of Financing

Source	Angakhola MH System	Daunekhola MH System	Tikhedhunga MH System
<b>Equity Participation</b>			
Community Equity (cash)	10,000	79,500	
Community Equity (labor and material)		144,837	
Community and Government Subsidy			1143001
DDC Equity		100,000	
VDC Equity		100,000	
<b>Grant</b>			
REDP		668,336	
Donors			2240000
ACAP			292835
HMG Subsidy	30,000	199,150	
<b>Loan</b>			
ADB N	60,000	189,686	695500
ACAP			606486
<b>Total</b>	<b>100,000</b>	<b>1,481,509</b>	<b>4977822</b>

##### Capital Costs

MH System	Total Capacity	Total Cost	Subsidy	Grant	Financial Cost	Financial Cost per kW
	(In kW)	(in Rs)	(in Rs)	(in Rs)	(in Rs)	(in Rs)
Angakhola	5	100,000	30,000	-	70,000	14000
Daunekhola	12	1,481,509	199,150	668,336	614,023	51169
Tikhedhunga	40	4,977,822	200,000	3,475,835	1,301,987	32550

##### Operating and Maintenance Costs

MH System	Operating Cost	Maintenance Cost	Total
	Salary of Operator & Manager	(3% of Total Cost)	
	in Rs. per year	in Rs. per year	in Rs. per year
Angakhola	18000	3000	21000
Daunekhola	18000	44445	62445
Tikhedhunga	79200	149335	228535

##### Revenue

MH System	Total Capacity	Capacity	Tariff Rate	Household Uses	Industrial Uses	Total
	(in kW)	(in Watts)	(in Rs. per watt per month)	(in Rs. per year)	(in Rs. per year)	(in Rs. per year)
Angakhola	5	3000	1	36000	0	36000
Daunekhola	12	6350	0.6	45720	29500	75220
Tikhedhunga	40	36000	0.9 & 0.6	334800	0	334800

## Financial Analysis<sup>1</sup> - Angakhola Micro-Hydro System

Existing Situation

Year	Revenue	Cost		Cash Flow		Dis- count Rate	Dis- counted Revenue	Discounted Cost		Discounted Net Cash flow		Cumulative Cash Flow	
		at Net Financial Cost	at Total Cost	at Net Financial Cost	at Total Cost	@ 6% per annum		at Net Financial Cost	at Total Cost	at Net Financial Cost	at Total Cost	at Net Financial Cost	at Total Cost
A	B	C	D	E	F	G	H	I	J	K	L	M	N
				(B - C)	(B - D)		(B X G)	(C X G)	(D X G)	(H - I)	(H - J)		
0	0	70000	100000	-70000	-100000	1	0	70000	100000	-70000	-100000	-70000	-100000
1	36,000	21000	21000	15000	15000	0.943	33962	19811	19811	14151	14151	-55849	-85849
2	36,000	21000	21000	15000	15000	0.89	32040	18690	18690	13350	13350	13350	-72499
3	36,000	21000	21000	15000	15000	0.84	30226	17632	17632	12594	12594	25944	-59905
4	36,000	21000	21000	15000	15000	0.792	28515	16634	16634	11881	11881	11881	-48024
5	36,000	21000	21000	15000	15000	0.747	26901	15692	15692	11209	11209	23090	-36815
6	36,000	21000	21000	15000	15000	0.705	25379	14804	14804	10574	10574	10574	-26241
7	36,000	21000	21000	15000	15000	0.665	23942	13966	13966	9976	9976	20550	-16265
8	36,000	21000	21000	15000	15000	0.627	22587	13176	13176	9411	9411	9411	-6854
9	36,000	21000	21000	15000	15000	0.592	21308	12430	12430	8878	8878	18289	2024
10	36,000	21000	21000	15000	15000	0.558	20102	11726	11726	8376	8376	8376	10400
11	36,000	21000	21000	15000	15000	0.527	18964	11063	11063	7902	7902	16278	18302
12	36,000	21000	21000	15000	15000	0.497	17891	10436	10436	7455	7455	7455	25757
13	36,000	21000	21000	15000	15000	0.469	16878	9846	9846	7033	7033	14488	32790
14	36,000	21000	21000	15000	15000	0.442	15923	9288	9288	6635	6635	6635	39425
15	36,000	21000	21000	15000	15000	0.417	15022	8763	8763	6259	6259	12894	45684
<b>Total</b>							349640	273957	303957	75684	45684		

	At Financial Cost	At Total Cost
<b>Net Present Value</b>	75684	45684

<sup>1</sup> All amount in Rs. (1 Euro = Rs 68)

