# Chapter 6
# A Case Study of Micro-hydropower in Nepal

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## 6.1 Introduction

Water wheels are effective devices for converting the motion of flowing water to steady mechanical power for the generation of electricity. Basically four types of unit are considered for rural applications. These are: i) traditional water wheel; ii) multi-purpose power unit; iii) cross-flow turbine; and iv) peltric-set, as shown in Figure 6.1.

For centuries, traditional water wheels have been made in Nepal using indigenous skills and materials. As a result, there is little conformity in design or performance; and replacement parts must be handcrafted to match the original. These units are limited to an output of about one HP and can be used for grinding only. Wood is the most common construction material and is used for all parts of the wheel except the main points of rotation where steel sleeves or rudimentary bearings are installed (Rijal 1993). The water for these units is typically supplied through an existing irrigation canal or a short diversion from a river. A wooden chute directs this flow to the exposed blades.

The multi-purpose power unit is basically an improvement on the traditional water wheel. There is a marked increase in unit efficiency because of an improved blade design and closed penstock. Though the unit is not powerful enough to drive all of the machinery simultaneously, the equipment can be changed easily, by disconnecting one drive belt and connecting another from a generator, for example. These devices are available in Nepal as off-the-shelf plants with capacities ranging between five and 20HP and are suitable for operation as an electrical add-on system, which can be disassembled for transport and easily reassembled on site (ICIMOD and CRT 1998).

Lower capacity (5-15kW) cross-flow turbine units are particularly suitable for electrical add-on systems, while medium capacity (25-50kW) units are suitable for electri-

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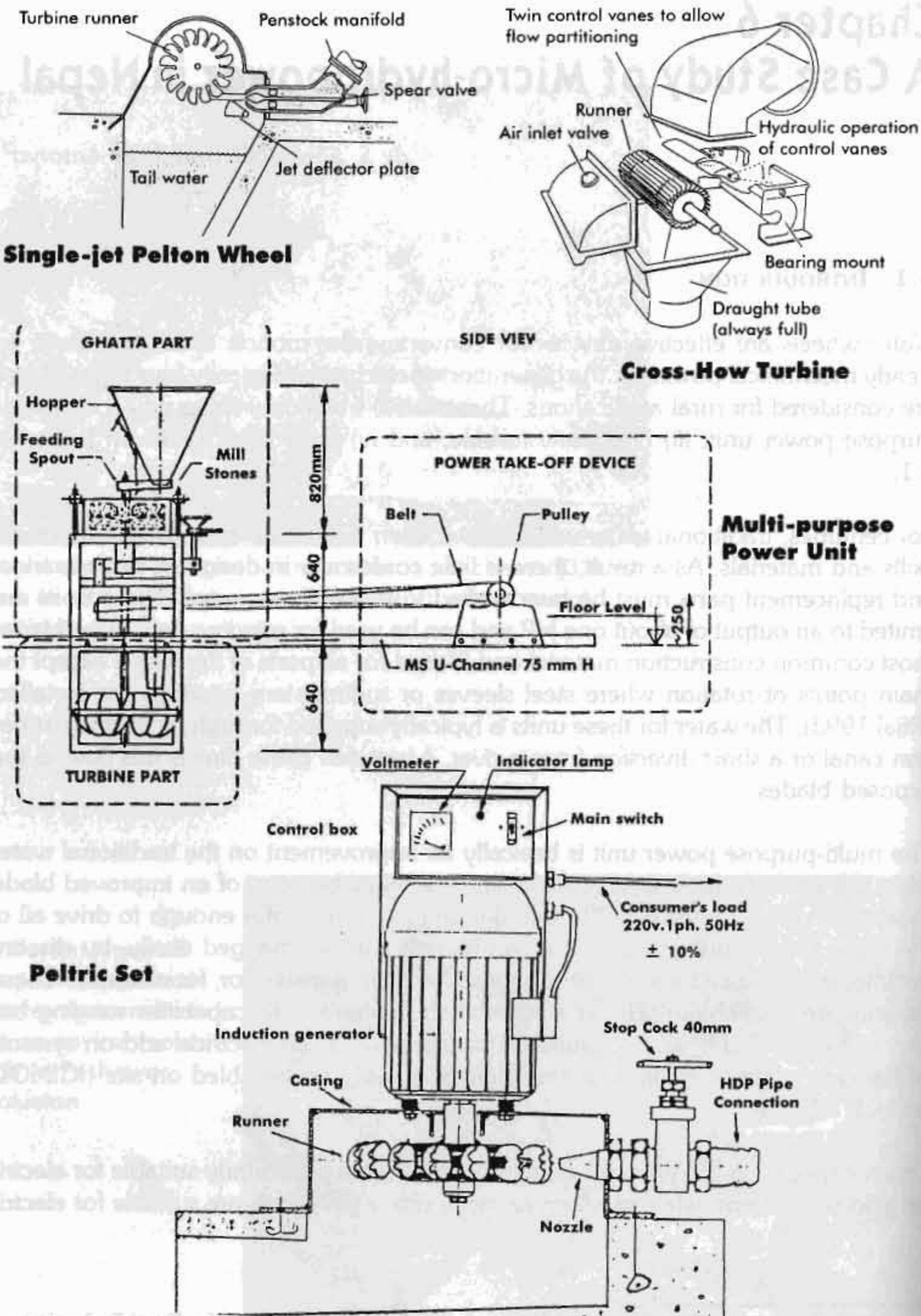



**Figure 6.1: Different types of Micro-hydropower Plants**

cal power production. The basic design of this type of turbine is a cylindrical runner with curved blades fixed on the outer rim. Water enters from the top or front, flows through the blades, thus crossing the blade twice as it passes across the runner. The flow of water occurs in a closed system. These turbines display characteristics of both impulse and reaction turbines (PEP 1995).

A peltric set is a small vertical shaft Pelton turbine with a generator co-axially coupled with it. It generates electricity from a small quantity of water which falls from a great height on the turbine to operate it. Such a device is the simplest form of combined turbine and generator, the turbine being of the impulse type and the generator of the induction type. An impulse turbine derives its power from the water pressure caused by a high head that accelerates the water through a nozzle, allowing it to strike a number of specially designed buckets attached round the periphery of the wheel. The induction generator produces electricity when it revolves at its designed speed, given the right number of excitation capacitors (CRT and ICIMOD 1998). It can be operated with a small quantity of water: 2.5-20 litres per second; and a falling head of 45-50m of gross head. Power output is 600W- 5kW at 220V single phase.

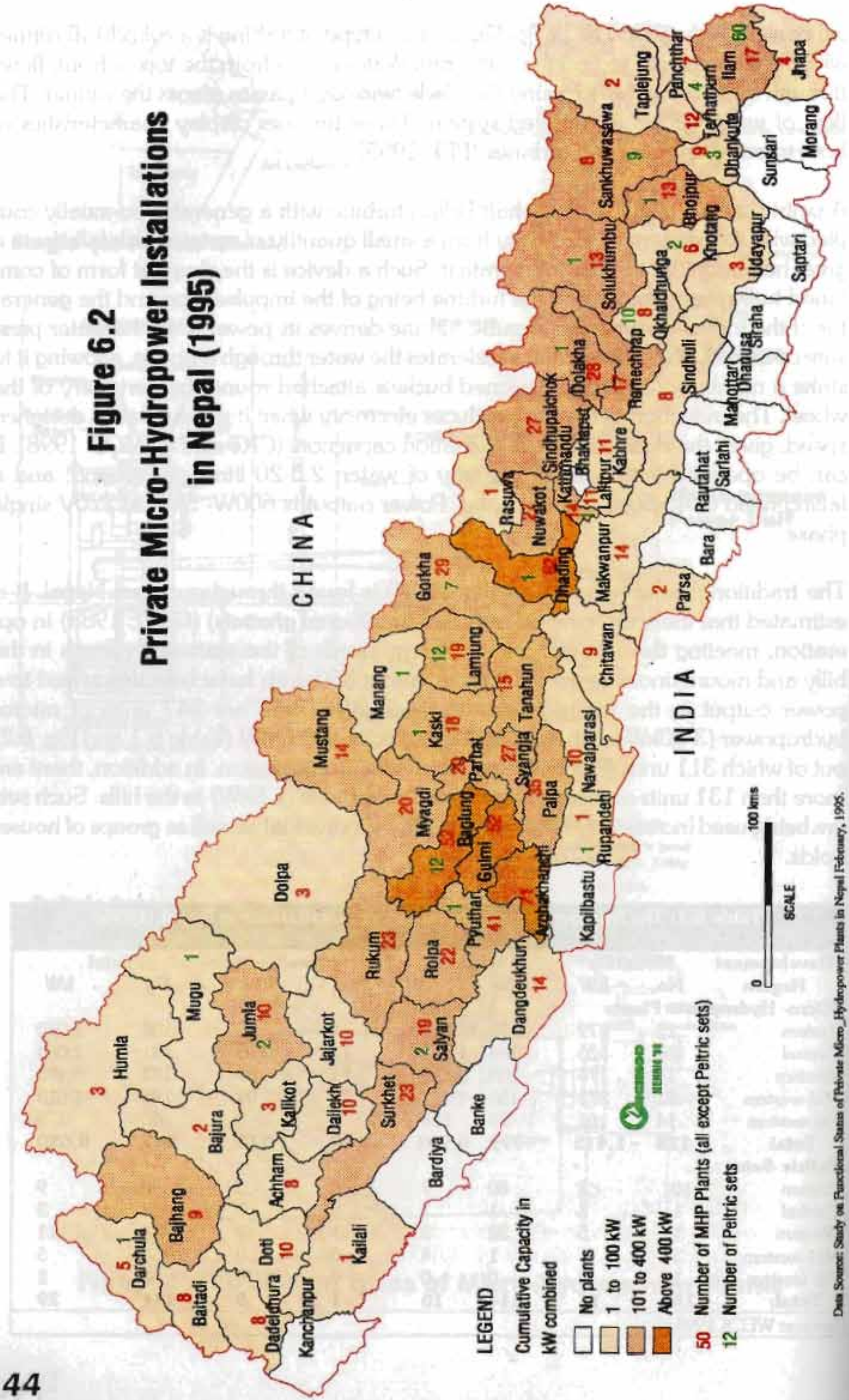
The traditional water wheel (less than 1kW) is found throughout rural Nepal. It is estimated that there are over 25,000 such traditional *ghatta*(s) (GATE 1983) in operation, meeting the agro-processing energy needs of the scattered villages in the hilly and mountainous regions. Of them, about 350 units have been improved to a power output in the range of one to three kW. There are 947 units of micro-hydropower (3-30kW) with the installed capacity of 8.6MW (Table 6.1 and Fig. 6.2) out of which 311 units (2.65MW) are for electricity generation. In addition, there are more than 131 units of recently developed peltric sets (1-5kW) in the hills. Such sets are being used increasingly for electrification by individual as well as groups of households.