## Financial Analysis<sup>1</sup> - Daunekhola Micro-Hydro System

Existing Situation

Year	Revenue	Cost		Cash Flow		Discount Rate	Dis-counted Revenue	Discounted Cost		Discounted Net Cash Flow		Cumulative Cash Flow	
		at Net Financial Cost	at Total Cost	at Net Financial Cost	at Total Cost	@ 6% per annum		at Net Financial Cost	at Total Cost	at Net Financial Cost	at Total Cost	at Net Financial Cost	at Total Cost
A	B	C	D	E	F	G	H	I	J	K	L	M	N
				(B - C)	(B -D)		(B X G)	(C X G)	(D X G)	(H - I)	(H - J)		
0	0	614023	1481509	-614023	-1481509	1	0	614023	1481509	-614023	-1481509	-614023	-1481509
1	75220	62445	62445	12775	12775	0.943	70962	58911	58911	12052	12052	-601971	-1469457
2	75220	62445	62445	12775	12775	0.89	66946	55576	55576	11369	11369	-590602	-1458088
3	75220	62445	62445	12775	12775	0.84	63156	52430	52430	10726	10726	-579876	-1447362
4	75220	62445	62445	12775	12775	0.792	59581	49463	49463	10119	10119	-569757	-1437243
5	75220	62445	62445	12775	12775	0.747	56209	46663	46663	9546	9546	-560211	-1427697
6	75220	62445	62445	12775	12775	0.705	53027	44021	44021	9006	9006	-551205	-1418691
7	75220	62445	62445	12775	12775	0.665	50026	41530	41530	8496	8496	-542709	-1410195
8	75220	62445	62445	12775	12775	0.627	47194	39179	39179	8015	8015	-534694	-1402180
9	75220	62445	62445	12775	12775	0.592	44523	36961	36961	7561	7561	-527133	-1394619
10	75220	62445	62445	12775	12775	0.558	42002	34869	34869	7133	7133	-520000	-1387486
11	75220	62445	62445	12775	12775	0.527	39625	32895	32895	6730	6730	-513270	-1380756
12	75220	62445	62445	12775	12775	0.497	37382	31033	31033	6349	6349	-506921	-1374407
13	75220	62445	62445	12775	12775	0.469	35266	29277	29277	5989	5989	-500932	-1368418
14	75220	62445	62445	12775	12775	0.442	33270	27620	27620	5650	5650	-495282	-1362768
15	75220	62445	62445	12775	12775	0.417	31387	26056	26056	5330	5330	-489952	-1357438
<b>Total</b>							730556	1220507	2087993	-489952	-1357438		

	At Financial Cost	At Total Cost
<b>Net Present Value</b>	-489952	-1357438

<sup>1</sup> All amount in Rs. (1 Euro = Rs 68)

## Financial Analysis<sup>1</sup> - Tikhedhunga Micro-Hydro System

Existing Situation

Year	Revenue	Cost		Cash Flow		Dis- count Rate	Dis- counted Revenue	Discounted Cost		Discounted Net Cash flow		Cumulative Cash Flow	
		at Net Fin- ancial Cost	at Total Cost	at Net Financial Cost	at Total Cost	@ 6% per annum		at Net Financial Cost	at Total Cost	at Net Financial Cost	at Total Cost	at Net Financial Cost	at Total Cost
A	B	C	D		F	G	H	I	J	K	L	M	N
				(B - C)	(B - D)		(B X G)	(C X G)	(D X G)	(H - I)	(H - J)		
0	0	1794821	4977822	-1794821	-4977822	1	0	1794821	4977822	-1794821	-4977822	-1794821	-4977822
1	334800	228535	228535	106265	106265	0.943	315849	215599	215599	100250	100250	-1694571	-4877572
2	334800	228535	228535	106265	106265	0.89	297971	203395	203395	94576	94576	-1599995	-4782996
3	334800	228535	228535	106265	106265	0.84	281105	191882	191882	89222	89222	-1510773	-4693774
4	334800	228535	228535	106265	106265	0.792	265193	181021	181021	84172	84172	-1426601	-4609602
5	334800	228535	228535	106265	106265	0.747	250182	170774	170774	79408	79408	-1347193	-4530194
6	334800	228535	228535	106265	106265	0.705	236021	161108	161108	74913	74913	-1272280	-4455281
7	334800	228535	228535	106265	106265	0.665	222661	151989	151989	70673	70673	-1201607	-4384608
8	334800	228535	228535	106265	106265	0.627	210058	143385	143385	66672	66672	-1134935	-4317936
9	334800	228535	228535	106265	106265	0.592	198168	135269	135269	62898	62898	-1072037	-4255038
10	334800	228535	228535	106265	106265	0.558	186951	127613	127613	59338	59338	-1012699	-4195700
11	334800	228535	228535	106265	106265	0.527	176368	120389	120389	55979	55979	-956720	-4139721
12	334800	228535	228535	106265	106265	0.497	166385	113575	113575	52811	52811	-903909	-4086910
13	334800	228535	228535	106265	106265	0.469	156967	107146	107146	49821	49821	-854088	-4037089
14	334800	228535	228535	106265	106265	0.442	148082	101081	101081	47001	47001	-807087	-3990088
15	334800	228535	228535	106265	106265	0.417	139700	95360	95360	44341	44341	-762746	-3945747
<b>Total</b>							3251661	4014407	7197408	-762746	-3945747		

	At Financial Cost	At Total Cost
<b>Net Present Value</b>	-762746	-3945747

<sup>1</sup> All amount in Rs. (1 Euro = Rs 68)

## Analysis with Increase in Electricity Tariff Rate<sup>1</sup> - Daunekhola Micro-Hydro System

Cost - Net Financial Cost

Capacity Utilization - 53% (6.35 kW)

Tariff Rate - Rs 1.52 and Rs 1.53 per watt per month from the fourth year

Year	Revenue		Cost	Cash Flow		Dis- count Rate	Discounted Revenue		Dis- counted Cost	Discounted Net Cash flow		Cumulative Cash Flow	
	at Rs. 1.52 per watt per month	at Rs. 1.53 per watt per month	at Net Financi al Cost	at Rs. 1.52 per watt per month	at Rs. 1.53 per watt per month	@ 6% per annum	at Rs. 1.52 per watt per month	at Rs. 1.53 per watt per month	at Net Financial Cost	at Rs. 1.52 per watt per month	at Rs. 1.53 per watt per month	at Rs. 1.52 per watt per month	at Rs. 1.53 per watt per month
A	B	C	D	E	F	G	H	I	J	K	L	M	N
				(B - D)	(C -D)		(B X G)	(C X G)	(D X G)	(H -J)	(I- J)		
0	0	0	614023	-614023	-614023	1	0	0	614023	-614023	-614023	-614023	-614023
1	75220	75220	62445	12775	12775	0.943	70962	70962	58911	12052	12052	-601971	-601971
2	75220	75220	62445	12775	12775	0.890	66946	66946	55576	11369	11369	-590602	-590602
3	75220	75220	62445	12775	12775	0.840	63156	63156	52430	10726	10726	-579876	-579876
4	144562	145,324	62445	82117	82879	0.792	114507	115110	49463	65044	65648	-514832	-514228
5	144562	145,324	62445	82117	82879	0.747	108025	108595	46663	61362	61932	-453469	-452296
6	144562	145,324	62445	82117	82879	0.705	101911	102448	44021	57889	58426	-395580	-393870
7	144562	145,324	62445	82117	82879	0.665	96142	96649	41530	54612	55119	-340968	-338751
8	144562	145,324	62445	82117	82879	0.627	90700	91178	39179	51521	51999	-289447	-286752
9	144562	145,324	62445	82117	82879	0.592	85566	86017	36961	48605	49056	-240842	-237696
10	144562	145,324	62445	82117	82879	0.558	80723	81148	34869	45854	46279	-194989	-191417
11	144562	145,324	62445	82117	82879	0.527	76153	76555	32895	43258	43659	-151731	-147758
12	144562	145,324	62445	82117	82879	0.497	71843	72222	31033	40809	41188	-110921	-106569
13	144562	145,324	62445	82117	82879	0.469	67776	68134	29277	38500	38857	-72422	-67713
14	144562	145,324	62445	82117	82879	0.442	63940	64277	27620	36320	36657	-36101	-31055
15	144562	145,324	62445	82117	82879	0.417	60321	60639	26056	34264	34582	-1837	3527
<b>Total</b>							1218670	1224034	1220507	-1837	3527		
							<b>Tariff Rate at Rs. 1.52 per watt per month</b>		<b>Tariff Rate at Rs. 1.53 per watt per month</b>				
<b>Net Present Value</b>							-1837		3527				

<sup>1</sup> All amount in Rs. (1 Euro = Rs 68)

## Analysis with Increase in Electricity Tariff Rate<sup>1</sup> - Tikhedhunga Micro-Hydro System

Cost - Net Financial Cost

Capacity Utilization - 90% (36 kW)

Tariff Rate - Rs 1.07 and Rs 1.08 per watt per month from fifth year

Year	Revenue		Cost	Cash Flow		Dis- count Rate	Discounted Revenue		Dis- counted Cost	Discounted Net Cash flow		Cumulative Cash Flow	
	at Rs. 1.07 per watt per month	at Rs. 1.08 per watt per month	at Net Financial Cost	at Rs. 1.07 per watt per month	at Rs. 1.08 per watt per month	@ 6% per annum	at Rs. 1.07 per watt per month	at Rs. 1.08 per watt per month	at Net Financial Cost	at Rs. 1.07 per watt per month	at Rs. 1.08 per watt per month	at Rs. 1.07 per watt per month	at Rs. 1.08 per watt per month
A	B	C	D	E	F	G	H	I	J	K	L	M	N
				(B - D)	(C - D)		(B X G)	(C X G)	(D X G)	(H - J)	(I - J)		
0	0	0	1794821	-1794821	-1794821	1.000	0	0	1794821	-1794821	-1794821	-1794821	-1794821
1	324000	324000	228535	95465	95465	0.943	305660	305660	215599	90062	90062	-1704759	-1704759
2	324000	324,000	228535	95465	95465	0.890	288359	288359	203395	84964	84964	-1619796	-1619796
3	324000	324,000	228535	95465	95465	0.840	272037	272037	191882	80155	80155	-1539641	-1539641
4	324000	324,000	228535	95465	95465	0.792	256638	256638	181021	75617	75617	-1464024	-1464024
5	462240	466,560	228535	233705	238025	0.747	345413	348641	170774	174638	177866	-1289385	-1286157
6	462240	466,560	228535	233705	238025	0.705	325861	328906	161108	164753	167798	-1124632	-1118359
7	462240	466,560	228535	233705	238025	0.665	307416	310289	151989	155427	158300	-969205	-960058
8	462240	466,560	228535	233705	238025	0.627	290015	292726	143385	146630	149340	-822575	-810718
9	462240	466,560	228535	233705	238025	0.592	273599	276156	135269	138330	140887	-684245	-669831
10	462240	466,560	228535	233705	238025	0.558	258112	260525	127613	130500	132912	-553746	-536919
11	462240	466,560	228535	233705	238025	0.527	243502	245778	120389	123113	125389	-430632	-411530
12	462240	466,560	228535	233705	238025	0.497	229719	231866	113575	116144	118291	-314488	-293239
13	462240	466,560	228535	233705	238025	0.469	216716	218742	107146	109570	111596	-204918	-181644
14	462240	466,560	228535	233705	238025	0.442	204449	206360	101081	103368	105279	-101550	-76365
15	462240	466,560	228535	233705	238025	0.417	192877	194679	95360	97517	99320	-4033	22955
<b>Total</b>							4010374	4037361	4014407	-4033	22955		