**Table 6.1: The Number of Micro-hydropower Installations in Nepal (1995)**

| Development | Mountain | | Hill | | Terai | | Total | |
|---|---|---|---|---|---|---|---|---|
| Region | No. | kW | No. | kW | No. | kW | No | kW |
| **Micro- Hydropower Plants** | | | | | | | | |
| Eastern | 23 | 279 | 75 | 766 | 4 | 25 | 102 | 1,070 |
| Central | 56 | 526 | 164 | 1,453 | 11 | 105 | 231 | 2,084 |
| Western | 14 | 178 | 358 | 3,218 | 11 | 89 | 383 | 3,485 |
| Mid-western | 21 | 272 | 156 | 1,247 | 14 | 94 | 191 | 1,613 |
| Far-western | 14 | 162 | 26 | 218 | 0 | 0 | 40 | 379 |
| **Total** | **128** | **1,415** | **779** | **6,902** | **40** | **313** | **947** | **8,630** |
| **Peltric Sets** | | | | | | | | |
| Eastern | 10 | 2 | 80 | 7 | 0 | 0 | 90 | 9 |
| Central | 1 | 2 | 1 | 1 | 0 | 0 | 2 | 3 |
| Western | 1 | 5 | 32 | 3 | 1 | 3 | 34 | 11 |
| Mid-western | 3 | 1 | 1 | 4 | 0 | 0 | 4 | 5 |
| Far-western | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 2 |
| **Total:** | **16** | **11** | **114** | **15** | **1** | **3** | **131** | **29** |

Source: WECS 1995

**Figure 6.2**
**Private Micro-Hydropower Installations in Nepal (1995)**



The investment cost of micro-hydropower plants is site-specific, the average installation cost varying from NRs 75,000 to 125,000 per kW. The average O&M costs of micro-hydro plants vary widely, depending on the type of ownership (individual, group, or community), location of the site, end uses, and type of turbine. Various studies show that the O&M costs vary from as low as two to three per cent to as high as 50-60 per cent of the total project cost.

The factors that have contributed to bringing the micro-hydro development programme to its present stage are the relatively low capital investment requirements, short construction periods, existence of large micro-hydro potential, indigenous technology of Nepali manufacturers, simple operation, government incentives in the form of loans and subsidies, and the involvement and interest of many international agencies.

## 6.2 Intermediation and Private Sector Participation

The role of financial intermediary is being played by the Agricultural Development Bank of Nepal (ADB/N). In the mid-seventies, it started to promote micro-hydropower for agro-processing in rural areas in order to stimulate the rural economy. ADB/N creates groups of small farmers, under the Small Farmer Development Project (SFDP), where this technology is feasible. Since 1993/94, it has handed over the management of 31 SFDPs to their group members, after converting them to cooperative societies. Wholesale lending (loan fund) is made available to these societies by ADB/N for relending to their members in order to minimise operational costs. Apart from domestic financial sources, grant and loan assistance is being received from bilateral and multilateral donor agencies such as USAID and SNV/Nepal.