	Tariff Rate at Rs. 1.07 per watt per month	Tariff Rate at Rs. 1.53per watt per month
Net Present Value	-4033	22955

<sup>1</sup> All amount in Rs. (1 Euro = Rs 68)

## Analysis with Increase in Electricity Tariff Rate<sup>1</sup> - Daunekhola Micro-Hydro System

Cost - Total Cost

Capacity Utilization - 53% (6.35 kW)

Tariff Rate - Rs 3.13 and Rs 3.14 per watt per month from the fourth year

Year	Revenue		Cost	Cash Flow		Dis- count Rate	Discounted Revenue		Dis- counted Cost	Discounted Net Cash flow		Cumulative Cash Flow	
	at Rs.3.13 per watt per month	at Rs.3.14 per watt per month	at Total Cost	at Rs.3.13 per watt per month	at Rs. 3.14 per watt per month	@ 6% per annum	at Rs.3.13 per watt per month	at Rs. 3.14 per watt per month	at Total Cost	at Rs.3.13 per watt per month	at Rs. 3.14 per watt per month	at Rs.3.13 per watt per month	at Rs. 3.14 per watt per month
A	B	C	D	E	F	G	H	I	J	K	L	M	N
				(B - D)	(C - D)		(B X G)	(C X G)	(D X G)	(H - J)	(I - J)		
0	0	0	1481509	-1481509	-1481509	1	0	0	1481509	-1481509	-1481509	-1481509	-1481509
1	75220	75220	62445	12775	12775	0.943	70962	70962	58911	12052	12052	-1469457	-1469457
2	75220	75220	62445	12775	12775	0.890	66946	66946	55576	11369	11369	-1458088	-1458088
3	75220	75220	62445	12775	12775	0.840	63156	63156	52430	10726	10726	-1447362	-1447362
4	268006	268,768	62445	205561	206323	0.792	212286	212889	49463	162823	163427	-1284539	-1283935
5	268006	268,768	62445	205561	206323	0.747	200270	200839	46663	153607	154176	-1130932	-1129759
6	268006	268,768	62445	205561	206323	0.705	188934	189471	44021	144912	145449	-986020	-984309
7	268006	268,768	62445	205561	206323	0.665	178239	178746	41530	136710	137216	-849310	-847093
8	268006	268,768	62445	205561	206323	0.627	168150	168628	39179	128971	129449	-720339	-717644
9	268006	268,768	62445	205561	206323	0.592	158632	159083	36961	121671	122122	-598667	-595521
10	268006	268,768	62445	205561	206323	0.558	149653	150079	34869	114784	115210	-483883	-480312
11	268006	268,768	62445	205561	206323	0.527	141182	141584	32895	108287	108688	-375597	-371624
12	268006	268,768	62445	205561	206323	0.497	133191	133569	31033	102157	102536	-273439	-269088
13	268006	268,768	62445	205561	206323	0.469	125652	126009	29277	96375	96732	-177064	-172355
14	268006	268,768	62445	205561	206323	0.442	118539	118876	27620	90920	91257	-86145	-81099
15	268006	268,768	62445	205561	206323	0.417	111830	112147	26056	85773	86091	-371	4993
<b>Total</b>							2087622	2092986	2087993	-371	4993		

	Tariff Rate at Rs. 3.13 per watt per month	Tariff Rate at Rs. 1.09 per watt per month
<b>Net Present Value</b>	-371	4993

<sup>1</sup> All amount in Rs. (1 Euro = Rs 68)

## Analysis with Increase in Electricity Tariff Rate<sup>1</sup> - Tikhedhunga Micro-Hydro System

Cost - Total Cost

Capacity Utilization - 90% (36 kW)

Tariff Rate - Rs 2.25 and Rs 2.26 per watt per month from the fifth year

Year	Revenue		Cost	Cash Flow		Dis- count Rate	Discounted Revenue		Dis- counted Cost	Discounted Net Cash flow		Cumulative Cash Flow	
	at Rs. 2.25 per watt per month	at Rs.2.26 per watt per month	at Total Cost	at Rs. 2.25 per watt per month	at Rs.2.26 per watt per month	@ 6% per annum	at Rs. 2.25 per watt per month	at Rs.2.26 per watt per month	at Total Cost	at Rs. 2.25 per watt per month	at Rs.2.26 per watt per month	at Rs. 2.25 per watt per month	at Rs.2.26 per watt per month
A	B	C	D	E	F	G	H	I	J	K	L	M	N
				(B - D)	(C - D)		(B X G)	(C X G)	(D X G)	(H - J)	(I - J)		
0	0	0	4977822	-4977822	-4977822	1	0	0	4977822	-4977822	-4977822	-4977822	-4977822
1	324000	324,000	228535	95465	95465	0.943	305660	305660	215599	90062	90062	-4887760	-4887760
2	324000	324,000	228535	95465	95465	0.890	288359	288359	203395	84964	84964	-4802797	-4802797
3	324000	324,000	228535	95465	95465	0.840	272037	272037	191882	80155	80155	-4722642	-4722642
4	324000	324,000	228535	95465	95465	0.792	256638	256638	181021	75617	75617	-4647025	-4647025
5	972000	976,320	228535	743465	747785	0.747	726335	729563	170774	555561	558789	-4091464	-4088236
6	972000	976,320	228535	743465	747785	0.705	685222	688267	161108	524114	527159	-3567350	-3561077
7	972000	976,320	228535	743465	747785	0.665	646436	649309	151989	494447	497320	-3072903	-3063757
8	972000	976,320	228535	743465	747785	0.627	609845	612555	143385	466459	469170	-2606444	-2594587
9	972000	976,320	228535	743465	747785	0.592	575325	577882	135269	440056	442613	-2166388	-2151974
10	972000	976,320	228535	743465	747785	0.558	542760	545172	127613	415147	417559	-1751241	-1734414
11	972000	976,320	228535	743465	747785	0.527	512037	514313	120389	391648	393924	-1359593	-1340491
12	972000	976,320	228535	743465	747785	0.497	483054	485201	113575	369479	371626	-990113	-968864
13	972000	976,320	228535	743465	747785	0.469	455712	457737	107146	348566	350591	-641547	-618273
14	972000	976,320	228535	743465	747785	0.442	429917	431827	101081	328835	330746	-312712	-287527
15	972000	976,320	228535	743465	747785	0.417	405582	407384	95360	310222	312025	-2490	24498
<b>Total</b>							7194918	7221905	7197408	-2490	24498		

	Tariff Rate at Rs. 2.25 per watt per month	Tariff Rate at Rs.2.26 per watt per month
<b>Net Present Value</b>	-2490	24498

<sup>1</sup> All amount in Rs. (1 Euro = Rs 68)



## Analysis with increase in Capacity Utilization and Electricity Tariff Rate<sup>1</sup> - Daunekhola MH System

Cost - Net Financial Cost

Household Uses - From the fourth year increase in Capacity Utilization yearly by 10% (till the 94% of the capacity is utilized) and Tariff Rate by 5%

Industrial Uses - From the fourth year increase the tariff rate by 7.8% per annum for the remaining life period

Year	Revenue			Cost	Cash Flow	Discount Rate	Dis-counted Revenue	Discounted Cost	Discounted Net Cash Flow	Cumulative Cash Flow
	From the Household Uses	From the Industrial Uses	Total	at Net Financial Cost		@ 6% per annum		at Net Financial Cost		
A	B	C	D	E	F	G	H	I	J	M
			(B+C)		(D-E)		(D X G)	(E X G)	(H - I)	
0	0	0	0	614023	-614023	1	0	614023	-614023	-614023
1	45720	29500	75220	62445	12775	0.943	70962	58911	12051	-601972
2	45720	29500	75220	62445	12775	0.890	66946	55576	11370	-590602
3	45720	29500	75220	62445	12775	0.840	63156	52430	10726	-579876
4	52890	31801	84691	62445	22246	0.792	67083	49463	17620	-562256
5	61088	34281	95369	62445	32924	0.747	71265	46663	24602	-537654
6	70556	36955	107511	62445	45066	0.705	75791	44021	31770	-505884
7	81492	39838	121330	62445	58885	0.665	80691	41530	39161	-466722
8	94124	42945	137069	62445	74624	0.627	85999	39179	46820	-419902
9	108713	46295	155008	62445	92563	0.592	91749	36961	54788	-365114
10	114149	49906	164055	62445	101610	0.558	91607	34869	56738	-308376
11	119856	53799	173655	62445	111210	0.527	91479	32895	58584	-249792
12	125849	57995	183844	62445	121399	0.497	91365	31033	60332	-189460
13	132141	62519	194660	62445	132215	0.469	91264	29277	61987	-127473
14	138748	67395	206143	62445	143698	0.442	91177	27620	63557	-63915
15	145686	72652	218338	62445	155893	0.417	91105	26056	65049	1133
<b>Total</b>							1221640	1220507	1133	

<b>Net Present Value</b>	<b>1133</b>
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<sup>1</sup> All amount in Rs. ( 1 Euro = Rs. 68)

## Analysis with increase in Capacity Utilization and Electricity Tariff Rate<sup>1</sup> - Daunekhola MH System

Cost - Total Cost

Household Uses - From the fourth year increase in Capacity Utilization yearly by 10% (till the 94% of the capacity is utilized) and Tariff Rate by 10%

Industrial Uses - From the fourth year increase the tariff rate by 24% per annum for the remaining life period