The role of technical intermediary is being carried out by investors (NEA, micro-hydro entrepreneurs), though upgrading of technical and operational skills is hampered by the acute shortage of trained technicians. Still, national institutions (WECS, NEA) as well as international organizations such as ITDG, ICIMOD, and UNDP are currently engaged in preparing training materials, while at the same time examining the socioeconomic, cultural, and institutional issues, along with the safety concerns, that ensure the sustainability of micro-hydro installations. Manufacturers themselves train operators during the installation of micro-hydro plants despite the fact that they lack managerial skills. CRT, it is true, organizes regular training programmes for *ghatta* technicians. Nevertheless, there is a gap in terms of institutions that can provide technical backstopping, a function that the successful dissemination of micro-hydro depends upon.

There is limited research and development activities with regard to micro-hydropower development. Some sporadic research activities have been carried out by the Development Consulting Service (DCS), Intermediate Technology Development Group (ITDG), Deutsche Gesellschaft fur Technishe Zusammenarbeit (GTZ), RECAST, Balaju

Yantra Shala (BYS), and Kathmandu Metal Industries (KMI) for the development of suitable technologies to improve efficiency (e.g., innovation of low-cost MPPUs, improved *ghatta*(s), and peltric units) and appliances to promote end-use diversification (e.g., low-wattage cookers, and electric driers).

There is a well-developed manufacturing capability within Nepal for the construction of micro-hydro plants. Swiss Technical Assistance support to BYS and United Mission to Nepal's (UMN) support to DCS have been instrumental to the rapid growth of the micro-hydro construction industry. The development and promotion of micro-hydropower is being handled mainly by the private sector. At present, there are about nine manufacturers of turbines and accessories (see Box 6.1) capable of manufacturing turbine equipment up to 300kW, and they are located mainly in Kathmandu and Butwal. Some of them have a built-in capability to produce turbine casing, penstock pipes, electro-mechanical equipment, and other accessories for hydropower plants up to 15MW in capacity. The total manufacturing capacity of all the manufacturers is more than 2MW per year.

**Box 6.1: Micro-hydro Manufacturers and Their Activities**

| Manufacturers | Activities |
|---|---|
| Balaju Yantra Shala (BYS) | Established in 1960, BYS is a joint-venture project of the Nepal Industrial Development Corporation (NIDC) and Swiss Development Corporation (SDC) Assistance, formerly SATA. Besides other products, it manufactures cross-flow turbines and associated equipment. It has exported micro-hydro turbines and equipment to some Asian and African countries and has support from the Swiss Development Corporation for research and development activities. SKAT, a Swiss agency for the promotion of appropriate technology, is also working closely with BYS. |
| Development and Consulting Services (DCS) | Established jointly by HMG/N and UMN in 1970, DCS conducts survey, design, and installation activities for micro-hydropower plants. Butwal Engineering Works (BEW) supplies water turbines to DCS. ITDG has financially and technically supported the DCS rural electrification project. |
| Nepal Yantra Shala and Engineering (NYSE) | Established in 1975, NYSE makes products ranging from improved grinding wheels to cross-flow turbines. |
| Kathmandu Metal Industries (KMI) | KMI is Nepal's oldest turbine-manufacturing workshop. It designed the first MPPU, and currently manufactures cross-flow and Pelton turbines. Recently, it started manufacturing peltric sets for small power outputs. |
| National Structure and Engineering Co. (NSECO) | NSECO was established in 1966. It manufactures cross-flow and water turbines. |
| National Power Producers (NPP) | NPP is a mechanical workshop which manufactures electric controls, induction generator controllers, and electric load controllers. |
| Nepal Hydro and Electric P. Ltd. | Set up jointly in 1985 by Butwal Engineering Works (BEW), UMN/DCS, and Kvarner, a Norwegian company, it has secured the technical support needed to produce turbines, governers, and related equipment in the range of 100-1,000kW. |
| Nepal Machine and Steel Structures (NMSS) | Established in 1986 as a private company, NMSS manufactures water turbines and related equipment. |
| Thapa Engineering Industry (TEI) | Set up in 1973, TEI specialises in cross-flow turbines. |

The companies manufacturing micro-hydro in Nepal have instituted the Association of Micro-Hydro Manufacturers (AMHM) as a platform for the development of the micro-hydro industry and micro-hydro sector. The association has set common standards for the industry. It is also playing a leading role in creating awareness about micro-hydropower by organizing exhibitions, publishing a newsletter, and conducting training programmes.