Year	Revenue			Cost	Cash Flow	Discount Rate	Dis-counted Revenue	Discounted Cost	Discounted Net Cash Flow	Cumulative Cash Flow
	From the Household Uses	From the Industrial Uses	Total	at Total Cost		@ 6% per annum		at Net Financial Cost		
A	B	C	D	E	F	G	H	I	J	M
			(B+C)		(D-E)		(D X G)	(E X G)	(H - I)	
0	0	0	0	1481509	-1481509	1	0	1481509	-1481509	-1481509
1	45720	29500	75220	62445	12775	0.943	70962	58911	12051	-1469458
2	45720	29500	75220	62445	12775	0.890	66946	55576	11370	-1458088
3	45720	29500	75220	62445	12775	0.840	63156	52430	10726	-1447362
4	55408	36580	91988	62445	29543	0.792	72863	49463	23400	-1423962
5	67044	45359	112403	62445	49958	0.747	83994	46663	37331	-1386631
6	81123	56245	137368	62445	74923	0.705	96839	44021	52818	-1333813
7	98159	69744	167903	62445	105458	0.665	111665	41530	70135	-1263678
8	118773	86483	205256	62445	142811	0.627	128780	39179	89601	-1174077
9	143715	107239	250954	62445	188509	0.592	148539	36961	111578	-1062498
10	158086	132976	291062	62445	228617	0.558	162528	34869	127659	-934840
11	173895	164890	338785	62445	276340	0.527	178468	32895	145573	-789267
12	191285	204464	395749	62445	333304	0.497	196675	31033	165642	-623625
13	210413	253536	463949	62445	401504	0.469	217517	29277	188240	-435385
14	231454	314384	545838	62445	483393	0.442	241425	27620	213805	-221580
15	254600	389836	644436	62445	581991	0.417	268901	26056	242845	21265
<b>Total</b>							2109258	2087993	21265	

<b>Net Present Value</b>	21265
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<sup>1</sup> All amount in Rs. ( 1 Euro = Rs. 68)

## Analysis with increase in Capacity Utilization and Electricity Tariff Rate<sup>1</sup> - Tikhedhunga MH System

Cost - Net Financial Cost

Household Uses - Existing Capacity Utilization and Increase in Tariff Rate by 10% per annum from fifth year

Industrial Uses - From the fifth year 90% Capacity Utilization and Tariff Rate Rs. 0.33 per watt per month

Year	Revenue			Cost	Cash Flow	Discount Rate	Discounted Revenue	Discounted Cost	Discounted Net Cash Flow	Cumulative Cash Flow
	From the Household Uses	From the Industrial Uses	Total	at Net Financial Cost	at Net Financial Cost	@ 6% per annum		at Net Financial Cost		
A	B	C	D	E	F	G	H	I	J	M
			(B+C)		(D-E)		(D X G)	(E X G)	(H - I)	
0	0	0	0	1794821	-1794821	1	0	1794821	-1794821	-1794821
1	324000	0	324000	228535	95465	0.943	305660	215599	90061	-1704760
2	324000	0	324000	228535	95465	0.890	288359	203395	84964	-1619796
3	324000	0	324000	228535	95465	0.840	272037	191882	80154	-1539642
4	324000	0	324000	228535	95465	0.792	256638	181021	75617	-1464025
5	324000	142560	466560	228535	238025	0.747	348641	170775	177866	-1286159
6	324000	142560	466560	228535	238025	0.705	328906	161108	167798	-1118360
7	324000	142560	466560	228535	238025	0.665	310289	151989	158300	-960060
8	324000	142560	466560	228535	238025	0.627	292726	143386	149340	-810720
9	324000	142560	466560	228535	238025	0.592	276156	135270	140887	-669834
10	324000	142560	466560	228535	238025	0.558	260525	127613	132912	-536922
11	324000	142560	466560	228535	238025	0.527	245778	120389	125389	-411533
12	324000	142560	466560	228535	238025	0.497	231866	113575	118291	-293242
13	324000	142560	466560	228535	238025	0.469	218742	107146	111595	-181647
14	324000	142560	466560	228535	238025	0.442	206360	101081	105279	-76368
15	324000	142560	466560	228535	238025	0.417	194679	95360	99320	22952
<b>Total</b>							4037361	4014410	22952	

<b>Net Present Value</b>	22952
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<sup>1</sup> All amount in Rs. ( 1 Euro = Rs. 68)

## Analysis with increase in Capacity Utilization and Electricity Tariff Rate<sup>1</sup> - Tikhedhunga MH System

Cost - Total Cost

Household Uses - Existing Capacity Utilization and Tariff Rate

Industrial Uses - From the fifth year 90% Capacity Utilization and Tariff Rate Rs. 0.83 per watt per month

Year	Revenue			Cost	Cash Flow	Discount Rate	Discounted Revenue	Discounted Cost	Discounted Net Cash Flow	Cumulative Cash Flow
	From the Household Uses	From the Industrial Uses	Total	at Total Cost		@ 6% per annum		at Total Cost		
A	B	C	D	E	F	G	H	I	J	M
			(B+C)		(D-E)		(D X G)	(E X G)	(H - I)	
0	0	0	0	4977822	-4977822	1	0	4977822	-4977822	-4977822
1	324000	0	324000	228535	95465	0.943	305660	215599	90061	-4887761
2	324000	0	324000	228535	95465	0.890	288359	203395	84964	-4802797
3	324000	0	324000	228535	95465	0.840	272037	191882	80154	-4722643
4	324000	0	324000	228535	95465	0.792	256638	181021	75617	-4647026
5	356400	358560	714960	228535	486425	0.747	534260	170775	363485	-4283541
6	427680	358560	786240	228535	557705	0.705	554268	161108	393160	-3890381
7	470448	358560	829008	228535	600473	0.665	551338	151989	399349	-3491032
8	517493	358560	876053	228535	647518	0.627	549646	143386	406261	-3084771
9	569242	358560	927802	228535	699267	0.592	549165	135270	413895	-2670876
10	626166	358560	984726	228535	756191	0.558	549866	127613	422253	-2248623
11	688783	358560	1047343	228535	818808	0.527	551727	120389	431338	-1817285
12	757661	358560	1116221	228535	887686	0.497	554728	113575	441153	-1376132
13	833427	358560	1191987	228535	963452	0.469	558850	107146	451704	-924428
14	916770	358560	1275330	228535	1046795	0.442	564080	101081	462998	-461430
15	1008447	358560	1367007	228535	1138472	0.417	570404	95360	475045	13615
<b>Total</b>							7211026	7197411	13615	