## 6.3 The Subsidy Scheme

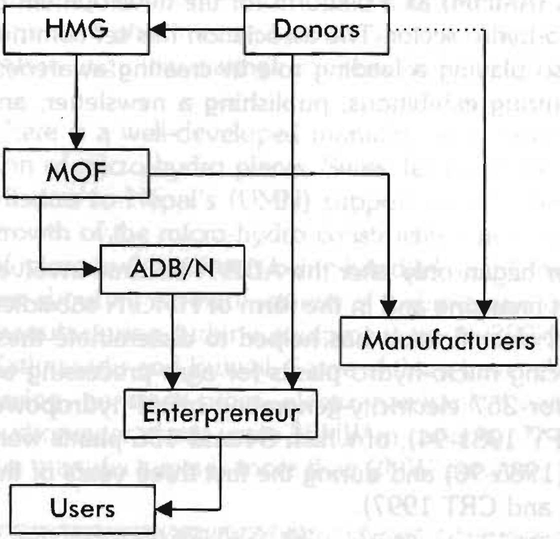
Extensive use of micro-hydropower began only after the ADB/N became involved in its promotion in the form of debt financing and in the form of HMG/N subsidies. The provision of subsidies for rural electrification has helped to disseminate these units more speedily. Besides financing micro-hydro plants for agro-processing activities, ADB/N provided backing for 257 electricity-generating micro-hydropower plants over a period of 14 years (FY 1981-94), of which 84 and 156 plants were installed during the Seventh Plan (1985-90) and during the first three years of the Eighth Plan, respectively, (deLucia and CRT 1997).

The subsidy on rural electrification was introduced in 1985, but discontinued in 1986. It was reintroduced in 1988 and once more discontinued from 1990 until 1992. The government again started releasing subsidies from 1993. The inconsistency in the implementation of the subsidy scheme is one of the reasons that manufacturers have not been able to rely solely on the income generated from the construction of micro-hydro plants; they do not see an assured market, and the risk involved is high because of government vacillation. For example, the annual turnover from micro-hydro amounts to less than five per cent in the case of BYS.

The present policy makes provision for subsidies only on the cost of electrical equipment and transmission and distribution systems. The subsidy is 75 per cent in remote mountainous districts and 50 per cent in the remaining districts. It does not differentiate between stand-alone (exclusively for electricity generation) and add-on plants (agro-processing equipment and generators), 20-40 per cent of the total plant cost being covered depending on project configuration. ADB/N is responsible for channelising the subsidies. It not only provides loans and subsidies but also assistance for surveys, feasibility studies, promotion, and training. The existing micro-hydropower subsidy flow mechanism is depicted in Figure 6.3. In the case of peltric installations, a subsidy is also provided for the cost of up to 100m of polythene pipe used in penstocks.

Foreign donors have also been assisting micro-hydro projects. For example, USAID, working through the Private Rural Electrification Project, provided a capital subsidy (40-50% depending on site), training, and administrative support to three micro-hydropower projects (deLucia and CRT 1997).

**Figure 6.3 Flow of Micro-hydro Subsidies**




The amount of subsidy provided for micro-hydropower is nominal if compared with the total investment budget for the hydropower sector. For example, the subsidy on micro-hydropower amounted to 0.3 per cent of the total expenditure in the power sector for FY 1996/97. This accounted for 15 per cent of all subsidies allocated to alternative energy programmes.

The existing subsidy policy on micro-hydropower does not take into account the remoteness of sites and transportation costs. Because of the mountain topography, there are many areas that are far from the few roads available. The level of subsidy should be linked to transportation costs rather than being awarded on a district basis.

The present scheme excludes subsidy facilities for self-financed projects, since subsidies are channelled through ADB/N to loan-financed projects only. Entrepreneurs who borrow from banks are required to pay interest on the subsidy until it is liquidated, which sometimes takes a few months. Such borrowers are required to provide land and buildings as collateral in order to be eligible for bank loans. They may not have sufficient land, or land values may be too low in rural areas to cover the cost of a micro-hydro project. This lack of physical collateral has kept entrepreneurs from taking advantage of subsidies.

## 6.4 Issues and Options

Various issues identified from case studies are related to policy and institutional matters, economic and social questions, and technical factors. These are briefly summarised in Table 6.2 and discussed in the following. Based on the issues identified, appropriate options are also discussed.