<b>Net Present Value</b>	13615
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<sup>1</sup> All amount in Rs. ( 1 Euro = Rs. 68)

# ANNEX - VII

## Economic Analysis

### Benefit Including Irrigation

Year	Benefit	Cost		Cash Flow		Discount Rate	Dis-counted Revenue	Discounted Cost		Discounted Net Cash flow		Cumulative Cash Flow	
		at Net Eco-nomic Cost	at Total Cost	at Net Eco-nomic Cost	at Total Cost	@ 6% per annum		at Net Eco-nomic Cost	at Total Cost	at Net Eco-nomic Cost	at Total Cost	at Net Eco-nomic Cost	at Total Cost
A	B	C	D	E	F	G	H	I	J	K	L	M	N
				(B - C)	(B -D)		(B X G)	(C X G)	(D X G)	(H - I)	(H - J)		
0	0	449186	1481509	-449186	-1481509	1	0	449186	1481509	-449186	-1481509	-449186	-1481509
1	2,047,844	44445	44445	2003399	2003399	0.943	1931928	41930	41930	1889999	1889999	1440813	408489.8
2	2,047,844	44445	44445	2003399	2003399	0.890	1822574	39556	39556	1783018	1783018	1783018	2191508
3	2,047,844	44445	44445	2003399	2003399	0.840	1719409	37317	37317	1682092	1682092	3465110	3873600
4	2,047,844	44445	44445	2003399	2003399	0.792	1622084	35205	35205	1586879	1586879	1586879	5460479
5	2,047,844	44445	44445	2003399	2003399	0.747	1530268	33212	33212	1497056	1497056	3083936	6957535
6	2,047,844	44445	44445	2003399	2003399	0.705	1443649	31332	31332	1412317	1412317	1412317	8369852
7	2,047,844	44445	44445	2003399	2003399	0.665	1361933	29559	29559	1332375	1332375	2744692	9702227
8	2,047,844	44445	44445	2003399	2003399	0.627	1284843	27886	27886	1256957	1256957	1256957	10959184
9	2,047,844	44445	44445	2003399	2003399	0.592	1212116	26307	26307	1185809	1185809	2442766	12144993
10	2,047,844	44445	44445	2003399	2003399	0.558	1143505	24818	24818	1118687	1118687	1118687	13263680
11	2,047,844	44445	44445	2003399	2003399	0.527	1078779	23413	23413	1055365	1055365	2174053	14319046
12	2,047,844	44445	44445	2003399	2003399	0.497	1017716	22088	22088	995628	995628	995628	15314673
13	2,047,844	44445	44445	2003399	2003399	0.469	960109	20838	20838	939272	939272	1934899	16253945
14	2,047,844	44445	44445	2003399	2003399	0.442	905763	19658	19658	886105	886105	886105	17140050
15	2,047,844	44445	44445	2003399	2003399	0.417	854494	18545	18545	835948	835948	1722053	17975998
<b>Total</b>							19889171	880850	1913173	19008321	17975998		

	At Financial Cost	At Total Cost
<b>Net Present Value</b>	19008321	17975998

<sup>1</sup> All amount in Rs. (1 Euro = Rs 68)

## Benefit Excluding Irrigation

Year	Benefit	Cost		Cash Flow		Dis- count Rate	Dis- counted Revenue	Discounted Cost		Discounted Net Cash flow		Cumulative Cash Flow	
		at Net Eco- nomic Cost	at Total Cost	at Net Eco- nomic Cost	at Total Cost	@ 6% per annum		at Net Eco- nomic Cost	at Total Cost	at Net Eco- nomic Cost	at Total Cost	at Net Eco- nomic Cost	at Total Cost
A	B	C	D	E	F	G	H	I	J	K	L	M	N
				(B - C)	(B - D)		(B X G)	(C X G)	(D X G)	(H - I)	(H - J)		
0	0	449186	1481509	-449186	-1481509	1	0	449186	1481509	-449186	-1481509	-449186	-1481509
1	299,558	44445	44445	255113	255113	0.943	282602	41930	41930	240672	240672	-208514	-1240837
2	299,558	44445	44445	255113	255113	0.890	266606	39556	39556	227049	227049	227049	-1013787
3	299,558	44445	44445	255113	255113	0.840	251515	37317	37317	214198	214198	441247	-799590
4	299,558	44445	44445	255113	255113	0.792	237278	35205	35205	202073	202073	202073	-597516
5	299,558	44445	44445	255113	255113	0.747	223847	33212	33212	190635	190635	392708	-406881
6	299,558	44445	44445	255113	255113	0.705	211177	31332	31332	179844	179844	179844	-227037
7	299,558	44445	44445	255113	255113	0.665	199223	29559	29559	169665	169665	349509	-57372
8	299,558	44445	44445	255113	255113	0.627	187946	27886	27886	160061	160061	160061	102688
9	299,558	44445	44445	255113	255113	0.592	177308	26307	26307	151001	151001	311062	253689
10	299,558	44445	44445	255113	255113	0.558	167272	24818	24818	142454	142454	142454	396143
11	299,558	44445	44445	255113	255113	0.527	157803	23413	23413	134390	134390	276844	530533
12	299,558	44445	44445	255113	255113	0.497	148871	22088	22088	126783	126783	126783	657316
13	299,558	44445	44445	255113	255113	0.469	140444	20838	20838	119607	119607	246390	776923
14	299,558	44445	44445	255113	255113	0.442	132495	19658	19658	112837	112837	112837	889760
15	299,558	44445	44445	255113	255113	0.417	124995	18545	18545	106450	106450	219286	996209
<b>Total</b>							2909382	880850	1913173	2028532	996209		