### 6.4.1 Water Rights

Water rights are among the critical issues identified in the case of the Charaundi electrification scheme. The diversion of water supplying the micro-hydro plant for irrigation shut the plant down. In the Water Resources Act, 1992, priority is given to irrigation over hydropower, but it is not clear whether an irrigation scheme can

**Table 6.2: Issues Pertaining to Micro-hydropower Plants**

| Case Study | Policy/strategy | Institutional | Economical | Technological | Social |
|---|---|---|---|---|---|
| Ghandruk micro-hydro | Water rights of the non-beneficiaries of MHP | a) Critical role of technical and financial intermediaries on the success of MHP<br>b) A syndrome of dependency of the community on Annapurna Conservation Area Project (ACAP) | Outside financial support is the critical component of MHP | Low load factor and quality testing of equipment necessary before installation | a) Coherent educated community of Gurungs a key factor for successful community management |
| Barpak micro-hydro | a) Lack of a legal framework to protect the interests of the utility company<br>b) Harassment during establishment of the plant | a) Lack of technical and managerial support in the initial phase, and of monitoring after installment<br>b) An exceptional example of successful micro-hydro in a remote area/Entrepreneur should have the following qualities:<br>• leadership and enthusiasm<br>• managerial capabilities<br>• sound economic background | a) The time lag between the installation and the load factor increases up to break-even point and upsets the financial output of the plant envisaged during the feasibility study. | a) Poor technical know-how increases the investment cost; poor transmission poles<br>b) Risk of floods and landslides to MH plant | a) Coherent educated community of Gurungs a key factor for successful community management |
| Salleri Chialsa mini-hydro | | a) innovative management practices lead to better plant performance<br>b) Lack of coordinated effort on rural industrial development<br>c) Cumbersome procedures for bank loans coupled with high interest rates | | Need for active research on appropriate technology for rural industrialisation and electricity applications in rural settings | |
| Sikles micro-hydro | | a) An organized and cohesive community is one of the reasons for the success<br>b) Support of technical and financial intermediaries (ACAP) is also a key factor in its success | a) Lack of loan accountability<br>b) Flat tariff leads to high load factor | a) Need for active research on productive end use of micro-hydro for rural industrialisation | a) Need for encouraging villagers to invest in their village |

| Case Study | Policy/strategy | Institutional | Economical | Technological | Social |
|---|---|---|---|---|---|
| Improved *Ghatta* in Jumla | a) Need for policy-level emphasis on promotion of improved *ghatta* | a) Support of technical and financial intermediaries (CRT/CSD) is critical for the technology dissemination | a) Community-owned/managed *ghatta* in rural setting where no charge is collected | a) Enough room for improvement in wooden chutes, vibrators, grinding stones, etc | |
| Urthu, Jumla micro-hydro | a) Need for policy-level encouragement of rural industrialisation through emphasis on productive end uses | a) Need to strengthen the organizational, managerial, and technical skills of the community before installing community-owned/managed MH plant | a) Need for training in transparent and simple book- and record-keeping systems<br>b) Need for revenue-generating productive end-use applications | a) Lack of timely service on the part of the manufacturer<br>b) Need for clear-cut guidelines for project feasibility studies | |
| Pancha Krishna MH, pioneer of Dhading | a) Insensitive subsidy policy on canal construction and micro-hydro mill | a) Lack of security of MH plant with respect to possible future water source use (drinking water and irrigation) | - | a) Long earthwork canal of individually-owned MH plant is difficult to maintain<br>b) Natural calamities cause frequent damage | |
| Charaundi, Dhading micro-hydro mill | a) Water rights' problem due to the later development of an irrigation project using the same source | - | a) Higher interest rate from the bank<br>b) Poor book and record keeping system | a) High maintenance costs of the long earthwork canal<br>b) Competition from the diesel mill due to subsidy on diesel and absence of locational barriers | |
| Kali Daha, Dhading micro-hydro | Need of clear-cut policy on damage due to floods and landslides | - | - | a) High maintenance cost of long earthwork canal | |

Source: ICIMOD 1993; WECS/UNDP 1994 ; WECS 1995; IUCN/CRT 1996; and detailed field surveys carried out by the study team divert water that is already in use for hydropower generation. In the case of such diversion, compensation provisions for the plant need to be made explicit.

### 6.4.2 Promotion of the Multiple Use of Water Resources

The multiple use of water resources, such as peltric units and fish farming (as in the case of Pancha Krishna), trout culture in micro-hydro water canals, sprinkler irrigation in peltrics, tail end water use in irrigation, and the use of peltrics in break pressure tanks, should be promoted.

### 6.4.3 Choice of Technology

The dissemination of smaller units such as improved *ghatta*(s), can bring positive advances in performance over the traditional *ghatta* and economic gains to marginalised *ghattera*(s), and also reduce drudgery at the household level (CRT 1995), as in the case of Urthu. During the planning phase, therefore, these smaller units should be given due importance.