	At Financial Cost	At Total Cost
<b>Net Present Value</b>	2028532	996209

<sup>1</sup> All amount in Rs. (1 Euro = Rs 68)

## ANNEX - VIII

### List of People and Organizations Contacted during Field Research

S.N.	Name	Designation	Organization
1	Hira Lal Singh	Joint Secretary	National Planning Commission, Kathmandu
2	Arun Dhoj Adhikari	Assistant Resident Representative	UNDP, Lalitpur
3	Kiran Man Singh	National Program Manager	REDP, Kathmandu
4	Satish Gautam	Energy Development Advisor	REDP, Kathmandu
5	Biswo Koirala	Environment Advisor	REDP, Kathmandu
6	Thakur Devkota	Energy Development Advisor	REDP, Kathmandu
7	Mahendra Neupane	District Energy Advisor	REDP, Kavre
8	Deepak Thapa	Technical Officer	ACAP, Pokhara
9	Arjun Bista	Information Officer	Agricultural Development Bank, Kathmandu
10	Hari Krishna Ghimire	Director	Nepal Electricity Authority, Kathmandu
11	Nand Kishore Rauniyar	Act. Deputy Managing Director	Nepal Oil Corporation, Kathmandu
12	Biswo Bhusan Amatya	Consultant	AEPC, Lalitpur
13	Laxmi Tamrakar	Energy Officer	AEPC, Lalitpur
15	Jeevan Acharya		United Mission to Nepal, Kathmandu
16	Dr. Govinda Nepal	Consultant	Intermediate Technology Development Group, Lalitpur
17	Alok Rajauria	Advisor	Intermediate Technology Development Group, Lalitpur
18	Shreedhar Devkota	Director	Small Hydro Power Development Project, GTZ, Lalitpur
19	Prof. JN Shrestha	Director	Center for Energy Studies, Institute of Engineering

## **Pinthali ( Daunekhola)**

People contacted for the household survey. (Name list in Annex V Page 1 )

### **Tikhedhunga**

1	Karna Bahadur Pariyar		
2	Surya Bahadur Gurung	Member - Management Committee	Tikhedhunga Micro-Hydro System
3	Nanda Lal Biswokarma	Community Member	
4	Bhim Lal Pariyar	Community Member	
5	Raju Gurung	Community Member	
6	Ram Prasad Sherchan	Community Member	
7	Prem Prasad Tulachan	Community Member	

### **Angakhola**

1	Yadav Paudel	Manager	Angakhola Micro-Hydro System
2	ManamatiZendimagar	Community Member	
3	Karna Bahadur Sinjali	Community Member	
4	Karma Singh Lama	Community Member	
5	Dev Bahdur Masarangi	Community Member	
6	Thaman Bahadur Gaha	Community Member	
7	Dev Singh Chindi	Community Member	
8	Tak Bahadur Shrestha	Community Member	
9	Ram Paudel	Community Member	



## Abstract

Economic welfare of people in the rural areas can be enhanced through increase in agricultural productivity and development of rural enterprises. Both of these approaches depend highly on the accessibility of commercial sources of energy. As there is a high potential for the utilization of hydropower in Nepal and considering that the rural communities are isolated and scattered, micro hydro (MH) systems serve as a viable alternative for enhancing the economic welfare in rural areas. As the establishment of MH systems require considerable resources, it is necessary to first evaluate the systems' economic desirability to gather its net welfare effect on the rural population. Interestingly, the analysis shows that MH systems can be a highly effective means of increasing the economic welfare of people in the rural areas, even though it may be in a weak financial situation. However, bearing in mind the need to ensure the long-term sustainability of these MH systems in delivering services, the financial viability of a system therefore becomes a crucial consideration.

**Sanjay Prasad Gorkhali** is a PhD-candidate in Economics at the Institute of Development Research and Development Policy (IEE), Ruhr-University Bochum with DAAD - Scholarship. He is focusing his research on Economic Analysis of Infrastructural Projects in Developing Countries. He obtained his MA in Development Management in 2002 from IEE and MBA from School of Management, Kathmandu University, Nepal in 1996. He has worked with UNDP financed Rural Energy Development Program in Nepal from 1997 to 2000 and provided short term consulting services to different UNDP financed programs from 2002 to 2004. He has also worked as a Lecturer at Kathmandu Academy of Tourism and Hospitality, Purvanchal University, Nepal in 2003-2004. In addition, he has worked as a Journalist for various National Dailies and Weeklies for several years in Nepal.