### 6.4.4 The Increase of Diesel Engine Mills

An increase in the number of mills operated by diesel engine and a reduction in the operation of micro-plants is one of the major observations made during the field survey. The constraints faced by micro-hydro plants, such as location, water resource utilisation, the high maintenance cost of a long canal, and lack of subsidy for the mechanical components (as against the high subsidy for diesel), are a few reasons for this.

### 6.4.5 The Need to Differentiate among Management Practices for Micro-hydro Technologies

There are various technologies and management practices within micro-hydro, and they require an in-depth understanding and set of policies for making them financially viable and technically and environmentally sound. *Ghatta*(s), improved *ghatta*(s), peltric sets, stand-alone generating plants, turbines with a mechanical drive only and those with an electric add-on are a few relevant parts of the classification. On the basis of these technologies one should differentiate between policies, so that, for instance the improved *ghatta* used for electrification in Urthu and Ghandruk is not dealt with at the same level as uniform policy tools. There is also a distinct need to classify micro-hydro according to the mode of management. Different modes of management will require different levels and kinds of support. Indeed, they play a vital role in the successful operation of the plant. For example, plants managed by *private entrepreneurs* require strong zeal, innovative ideas, good management capabilities, social commitment, and leadership from the entrepreneur. The electrification of Barpak is an excellent example of such a scheme. It has been found that an agent (third party) needs to be present who is capable of enforcing community-accepted rules for the successful operation of *community-managed plants*. Further, strong community organization, democratic leadership, technical and managerial skill enhancement, and continuous technical back-up are necessary pre-conditions for making micro-hydro ventures successful, as illustrated by the Ghandruk and Sikles electrification schemes. Salleri Chialsa's innovative management approach (i.e., *limited liability* or *public company plant*) is a good example of a professionally managed scheme which has led to the financially successful operation of the plant and, thereby, contributed to the overall development of the rural area through rural industrialisation.

### 6.4.6 Unrealistic Project Feasibility Study

An accurate project feasibility study and design are essential for the success of any enterprise. The overambitious projection of use of electricity by villagers in feasibility studies is one of the main reasons for failure (deLucia and CRT 1997). Similarly, unrealistic provisions for the maintenance of long earthwork canals and inaccurate head/discharge measurements have forced many micro-hydro entrepreneurs to face financial loss and often bankruptcy. In preparing a feasibility study, it is important to recognise the implications of the assumptions one is making about the socioeconomic base, the technical and managerial capabilities of the community, and market potential (or load estimation). For example, the micro-hydro plant of Saroj Adhikary in Jogimara has not been operational since its installation due to faulty survey and design.

### 6.4.7 Accountability of Services Provided for Feasibility Studies and Designs

The accountability of surveyors and manufacturers needs to be ensured through appropriate institutional mechanisms. The cost of a feasibility study should be reimbursed regardless of the project's feasibility. However, the question poses some problems. One solution would be that a third party, a consulting firm or micro-hydro association, in a manner acceptable to the manufacturer, entrepreneur, and bank, conduct the feasibility study. The cost of the study would eventually be borne by the entrepreneur if the project is implemented. Otherwise the cost would have to be reimbursed to the consultant through making available some kind of funding from the bank. There is also some need for a financial commitment on the part of the entrepreneur during feasibility studies to ensure genuine interest.

### 6.4.8 Technical Back-up and Monitoring

Technical back-up and monitoring is one of the main issues in the field of micro-hydropower. As a bank is a financing agency, it monitors only from a financial perspective, while manufacturers are by nature profit-making entrepreneurs, their main concern being the sales' volume of their micro-hydro equipment. There is no agency to monitor the performance of micro-hydropower plants. According to the micro-hydro owners, bank officials, and manufacturers interviewed, "There should be a monitoring and backstopping agency to improve the technical and managerial capabilities of the micro-hydro manager to make the micro-hydro plant a technically, economically, and environmentally sound venture."

### 6.4.9 Insurance of and Warranties on Plants

A case study of micro-hydropower in Dhading has revealed that serious damage was done to plants due to the floods in BS 2040 and 2051. This was the reason, for example, why Pancha Krishna discontinued operation of this plant in Malekhu. In order to save entrepreneurs from such calamities, insurance should be made mandatory. Similarly, long-term warranties provided by manufacturers could be instrumental in avoiding losses that may accrue to the plant owner due to manufacturing defects.

### 6.4.10 Training of Operators

Most of the micro-hydro plant operators interviewed have not received structured training (CRT 1995). Availability of trained operators is a prerequisite for the successful operation of micro-hydro plants. Offering structured training should be made mandatory for manufacturers, while there is also a need for them to provide 'training to trainers of training skills'. Most of the micro-hydro plant owners and managers need training regarding the management of plants (simple record and account keeping, simple business skills, etc).

### 6.4.11 Quality Control and Standardisation

According to farmers interviewed, the micro-hydro plants installed in the initial stages during the 1980s are of better quality than those being installed at present. The quality of raw material used, the safety code to be followed during installation, and the rated power of turbines and generators need to be standardised; many complaints having been voiced by plant owners in this respect. There is also a need to have a monitoring agency for the quality control and standardisation of installed micro-hydro plants.

### 6.4.12 End Use Diversification

It is observed in almost all micro-hydro plants (except peltrics) that supplying electricity for lighting alone is not financially viable due to the low load factor. Technologies have been established for diversified end uses such as agricultural processing (grinding *chakki*, hulling, pressing oil pounding, *chiura* (beaten rice), shelling, etc.). There is a need for research on and development and promotion of the other innovative technologies needed locally, including cold storage, small dairy operations, ice production, crop or fruit drying, power looms, carpet weaving, rural transportation, wood carving, handmade paper, and food processing. These developments will not only increase the profitability of plants by increasing the load factor but also bring positive changes to the village economy through rural industrialisation. A special fund should be allocated for such technology research and development.

### 6.4.13 Maintenance of Earthen Canals

The characteristics of feeding canals are one of the critical factors determining the smooth operation of micro-hydro plants. High seepage, damage from frequent landslides and floods, and blockage result in high maintenance costs and the unreliability of plant operations. The availability of construction manuals and an enforced code of standards for constructing canals will result in reduced costs for maintenance.

### 6.4.14 Gender Issues

Since agro-processing, cooking, and weaving activities are primarily carried out by women, use of hydropower can be expected to have a significant impact on women's work loads, increase their productivity, and improve their health conditions (see Tab. 6.3). The installation of MHP has not only reduced the drudgery of women but also altered the division of labour between the sexes. For example, previously only women were involved in grinding and husking operations, but, after the installation of MHP, male family members also carry loads for processing. Regarding the participation of women in the planning, implementation, operation, and management of micro-hydro plants, no documentation exists. As there is no gender-oriented policy for the development of micro-hydro, it may be assumed that women's participation in micro-hydro projects, particularly the aspects of them just mentioned, is either non-existent or quite negligible.

**Table 6.3: Women's Daily Allocation of Time before and after the Installation of a Micro-hydro Units**

| Time | Before | Time | After | Remarks |
|---|---|---|---|---|
| 3:00-4:00 | Get up, do grinding and husking | 3:00-4:00 | Sleep | |
| 4:00-5:00 | Cook animal food and feed cattle, do cleaning | 4:00-6:00 | Get up, cook animal Food, and do cleaning | |
| 6:00-7:00 | Make fire, fetch water, milk cow and boil milk, prepare for puja | 6:00-7:00 | Make fire, fetch water, milk cow and boil milk, prepare for puja | |
| 7:00-8:00 | Prepare breakfast, feed children, send children to school, feed men, and eat themselves | 7:00-8:00 | Prepare breakfast prepare, feed children, send children to school, feed men, and eat themselves | |
| 8:00-10:00 | Prepare lunch | 8:00-10:00 | Prepare lunch | |
| | | 10:00-11:00 | Rest | |
| 10:00-11:00 | Collect grass, fuelwood, and fodder for animals | 10:00-11:00 | Collect grass, fuelwood, and fodder for animals | |
| 11:00-12:00 | Lunchtime, clean utensils and house | 11:00-12:00 | Lunchtime, clean utensils and house | Collect fuelwood once a week |
| 12:00-14:00 | Provide water for animals and do grinding and husking | 12:00-14:00 | Provide water for animals | |
| 14:00-15:00 | Prepare *khaja* and do cleaning | 14:00-15:00 | Prepare *khaja* and do cleaning | |
| 15:00-17:00 | Collect grass, fuelwood | 15:00-17:00 | Collect grass, fuelwood, sometimes go to mill for grinding | Sometimes her husband and son help to carry grain to the mill |
| 17:00-18:00 | Prepare animal food | 17:00-18:00 | Prepare animal food | |
| 18:00-21:00 | Cook dinner, feed children, feed adults, and eat | 18:00-21:00 | Cook dinner, feed children, feed adults, and eat | |
| 21:00-23:00 | Clean utensils and sleep | 21:00-23:00 | Clean utensils and sleep | |

Source: Field study (Gajuri) and A Gender Analysis Vols. I and II, Dolkha-Ramechhap Community Forestry, Resource persons: Mrs. Sunmaya Shrestha and Mrs. Panch Kishna Shrestha

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